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ABSTRACT

This report provides a survey of existing policies and procedures for Massachusetts school planning and construction processes; and explains systems building as a set of procedures, the most important of which procedures are market aggregation and component prebidding. The importance of systems building in reducing construction costs and improving school facilities in Massachusetts is also discussed. The study recommends the creation of a Statewide corporation to oversee and finance school construction throughout the State while insuring continued local participation in educational planning and design. A related document is EA 004 072. (RA)

The Massachusetts Advisory Council on Education is an independent state agency created by special legislation (General Laws, Chapter 15, Section 1H) for the purpose of recommending policies designed to improve the performance of all public education systems in the Commonwealth. As such the Advisory Council provides support for studies which will recommend policies promoting and facilitating the coordination,effectiveness and efficiency of these educational systems.

A SYSTEMS APPROACH FOR MASSACHUSETTS SCHOOLS

Errata

Page	Item
iv	Fifth sentence should read "If all 10,700 classrooms needed during the next five years are constructed, the estimated cost will be $1,500,000,000."
ix	Second paragraph, last sentence should read "At current rates this is upwards of $1.5 billion of new construction."
38	Footnote should refer to Chapter III-8.
44	The publisher of the volume cited in paragraph 4 is the Council of Educational Facility Planners.
91	Footnote should refer to Appendix III-1-1.
92	Footnote should refer to Appendix III-1-2.
156	Last sentence should begin "Without a research..."
164	Footnote 2 should refer to Appendix III-13.
234	Footnote should refer to Appendix IV-6.
249	The reference in the second last paragraph should be to Chapter III-8.
250	The reference in the second paragraph should be to Chapter III-8.
261	The reference in the second paragraph should be to Chapter IV-7.
269	Item a under Project Cost Savings in Exhibit I should have a conlcuding parenthesis.

A SYSTEMS APPROACH FOR MASSACHUSETTS SCHOOLS - FINAL REPORT

Errata - 2

Page	Item
viii	Line 3 should read "...construction, fees, site development and equipment."
xii	Paragraph 5, the number in item c should be 5 percent.
xiv	Paragraph 6, delete item b.
xvi	Paragraph 1, the range of percentages for the first course of action should be 19-29%.
296	Paragraph 1, second sentence should read "... has both highest potential savings and a greater potential for ..."

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A STUDY OF SCH

for the

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by

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Judge Charles

PROACH FOR MASSACHUSETTS SCHOOLS

A STUDY OF SCHOOL BUILDING COSTS

for the

MASSACHUSETTS ADVISORY COUNCIL ON EDUCATION

by

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FOREWORD

Growth in population, modern technology and inflation have raised the economic costs of servicing and governing our complex society to an almost unbearable load. The leisurely, relatively simple, decentralized practices of the past do not respond to the opportunities of modern technology, and they are wasteful in responding to increasing demands and costs. Our pubiic schools, spending $1,200,000,000 a year, are the State's biggest business - public or private. Providing housing for 1,100,000 school students constitutes the State's largest single construction business, $150,000,000 in 1971. If all 10,700 classrooms needed during the next five years are constructed, the estimated cost will be $1,200,000,000. Inflation and interest will increase their ultimate cost to between two and three billion dollars. One response of many communities is to delay further needed buildings which causes their children to be overcrowded into extended or double sessions in inadequate buildings often over a half century old. This understandable delay not only deprives generations of children, but it transfers to future years at higher costs the inevitable responsibility to build schools. On the conviction that people in Massachusetts and their leaders need to know what possibilities are available to them, and informed by the study of the Business Task Force for School Management that modern management practices and application of modern buildings systems could appreciably reduce the cost of our school buildings, the Advisory Council commissioned the study reported in this volume. It engaged the noted architectural firm of Campbell, Aldrich and Nulty to assemble a team of experts in finance, law, management of technology, architecture and education. This team has gathered extensive information, appraised most of the factors affecting

school building costs, developed a series of
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school building costs, developed a series of steps to reduce those costs and presented them for discussion at meetings across the Commonwealth. The result of these efforts, funded by $135,000 of the State funds and $10,000 of Federal funds, appears in this report. The estimates of savings and the methods for achieving them are based upon the sparse information which is available and upon the judgments of the study experts after extensive consultation. The most important and controversial recommendation is that the Legislature create a modern management tool in the form of a new corporation. This corporation, with appropriate safeguards, would be empowered to bring together all of the practices in planning. building and financing our schools and to execute them so as to transfer the financing of our schools to the State and in doing so reduce the cost so markedly as to cost the State little more than it will pay in its present partial funding program.

If even fifty percent of the estimated economies could be achieved in the costs of the schools we must build during the next five years and paid for over the next ten to twenty years, the people would be relieved of a half billion dollars of taxes, and the savings would continue on buildings constructed beyond five years from now. This amount is the equivalent of 25% of the current $2,000,000,000 operating budget of the State.

An examination of the analyses and recommendations of this study suggests an agenda to which the people and their leaders should give careful attention. On behalf of the Advisory Council and the Legislature which created it and funded it and the Governor who appointed it, we present this extensive and significant study and urge that it be given the consideration the dimensions of its subject require.

William C. Gaige
Director of Research

PREFACE

In June 1970, the Massachusetts Advisory Council on Education commissioned the Boston architectural firm of Campbell, Aldrich and Nulty to assemble an interdisciplinary team "to conduct a (year-long) study of school building with particular emphasis on the feasibility of implementing building systems in the planning and construction of schools in the Commonwealth of Massachusetts."

The scope of the study was deliberately made broad. The total school delivery process was recognized to be an intricate network of complex and interactive factors. Likewise, it was recognized that "systems building" is not simply a way of putting building components together, but a total process with implications on planning, design, bidding, contracting and construction management.

A team of experts in a wide range of fields was assembled to collaborate on this study with Campbell, Aldrich and Nulty. These firms and individuals included:

Building Systems Development, Inc., of San Francisco, California. This is the firm which has pioneered the development of systems in North America.

George J. Collins, of Boston. Dr. Collins is a lawyer, an educational consultant, and former Assistant Commissioner of Education of the Commonwealth.

Mahoney, McGrath, Atwood and Goldings, attorneys, Boston, This firm is experienced in construction contract law. Judge Charles F. Mahoney is a former Commissioner of Administration and Finance of the Commonwealth, and Morris Goldings, Esq., is counsel to two State building authorities.

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McKee-Berger-Mansueto, Inc., of New York, Chicago and Boston, who are national leaders in the field of cost estimating and construction management.

F.S. Moseley, and Co., of Boston, who are securities analysts and brokers who have been active in the field of municipal and state bonds for many years.

SRS Consultants, Inc., Boston, who are broad based consultants active in the fields of educational, health, and research facilities.

The full Study Team was a large number of hard working individuals who are acknowledged in the credits at the end of the Report.

At all stages of the Study, the steadfast support and constructive criticism of the MACE Director of Research, Dr. William E. Gaige, and his Assistant Director, Dr. Allan Hartman, were invaluable.

In response to its charge, the study team compiled a detailed picture of the existing school delivery process. With the assistance of the School Building Assistance Bureau of the State Department of Education, basic data were compiled on all school construction projects begun since mid-1965. The existing planning and approval process, building codes, the current state of building technology, labor markets, bidding and contracting procedures, and means of finance were all thoroughly investigated, yielding a comprehensive view of the present mechanisms by which a schoolhouse is built. At the same time, the team also investigated the advantages and possible uses of systems building, drawing heavily on the experiences of recent large-scale multi-school programs in Florida, California, Toronto and Montreal, and a variety of individual school projects, including some already under way in Massachusetts.

In order to secure the informed advice of a large number of organizations and individuals either involved in or affected by school construction, an Advisory Study Committee was formed. Its membership included representatives of the Legislature, taxpayer groups, contractors, architects, industrialists, organized labor, and educators, lawyers, financiers and officials from local, state and federal government. The Committee met as a whole three times during the year with the study team -- once during the early stages of the study, once as the team was beginning to develop its preliminary recommendations, and once to discuss the preliminary draft of the report. Also, individual Committee members met with persons from the study team from time to time over matters of mutual concern. The Committee served its function particularly admirably in reviewing the Preliminary Draft of the study, which was circulated in August of this year. Many members contributed conscientiously of their time in submitting constructive comments, some in great detail, on all parts of the study, and it may be said that the degree to which the study is sound and realistic may in part be due to their observations. The full list of the members of this committee appears in the front of this report.

Two series of five regional meetings were held in various communities around the state, in early winter and in May. These meetings, open to all interested persons and groups, accomplished on a local level much the same ends as the meetings held with the Advisory Study Committee:

At the first meeting, to give the study team insight at first hand into current problems relating to school construction, to allow the study team to discuss with the participants the nature and advantages of systems building, and for the team to receive comments and suggestions to help give further guidance to their work;

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Nelson W. Aldrich, FAIA
Project Chairman
November, 1971

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The persons attending both series of meetings provided the study team with much useful information and insight into the nature of the existing school delivery process and many helpful suggestions and criticisms, a great number of which have been incorporated into the final recommendations of this study.

Particular thanks for their sympathetic and constructive help are given to Henry Hersey of the Massachusetts Selectmen's Association, Thomas Piggott of the Massachusetts Mayors Association, Lyman Ziegler of the Massachusetts Taxpayers Foundation, Robert Capeless of the Massachusetts Tax Commission and Kevin Shea of Speaker David Bartley's staff.

Nelson W. Aldrich, FAIA
Project Chairman
November, 1971

SYNOPSIS OF FINDINGS AND RECOMMENDATIONS

The following is a synopsis of the findings and recommendations of this study. Any digest of 300 pages of research inevitably will omit many significant points. It is offered here as a guide to help readers in initially comprehending the full picture detailed by the study. Numbers in parentheses refer to chapters in the body of the report.

SECTIONS II AND III - THE EXISTING SCHOOL DELIVERY PROCESS

In Massachusetts, as in most other states, the design and construction of public schools is a function of the local district, which, with its consultants, plans and designs each new facility, contracts for its construction, raises the majority of the funds to pay for it and operates it for the duration of its useful life (II-1).

The construction of recent Massachusetts schools is generally high quality and durable. In most cases, designs are up to date, functional and attractive. The design of most existing schools, however, fails to recognize that change will probably be the most certain element of their environment. The situation is improving rapidly, but few schools incorporate adequate provisions for rapid and economical change, and consequently remodelling costs remain higher than they might be if the designs for new schools included adaptability to new configurations as one of their parameters (III-7, 9, 10).

Due in large part to the press of more urgent matters, there is inadequate attention given to long range planning and need forecasting at the local level. As a result, the need for new school facilities is frequently allowed to become critical before the planning and design process is initiated, with the result that the new building will not be constructed until some time

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All new schools must be approved by the state other interested state agencies. The state pl generally effective, although cumbersome. Sev involved in all aspects of the planning and de is a lack of central coordination among them. written standards, procedural handbooks or inf Department of Education, this situation makes virtually a necessity for each project (II-4).

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after the need for it has become very serious, and making effective allocation of the community's financial resources very difficult. Many communities do not maintain permanent building committees, with the result that there is little carry-over of experience from one project to the next, requiring that the building committee learn its role anew for each project (II-2).

All new schools must be approved by the state Department of Education and other interested state agencies. The state planning and approval process is generally effective, although cumbersome. Several state agencies are involved in all aspects of the planning and design of new schools, and there is a lack of central coordination among them. Coupled with the absence of written standards, procedural handbooks or information service from the Department of Education, this situation makes the services of a consultant virtually a necessity for each project (II-4).

The approval practices of the Department of Education result in more than adequate floor space. In some cases the per-pupil gross areas are substantially larger than those found in other states. Likewise, net to gross area ratios are sometimes as low as 54%. The commonwealth places no limit on the maximum per-pupil area or cost which can qualify for financial aid; compact, well-planned schools are reimbursed at the same rate as less economical ones. (III-12)

New school construction is largely financed through the local property tax. The ability of local property-owners to pay for new school facilities varies widely from town to town across the Commonwealth, frequently in inverse ratio to the need. Equality of educational facilities for all residents of the Commonwealth is simply not feasible when the major impact of school construction costs falls on the individual community. State construction aid provides some assistance, ranging between 40% to 65% of the cost of construction, fees, and equipment. Local referenda, required for the approval of the bond issues necessary to pay for new schools, are a major source of delay and added cost; large numbers of recent local bond issues have been rejected by the electorate, reflecting the frustration of voters with high building costs and property taxes. These communities frequently end up with "less school, later, for more money," due to the effect of rising costs. There is a need for a means of financing new school construction which will not add further to the burden obstacle now presented by the two-thirds majority required for passage of a local referendum. (II-2, 3).

The building codes which govern school construction, with minor exceptions, are uniform throughout the Commonwealth. Their provisions are generally reasonable, although their format tends to discourage innovation in favor of "tried and true" materials and processes. School building regulations are written by the Board of Schoolhouse Structural Standards, but are enforced by the Department of Public Safety, whose inspectors may have different interpretations of the regulations from those intended by the Board. Within the Department of Public Safety, different persons from those who approve plans and specifications inspect in-progress construction for compliance, and they again may differ in their interpretations of code material and required compliance. There is no appeal from this situation short of taking a dispute to court.

School construction as a process is characterized by high costs, fragmentation of responsibility, inadequate cost and time control, wide fluctuations in the amount of work in progress, and seasonality. Although contracting is

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one of the largest industries in the United States, it is largely composed of small businesses. The multiplicity of subcontractors and suppliers involved in a typical project serves to diffuse responsibility and to encourage buck-passing. Schedules are frequently not met; two thirds of the study's sample of recent schools were not completed until after the agreed-upon date, with the average delay running about thirty-five to forty percent more than the originally-allotted time. The correlation between project size and the duration of construction is low. Cost control is inadequate; especially in periods of inflation. Designers' estimates of probable cost are subject to a variety of external factors, such as other construction market conditions, and as a consequence, are frequently inaccurate. The times at which projects are placed on the market for bids are not coordinated in any way, and great fluctuations in the amount of available construction work are common. The bidding process results in the selection of a contractor being dependent in effect on price alone and provides no feasible way to reward superior performance (III-1, 5, 6).

In recent months construction costs have been rising at an annual rate of approximately twelve percent (doubling in six years), although there are indications of an imminent lessening to seven percent (doubling in ten years). Construction wages in the Northeast are among the highest of any region of the 48 contiguous states. Labor productivity has been slowly increasing, but this increase has not kept pace with wage increases. It is likely that the state law setting the minimum wages to be paid to labor on state-assisted construction projects may have served to intensify the upward pressure on wages and wage-related costs. Despite high wages and frequent labor shortages, however, the average annual wage in the building trades is lower than for factory workers, due to the seasonal nature of employment in the field. The supply of labor which is forecast for the next decade appears to be inadequate to meet the anticipated demand for new construction. (III-3)

The five-year projection of needs shows that Massachusetts will have to build 30 to 40 million square feet of new school space, in order to meet current needs. At current rates this is upwards of $1.2 billion of new construction. (III-13).

In looking into trends in school planning, the only certainty is change. The surest way to deal with it is to provide flexible school facilities.

SECTION IV AND V THE SYSTEMS APPROACH AND SYSTEMS BUILDING

In its essence, the systems approach is simply a working method which, instead of attempting to solve a complex problem piecemeal, approaches it is an orderly way by defining goals, analyzing means of achieving them and then carefully organizing the actual progress to a solution. As applied over the past decade to the construction of schools in programs in California, Metropolitan Toronto and elsewhere, the systems approach has yielded new ways of organizing the school delivery process which have resulted in systems construction: a series of components which may be assembled, rapidly and without cutting or fitting, into attractive, economical and flexible school buildings which are a better buy than conventionally constructed structures. (IV-1)

Systems building is not guaranteed to produce less expensive schools, although its use in many instances has resulted in lower construction costs than for conventional buildings. Systems construction produces buildings which incorporate

more needed facilities and more flexible spa
because systems construction is much faster
allows new schools to be finished and begin
savings in total project and peripheral cost

As presently known in North America school b
a single highly successful program known as
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more needed facilities and more flexible space for the same dollar. And because systems construction is much faster than traditional building, it allows new schools to be finished and begin their use earlier at considerable savings in total project and peripheral costs. (IV-2).

As presently known in North America school building systems grew out of a single highly successful program known as School Construction Systems Development, which was active in the early 1960s in California. A voluntary consortium of about a dozen school districts created an aggregated market for building components. The market was sufficiently large to interest manufacturers in developing new products and modifying existing ones for use by the local architects in designing the individual schools. Performance specifications established what was expected of the components while leaving open the means by which the performance was achieved. This was the first time in the construction industry in this country that groups of manufacturers came together to develop compatible components to that extent. Since the completion of the SCSD program there have been a number of successful systems building programs throughout the United States and Canada, which both developed new components and took advantage of existing ones. In addition, over 1300 individual schools have been built using systems components (IV-3). Readily available coordinated building components now include structure; heating, ventilating and air-conditioning equipment; integrated ceilings; electrical and electronic distribution equipment; and interior partitions. Taken together, these components can account for 40-50% of the construction cost of a new school. In effect, the use of systems components extends the standardization already used in screw threads, metal gauges, light bulbs and so on, to the scale of the building itself. The quality of designs possible with systems components is, as with conventional buildings, a function of the architect and his client.

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Systems components are no more or less inhibiting to a designer than standardized door sizes, floor tiles or lighting fixtures. Since the architect is relieved of the necessity of forcing a collection of unrelated parts into some sort of a fit, he can devote more of his time and effort to apportioning space and creating an esthetically attractive environment for education (IV-2).

Systems building is a set of procedures, not a collection of building components. Among the most important of these procedures are market aggregation and component pre-bidding. By bringing together the needs of a number of schools, the size of the market for components is made large enough to enable suppliers to offer both lower prices and to show a greater willingness to make modifications to their products in response to the needs of the particular situation. Likewise, by bidding these components when the individual schools are still in the early design phase, both cost control and savings are possible. After the systems components have been bid and the successful suppliers named, the architects for the individual schools are able to proceed with their designs on the basis of specific, known products and firm prices for the majority of their work (IV-4). Each of the aspects of the systems may be utilized separately with some benefit. However, the aspects are mutually supporting, and their full benefits are only achieved when all are used together. It is a case where the whole is greater than the sum of the parts. (IV-4)

Many people initially confuse the systems concept with standard plans. It is important to recognize the differences between stock plans and systems building: stock plans standardize complete buildings, while with systems building only the components are standardized. These components may be utilized to create any plan which is needed to meet the needs of the school.

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Based on the failure of the recent New York state program and other experiences around the country, it appears that the standard plan solution is intrinsically inferior in quality and flexibility to systems building, primarily because an entire school is too large and cumbersome a "component" to use effectively without requiring expensive modification to adapt the prototype design to the particular nature of each individual project. (IV-6)

The existence of a number of schools using systems components which are currently under construction within the Commonwealth clearly establishes that it is possible, feasible and economical to use systems building to construct schools at the present time. These schools however, although they use systems components, have been bid and contracted for in the conventional manner. In order to secure the full advantages of a systems approach to school construction on a statewide basis, including market aggregation and component pre-bidding, various modifications would have to be made to the existing system. (IV-7)

The present bidding law of the Commonwealth is not favorable to specifying components by the performance required of them rather than by the materials and methods to be used. The statutory categories of filed sub-bids are not well-suited to systems components; although it is technically not legal, some recent projects have been successfully bid using, for instance, a single sub-bid for "integrated ceiling," rather than splitting that component, as required by law, into its electrical, acoustical tile, heating and other parts. (V-1).

Prequalification of bidders, felt to be an indispensible part of developmental systems building programs, presently is illegal in Massachusetts. Staged bidding, either in the form of component pre-bidding or of "fast-tracking," is cumbersome, although legal. (V-1)

Building codes, while conservative and actually outdated in a few instances, should present no obstacle to the widespread introduction of systems building. There is, however, a need for more consistent enforcement of the code's provisions which are subject to interpretation, and more responsive procedures for appealing unfavorable rulings by inspectors. (V-2)

In general, the attitude of informed representatives of organized labor appears to be guarded, but reasonable. There is every reason to believe that systems building can offer labor more jobs, more stable employment and an improved annual wage situation. If this is so, they can be expected to become increasingly helpful in implementing a systems program. (V-3).

The cost experience of other large-scale systems building experiments suggests that should a systems program be undertaken in Massachusetts, after an initial short period of variable prices due to unfamiliarity with the process, costs will drop. Due to the slower rise in cost foreseen for systems construction than for conventionally built structures, the competitive position of systems will steadily improve as time passes, and from the start will provide a significantly greater building value per dollar invested in new school construction. (V-5).

SECTION VI - POSSIBLE AND RECOMMENDED COURSES OF ACTION

The courses of action and recommendations contained in this report were developed with several goals in mind:

- to provide for the construction of school buildings at less than the currently prevailing costs;
- to close the gap between the time when a new school is first needed and it is available for use;
- to accomplish the first two g
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built;
- to provide a degree of relief
removing school construction
the property tax;
- to encourage continuing impro
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A Possible Course of Action:

Piecemeal Changes within the Existing

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- to accomplish the first two goals with buildings of a quality which is equal or superior to school houses currently being built;
- to provide a degree of relief to the property taxpayer by removing school construction financing from dependence on the property tax;
- to encourage continuing improvement in the quality, economy and delivery time of new schools;
- to achieve all of these goals as rapidly as possible (VI-1)

The results of the study indicate that there are basically two courses of action by which these goals might be achieved. The first course of action is the decentralized, piecemeal approach to improvements, which would essentially retain the existing administrative relationships and procedures. The second course of action would radically transform the school delivery process by transferring the responsibility for school construction from the municipalities to a single new organization, the Massachusetts School Construction Corporation, which would be funded entirely by the State. While both courses are feasible and would produce major improvements, it is believed, for reasons of cost and time savings, and efficiency in the delivery process, that the second course would be far more likely to achieve the necessary goals; accordingly, implementation of such a corporation is the official recommendation of this study. (VI-1).

<u>A Possible Course of Action</u>:

<u>Piecemeal Changes within the Existing Framework</u> (VI-2)

The existing framework of the Massachusetts school delivery process may be modified by specific legislative and administrative actions, each of which would be addressed to solving a specific problem. In the aggregate those changes might approach the stated goals.

Proposals for piecemeal changes within the existing legal and administrative framework could provide for moderate increases in state activism and financial support for the construction of public schools. The present jurisdiction of the Board of Education would be continued and the School Building Assistance Bureau strengthened; there could be changes relating to public safety regulations and building codes; there could be modification of the bidding laws to accommodate special requirements of systems building; there could be increases in state aid; and changes could be made in the method by which local communities determine school needs. The basic relationship between state and local government in the school delivery process would, however, remain unchanged, with the local districts initiating action and the state responding.

The staffing pattern and salary levels of persons working in the Department of Education, particularly within the School Building Assistance Bureau, should be strengthened and increased. Specialists in school planning have been in demand throughout the country for many years, but the Commonwealth's salary schedule has not provided salaries competitive with universities, private consulting firms, or city school systems. To enable an agency such as the School Building Assistance Bureau to perform its present tasks effectively and to assume new responsibilities, such as maintaining an inventory of existing and needed spaces, the evaluation of the condition of existing instructional spaces and developing long-range plans for meeting future enrollment increases,

an enlarged and improved staff is essentia

The following other changes in the procedu are recommended:

a. Simplify the steps which must be taken for state construction assistance.

b. Provide increased procedural assistanc services to municipalities and school

c. Establish and publish space standards believed that a thoroughgoing re-evalu requested would show possibilities for in the size of a typical school with r

d. Develop within the School Building Ass spaces and costs, using statistical an presently available or becoming availa of the Department of Education.

e. Undertake and keep up to date a comple school building needs and facilities t comprehensive planning.

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The following other changes in the procedures of the Department of Education are recommended:

a. Simplify the steps which must be taken by local districts when applying for state construction assistance.
b. Provide increased procedural assistance through public information services to municipalities and school districts.
c. Establish and publish space standards for new schools. It is believed that a thoroughgoing re-evaluation of the areas presently requested would show possibilities for a reduction of up to 15 percent in the size of a typical school with no decrease in educational quality.
d. Develop within the School Building Assistance Bureau a bank of data on spaces and costs, using statistical and data processing capabilities presently available or becoming available in other divisions or bureaus of the Department of Education.
e. Undertake and keep up to date a complete inventory of public school building needs and facilities to serve as the basis for continuous comprehensive planning.

It is probably not feasible to reduce the number of state agencies involved in the approval of a new school. Improved coordination among them is, however, highly desirable. As a minimum, it is proposed that the existing overlap between the Department of Education and the Department of Public Safety be resolved by giving the standard-setting initiation to the Department of Education.

It is proposed that there be established within the Department of Public Safety a new Board of School Building Standards to set up new building regulations. This board would serve as final arbiter of standards in cases of overlapping jurisdiction between the Department of Education and the Department of Public Safety. It would also have exclusive appellate jurisdiction over the decisions of the Commissioner of Public Safety, Department of Public Safety plan and field inspectors pertaining to school building construction and the applicable codes and regulations.

Specific amendments to the present laws relating to public construction, notably the filed sub-bid law, will facilitate the use of systems building techniques:

a. The filed sub-bid law should authorize the use of systems categories in any technologically feasible area.
b. The ambiguity under present statutes with respect to serialized bidding upon one project, otherwise sometimes described as "fast tracking" should be clarified to make this procedure legal.
c. The law should be modified to accommodate the use of performance specifications.

Professional construction management offers the potential for significant savings in both construction time and cost. Its advantages appear to be greater with systems building than with conventional construction, but are probably sufficient to justify its use in both situations.

The benefits of market aggregation for the purchase of not only systems components but also a variety of products for use in school construction are considerable. The Commonwealth should encourage districts which desire to combine forces for this purpose, through such means as:

a. Paying a higher than normal rate o
participating in an aggregation pr
b. Providing central administrative s
   - Product investigation, specific
   - Coordination of separate school
     aggregation program; provision
     ensure participation after init
   - Bulk bidding and purchase of pr
c. Providing a state guarantee of a m
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It is proposed that the State require
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gh such means as:

a. Paying a higher than normal rate of state aid to school districts participating in an aggregation program;
b. Providing central administrative services such as:
    - Product investigation, specification and selection;
    - Coordination of separate school districts into a voluntary aggregation program; provision of contractual mechanisms to ensure participation after initial commitments have been made;
    - Bulk bidding and purchase of products.
c. Providing a state guarantee of a minimum sized order so that if an individual district dropped out of an aggregated market program, the advantage of volume purchasing would not be lost. The state would then undertake to find another district to take the first one's place.

In addition to increasing the size of construction grants, the Commonwealth might extend an unconditional guarantee of both the principal and interest of each district's school bond issues. An alternative would be the replacement of the present two-thirds vote required for a local district to assume indebtedness with a simple majority.

It is proposed that the State require each local district to establish a permanent school building committee which would survey existing school facilities, project school building needs and develop comprehensive land use plans. The committee would also be responsible for the provision of sites and would be empowered to prepare educational specifications, retain architects, and approve plans. The establishment of such standing committees would provide the continuity which has thus far been lacking in most districts.

The Recommended Course of Action:

Establishment of a Massachusetts School Construction Corporation (VI-3)
The recommended action of this report is the establishment of a Massachusetts School Construction Corporation, providing for the assumption by the Commonwealth of major responsibility for the design, construction and financing of public schools. The Commonwealth would continue to act in cooperation with the local districts, but the State would assume the leading role.

The functions of the Corporation would fall into three general areas:

- Coordination of comprehensive statewide planning for new schools
- Management and financing of new school construction
- Research and development toward improving the means of meeting the State's school building needs.

It would assist the local districts in developing comprehensive surveys of existing school building facilities, making projections of school building needs, and preparing comprehensive school land use plans. Such plans would cover a five-year period. They would be developed by each district and kept current by means of annual updating and would form the basis of a statewide inventory of existing facilities and projections of future needs. The costs of such planning would be funded by the Corporation. The plan would be done either by educational and planning staffs within the local communities, or by outside consultants.

The Corporation would fund the planning, design and construction of all public schools and would be the contracting agency for all school construction. In cooperation with the Department of Education, it would establish space

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All other costs of planning, design and c
the Corporation.

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In addition, the following functions are

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planning standards for public schools. Local districts desiring to exceed such standards would be required to bear the additional costs incurred. All other costs of planning, design and construction would be carried by the Corporation.

A continuing program of research and development relating to construction techniques, building materials, planning, and cost data analysis is proposed. These factors are currently beyond the financial limits and resources of individual local districts. The changes which have occurred in building technology and the resultant development of new building techniques makes the provision of this service an essential part of any economical school construction process.

In addition, the following functions are proposed.

a. The Corporation would cooperate with the Department of Education in the development of educational program specifications.
b. The Corporation would approve local districts' selections of architects and would provide design review.
c. The Corporation would administer the purchase of components for school construction and the construction of school facilities under a new system of competitive bidding.
d. The Corporation would aggregate local districts into large markets to achieve the economies inherent in large-scale bulk purchasing of both systems and non-systems building components.

The financial powers to be granted the new Corporation would enable it to issue, subject to the approval of the Governor and the General Court, notes and bonds backed by the full faith and credit of the Commonwealth. Bond issues could be sufficiently large to attract nationwide syndicates, thereby enabling the Corporation to obtain the lowest possible rate of interest available at any given time. The State would provide the initial appropriation for the agency startup costs. Thereafter, money that is required for the operation of the Corporation and the funding of projects would be derived from a portion of the construction cost savings made. Annual payments of principal and interest on these bonds would be made from the State's general revenues.

The local districts would retain jurisdiction over site selection, educational program, space requirements (consistent with state-established standards) selection of an architect, and approval of preliminary plans. Thereafter the design, construction and funding of each school facility would be carried out by the Corporation.

Each district would be required to establish a standing school building committee, which would have the following responsibilities:

- to survey existing school facilities, prepare projections of school building needs, and prepare a comprehensive school land use plan;
- to provide necessary sites;
- to obtain an educational program and space requirements for each specific school project;
- to select an architect subject to the approval of the Corporation;
- to approve preliminary plans;
- to accept the completed school building on behalf of the local district.

The Board of Education would retain its pre
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The Board of Education would retain its present functions relating to the establishment of minimum standards for all public school buildings. However, it is proposed that the board be required to establish and promulgate minimum standards as binding regulations on or before June 30, 1972, in accordance with the provisions of the existing Administrative Procedure Act.

The provisions of the School Building Assistance Act would continue for all projects not under the Corporation until June 30, 1976, or as required.

The proposed changes to the present functioning of the Department of Public Safety are substantially the same as those proposed under the first course of action.

The form and structure of the proposed School Construction Corporation would be a state agency within one of the existing executive offices under the present cabinet system. No recommendation is made here as to the particular cabinet secretariat in which this autonomous corporation should be placed.

In order to provide an organization which is representative of and responsive to the educational interests of the State as a whole, the Corporation's board of directors would be appointed by the Governor and be drawn from a variety of cities and towns from all parts of the State, with balanced representation of the major political parties and interest groups.

The Board of Directors would appoint the requisite professional staff and would be responsible for the achievement of the objectives of the Corporation. The Corporation would not be subject to the provisions of the Civil Service laws. Since the tasks to be performed by this agency require the highest degree of flexibility and competence, salaries commensurate with those paid for comparable skills in the private sector are necessary.

Comparison of the First and Second Course (VI-4)

Both the first and the second courses of action could realize significant savings in initial construction cost of schools. The potential cost savings under the second course (the Corporation) are higher (30-36%) than those achieved if all parts of the first course (changes within the existing framework) were enacted (19-39%). However, the real difference would almost certainly be greater than above, because the piecemeal nature of the changes within the existing framework is such that there is little likelihood that all would be enacted. The Corporation by contract could be a comprehensive program, and would stand an excellent chance of realizing its full potential savings.

Both courses of action likewise could significantly speed up the school planning and construction process, but again the Corporation would have the greater potential for savings. The Corporation could be expected to reduce by 1½ to 2 years the relatively normal 4 years for the period from identification of need to occupancy. The changes within the existing framework could by contract be expected to save only 6 to 12 months on the process. Again, the piecemeal nature of this course makes it unlikely that all proposed changes would actually be carried out. Each course of actior would eliminate the local bond issue referendum and its serious potential for delay.

Conclusion

It is evident that the creation of a public school building corporation would be an innovative and daring step for the Commonwealth to take. It would certainly not be an easy one, nor one to be undertaken lightly. Nevertheless, the members of the study team are firmly convinced that the potential savings in cost and time and the equalization of the opportunities of all school districts for new school construction amply justify the risks and hard work which its implementation would entail.

INTRODUCTION

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The Need

School construction is a heavy burden for the taxpayer. Millions of dollars are spent each year on new elementary and secondary schools and on major remodeling, modernization, and additions. In Massachusetts the cost of school building now approaches $36 per square foot. The toal amount spent on new school construction alone exceeded $150 million in 1970, and school superintendants report that vastly more space will be required in the next five years.

This report details ways in which the cost of school construction in Massachusetts can be substantially reduced--perhaps by as much as 35 percent--while the quality of construction is increased, local participation is retained, and the overall processing time is greatly reduced. Considering the continuing need for school construction and the desire of citizens to hold the line on taxes, the program presented here is one that demands immediate consideration and early action.

The potential savings could ultimately total billions of dollars, but equally important, there is an opportunity to provide Massachusetts school children with high quality facilities which otherwise might not be available at all.

Taxpayer resistance to footing the bill for new construction is reaching a state of revolt. Through the mechanism of the bond referendum voters are registering their general displeasure at the use of the local property tax to pay for a multiplicity of services. The high rate of construction cost escalation leads to costs for new schools which rarely fail to shock taxpayers.

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Systems Construction as the Catalyst for

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As a result, bond issues are being rejected at an unprecedented rate, often without regard to the desperation of the need. Yet the cost of school buildings is far from the most significant item on the local property tax. It is a source of ire mainly because it is one of the few large items on the budget which the taxpayer feels he can affect directly. And it is the children who suffer.

When construction of a new elementary school is delayed eight years, a child who might have attended school under optimum conditions instead will have the experience of spending eight years in rundown and very possibly over-crowded conditions.

The recommendations in this study present no easy solution, but this reflects the fact that the problem is complex and many-sided. The recommendations are an attempt to recognize these problems, to examine the potential methods of dealing with them, and to chart a course of major improvement which can realistically be followed without throwing the existing social-political-economic forces out of balance.

Systems Construction as the Catalyst for Change

Many of the terms of the recommendations could have been implemented years ago. One which could only recently have been developed is the systems approach to school construction. If a great deal of stress is given to this concept in the study, it is partly because it is relatively unknown to the public, but more importantly because it is the catalyst which could bring into existence an organization which would make all the other changes possible.

System building, or the systems approach to school construction, is a process of coordinating and exploiting a variety of techniques for improving productivity in construction. Most of the techniques have been found as a matter of course in other industries. However, the intensely fragmented nature of the construction industry has until recently prevented their implementation. For instance, a typical small school may involve six to eight professional design firms, 20 to 30 contractors, 40 to 60 different suppliers and 200 to 300 or more different building products.

The inefficiencies of most construction projects are obvious to even a casual observer, but their remedy has defied implementation largely because each problem was interrelated with others, so that adjustment of one factor would actually have repercussions on several different participants in the process; change could only be introduced if all parts of the process were coordinated. In particular, the inherently discontinuous nature of the client in the process contributed to this situation. In other words, the fact that the average building client is relatively small and builds relatively infrequently, (for many it is once in a lifetime) means that the party with the greatest interest in improvement is in the weakest position to do anything about it. None of the "full time" or professional members have the same vested interest in improving the situation. This situation can only be overcome if the clients can find a mechanism to pool their efforts and to provide the continuity which is essential to productive change.

Systems construction is a procedure for operating within such a context. It involves changes in planning, design, scheduling, bidding, contracting, manufacturing, and site assembly. Many of the changes are not very radical, and some changes have recently been accomplished. The "system" is in <u>coordinating all</u> of them, taking advantage of repetition to improve on later jobs what went wrong on earlier ones, and exploiting further the things that went right.

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<u>Organization of this Study</u>

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A process which does not have continuity and central control therefore cannot, strictly speaking, be considered systems construction. By the same token, if a central body exists to coordinate systems construction, it will inevitably involve itself in matters outside the realm of what is strictly construction, such as planning standards and finance. It very quickly becomes apparent that all savings or other improvements are relative; it is not enough to look for improvement in one area without checking the effect of that change on other areas of concern which are inevitably involved. Therefore, in the sense that all these factors should be coordinated, all may be said to fit into the very broad definition of what is called systems.

Although a number of significant systems programs are underway in various parts of the continent, no full-fledged systems program has been going long eough to give a second or third-round reading of the results. If the Commonwealth of Massachusetts were to institute a program on a statewide basis, it would be the largest school systems building program in North America, and would have the potential of realizing savings far beyond those already achieved.

<u>Organization of this Study</u>

The material in this report has been organized to provide a sequential development of the case to support its recommendations. Thus, Section I provides outlines of the problem and supplies a frame of reference for understanding the concept of systems.

Section II provides a background for understanding the Massachusetts school planning and construction process from several viewpoints. Those who are familiar with the process may want to proceed to the next section. Others may want to use it as a reference to fill in background essential to understanding subsequent material. Many school building committees tangling with the procedures for the first time may find it a useful guide to understanding and anticipating the school building process.

Section III surveys those matters most pertinent to an analysis of the problems and the potentials of the process. It evaluates where we are, and projects the needs for coming years. It is essentially the statement of the problem, although, as will be seen, the process itself (Section II) is a problem.

Section IV introduces the concept of system building, explains its principles and records experience to date with systems.

Section V then develops the significance of systems in the context of the Massachusetts school delivery process (Section II) and the surveys of the Massachusetts situation.

Finally, taking these factors into consideration, Section VI, lists a set of goals, outlines two possible courses of action to achieve these goals, compares these two courses of action, and explains why one is recommended over the other.

A DESCRIPTION OF EXISTING SCHOOL PLANNING, APPROVAL AND CONSTRUCTION PROCEDURES IN MASSACHUSETTS

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OF EXISTING SCHOOL

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LEGAL BASIS OF THE SCHOOL CONSTRUCTION PROCESS

CHAPTER II - 1

The State Constitutional Background

Massachusetts education law begins, as does all state law, with the Constitution of the Commonwealth. That famous document, written in semi-secrecy by John Adams for the Constitutional Convention which met in Cambridge in 1779 and 1780, contains the following remarkable section, in Part the Second, Chapter 5. It sets the theme, if not the ultimate direction, of numerous later, albeit less lofty, enactments:

> THE ENCOURAGEMENT OF LITERATURE, ETC.
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> Duty of legislatures and magistrates in all future periods
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> Wisdom, and knowledge, as well as virtue, diffused generally among the body of the people, being necessary for the preservation of their rights and liberties; and as these depend on spreading the opportunities and advantages of education in the various parts of the country, and among the different orders of the people, it shall be the duty of the legislatures and magistrates, in all future periods of this commonwealth, to cherish the interests of literature and the sciences, and all seminaries of them; especially the university at Cambridge, public schools and grammar schools in the towns; to encourage private societies and public institutions, rewards and immunities, for the promotion of agriculture, arts, sciences, commerce, trades, manufactures, and a natural history of the country; to countenance and inculcate the principles of humanity and general benevolence, public and private charity, industry and frugality, honesty and punctuality in their dealings; sincerity, good humor, and all social affections, and generous sentiments among the people.

This provision of the Constitution reflects one significant feature of the structure of the government of the Commonwealth. The state government is,

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THE SCHOOL CONSTRUCTION PROCESS

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eflects one significant feature of the ommonwealth. The state government is, by the Constitution and by the colonial history which preceded the Constitution, the origin of all legal power and authority in the municipalities. All cities and towns in the Commonwealth derive their powers from the state Constitution and from enactments of the General Court, as legislature for the entire state. As it was said of the Houses of Parliament, that they could make a woman a man and a man a woman, so the General Court of Massachusetts can create a new city or town and abolish an existing one; and, more significantly, it may enact legislation at any place within that broad spectrum of authority.

The central significance of this doctrine of state preeminence has withstood the equally important but legally complex notion of home rule. The doctrine of "Home Rule" has been essentially a parallel theme to state preeminence, introduced from time to time as a reflection of the doctrine of the American states that checks and balances are necessary to a republican form of government. Thus the Second Amendment to the Massachusetts Constitution, adopted by the Constitutional Convention of 1820 and in effect until superseded by the Eighty-ninth Amendment in 1966, reaffirmed the power of the General Court with respect to city and town governments with only minor restraints. The original Second Amendment provided that the "General Court shall have full power and authority to erect and constitute municipal or city governments, in any corporate town or towns in this Commonwealth, and to grant to the inhabitants thereof such powers, privileges and immunities not repugnant to the Constitution as the General Court shall deem necessary or expedient for the regulation and government thereof...." The sole exceptions to this rule were that, without the consent of the majority of the townspeople, a town of less than 12,000 inhabitants could not be required to become a city, and, in a town of less than 6,000 inhabitants, the limited town meeting form of government could not be required by the General Court.

When in 1966 the so-called Home Rule Amendment was, for the first time, adopted as the Eighty-ninth Amendment to the Constitution, it began with a reaffirmation not only of the "customary and traditional liberties of the people with respect to the conduct of their local government" but also with a reminder that the rights of self-government in local matters existed "subject to the provisions of this article and to such standards and requirements as the General Court may establish by law in accordance with the provisions of this article." While the Home Rule Amendment substantially formalized and expanded the procedures by which cities and towns may adopt and amend charters (previously the sole prerogative of the General Court), the power of the General Court to act with relation to cities and towns was retained in Section 8 of the Amendment and this power is significantly broad as it relates to all municipal functions, including the establishment of the public schools.* Thus, the General Court retains, notwithstanding the Home

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* Section 8 provides in relevant part as follows:

Section 8. Powers of the General Court.--The general court shall have the power to act in relation to cities and towns, but only by general laws which apply alike to all cities, or to all towns, or to all cities and towns, or to a class of not fewer than two, and by special laws enacted (1) on petition filed or approved by the voters of a city or town, or the mayor and city council, or other legislative body, of a city, or the town meeting of a town, with respect to a law relating to that city or town; (2) by a two-thirds vote of each branch of the general court following a recommendation by the governor; (3) to erect and constitute metropolitan or regional entities, embracing any two or more cities or towns or cities and towns, or established with other than existing city or town boundaries, for any general or special public purpose or purposes, and to grant to these entities such powers, privileges and immunities as the general court shall deem necessary or expedient for the regulation and government thereof; or (4) solely for the incorporation or dissolution of cities or towns as corporate entities, alteration of city or town boundaries, and merger or consolidation of cities and towns, or any of these matters.

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Rule Amendment, the power to enact, by General Laws which apply alike to all cities or to all towns or to all cities and towns or to a class of not fewer than two, all the legislation which it had the power to enact prior to the Home Rule Amendment; and it can enact special laws for an individual city or town upon a petition by that municipality or upon a two-thirds vote of the General Court following a recommendation of the Governor.

The subtleties of this American form of governance, state preeminence with local government home rule, are shown no more effectively than in the field of school building construction. Taking the constitutional mandate "for the encouragement of literature" the Commonwealth has developed a complex series of interrelated procedures which it is the purpose of this chapter to explore.

The Department of Education

The branch of state government to which the general purpose of promoting the Commonwealth's interest in education has been committed is the Department of Education. Tracing its antecedents to an enactment of the General Court as early as 1837 (Statutes of 1837, Chapter 241), the present Department of Education now exists pursuant to the provisions of Chapter 15 of the General Laws. The Department is under the supervision and control of the Board of Education (G. L. Chapter 15, Section 1). Its membership is significantly prescribed by Section 1E of Chapter 15. Thus, in addition to *ex officiis* members such as the Chancellor of the Board of Higher Education and the Director of Research of the Advisory Council on Education, its other eleven voting members must by law include two women and a representative of labor and may not include any person employed by or deriving regular compensation from any educational institution or public or private school system in the Commonwealth, nor be a Commonwealth employee or member of a governing board of any higher educational institution nor, indeed, a member of any school committee. This essentially lay Board of Education, together with the Commissioner of Education appointed by it and serving as its chief executive officer and as the "chief state school officer for elementary and secondary education," is required by Section 1F of Chapter 15 to establish seven divisions in the following areas: (a) curriculum and instruction; (b) administration and personnel; (c) research and development; (d) school facilities and related services; (e) state and federal assistance; (f) occupational education; and (g) special education.

Section 1G of Chapter 15 of the General Laws sets forth the powers of the Board of Education as well as its duties. Among the duties are to "provide such necessary services to local public schools as are beyond their capacity to support separately." In addition, the Board "shall provide centralized, statewide, long-range planning service for public schools" and provide "a common center for the development, evaluation and adaptation of educational innovations for public schools." The Board has the duty to "establish maximum pupil-teacher ratios for classes in public, elementary and secondary schools." It shall establish "minimum educational standards for all courses which public schools require their students to take."

All of these duties relate inevitably to the matter of construction of school buildings: but, in addition, the Board of Education has a specific duty in the area of school building construction. Thus, Section 1G provides "the Board shall establish minimum standards for all public school buildings...,"

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The potentially vast powers of the Board of Education are not without sanctions to require their enforcement. The Board is required to "see to it that all school committees comply with all laws relating to the operation of the public schools." In the event of noncompliance, the Commissioner of Education "shall refer all such cases to the Attorney General of the Commonwealth for appropriate action to obtain compliance." With relation to all of its work, the Board is asked to provide statistical data for use by other agencies of the Commonwealth and by the cities and towns.

In this legal and historical review of the powers of the Commonwealth with respect to public education and of the powers of the Board of Education in particular, two areas of great political and social significance should be mentioned as they relate to the matter of school building construction. One has its origin, insofar as it resulted in legal enactments, in the nineteenth century and the other, though a product of the great "American Dilemma" of similar vintage, dates most directly from developments of only the last decade. These are the issues of religion and race, and no study of school building construction would be complete without reference to the legal status of each of these issues. With respect to both, the last words of law and policy have surely not been written.

1. The Anti-Aid Prohibition on Public Aid for Private Schools

As early as the 1850's, the Constitution of the Commonwealth significantly had incorporated into it the first Anti-Aid Amendment prohibiting the use of publicly appropriated funds to "any religious sect for the maintenance exclusively of its own schools" (Eighteenth Amendment to the Constitution of the Commonwealth). It is interesting to note that in addition to the prohibition, the Amendment had an affirmative requirement with respect to support of schools:

> All monies raised by taxation in the towns and cities for the support of public schools, and all monies which may be appropriated by the state for the support of common schools, shall be applied to, and expended in, no other schools than those which are conducted according to law, under the order and superintendence of the authorities of the town or city in which the money is to be expended; and such money shall never be appropriated to any religious sect for the maintenance exclusively of its own schools.

This version of the Eighteenth Amendment to the Massachusetts Constitution coexisted, of course, with the First Amendment to the United States Constitution, made applicable by various judicial doctrines and decisions to the states through the Fourteenth Amendment to the United States Constitution, providing that "Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof,..."

At the Constitutional Convention of 1917-1918 in Massachusetts the Eighteenth Amendment to the state Constitution was revised in such a way that, after adding a section prohibiting the passing of any law "prohibiting the free exercise of religion" and repeating the affirmative requirement relating to the application of tax monies for the support of public schools, the prohibition on aid to nonpublic schools was expanded as follows:

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: as follows:

> And no grant, appropriation or use of public money or property or loan of public credit shall be made or authorized by the Commonwealth or any political subdivision thereof for the purpose of founding, maintaining or aiding in a school or institution of learning, whether under public control or otherwise, wherein any denominational doctrine is inculcated, or any other school, or any college, infirmary, hospital, institution or educational, charitable or religious undertaking which is not publicly owned and under the exclusive control, or under supervision of public officers or public agents authorized by the Commonwealth or federal authority or both, ...; and no such grant, appropriation or use of public money or loan of public credit shall be made or authorized for the purpose of founding, maintaining or aiding any church, religious denomination or society.

The long history of the effect of the provisions of both state and federal constitutions prohibiting public aid to nonpublic schools is beyond the immediate scope of this report. In the past several years, numerous attempts have been made to establish by legislation various devices to avoid what many have assumed to be a total prohibition of aid to nonpublic schools in any form. Many of the proposals, if adopted, and if found by inevitable judicial reviews to be consistent with federal and state constitutional doctrine, could have a great effect upon the status of school building in the Commonwealth of Massachusetts. The recent decisions of the United States Supreme Court in Tilton v. Richardson, 39 U.S.L.W. 4857 (June 29, 1971) and Lemon v. Kurtzman, 39 U.S.L.W. 4844 (June 29, 1971) would, however, seem to limit severely the extent to which many of these devices could satisfy that court and, that being the case, their compliance or noncompliance with state constitutional requirements is academic. For this reason, this report must conclude that in the foreseeable future there will be no change of any significant nature in the matter of public aid for nonpublic school construction and operation.

2. Eliminating Racial Imbalance

In 1965, the General Court added to the duties of the Board of Education a requirement that it "provide technical and other assistance in the formulation and execution of plans to eliminate racial imbalance." Among the sanctions available to the Board of Education is the prohibition of any project in a municipality or district found not to have made "progress within a reasonable time in eliminating racial imbalance in its schools." In addition, the Board of Education may increase the amount of its aid, under present law, for schoolhouse construction to 65 percent of approved costs whenever the Board of Education is satisfied that the construction of the schoolhouse is for the purpose of reducing or eliminating racial imbalance in the school system.

The effect of racial imbalance mandates upon school construction is uncertain not for constitutional reasons--their original purpose was to insure acknowledged constitutional rights--but for political and governmental factors. Thus more than one major city in the Commonwealth is seeking a legislative exemption from the racial imbalance law and its fiscal sanctions. The outcome and legality of such attempts is unclear.

School Building Assistance Bureau

Against the background of the constitutional and statutory provisions which have been described above with respect to the role of the state and the establishment of a potentially powerful Department of Education, the General Court established in 1948 a specific agency, then called the School Building Assistance Commission, with detailed powers and responsibilities in the area of school construction and school finance. Originally

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From 1948 to 1966 the SBAC was an independent state agency. With the enactment of the Willis-Harrington Act reorganizing the state educational structure, the agency became a bureau within the Department of Education. The present SBAB (School Building Assistance Bureau) now administers the provisions of Chapter 645 of the Acts of 1948 as part of the Department of Education's Division of School Facilities and Related Services. The Bureau is under the direction of an administrator. A detailed study of its administrative process is provided in the next chapter.

Department of Public Safety

It was noted above that the otherwise unlimited powers of the Board of Education to "establish minimum standards for all public school buildings" contained in G. L. Chapter 15, Section 1G, was modified by the proviso that these standards be subject to the provisions of law relating to the Department of Public Safety regarding such public buildings. The specific statutory reference contained in Section 1G is to Section 15 of Chapter 143 of the General Laws. This overview of present statutory procedures must, therefore, consider the role of the Department of Public Safety as next in significance to that of the Department of Education and the School Building Assistance Bureau themselves.

Chapter 143 of the General Laws begins with definitions in Section 1. The definition of "building" and "public building" in Chapter 143 is, significantly for the purposes of this study, as follows:

> "Building," a combination of any materials, whether portable or fixed, having a roof, to form a structure for the shelter of persons, animals or property. For the purpose of this definition "roof" shall include an awning or any similar covering, whether or not permanent in nature. The word "building" shall be construed where the context requires as though followed words "or part or parts thereof."
>
> "Public building," any building or part thereof used as a public or private...schoolhouse...

Section 15 of Chapter 143 provides that no building so defined which is designed to be used as a public school, or on which alteration shall be made for the purpose of using it in whole or in part as a public school, shall be erected or altered until a copy of the plans and specifications for construction or alteration has been deposited with the Supervisor of Plans by the owner or architect. The Supervisor of Plans is, under Section 1, defined as a building inspector of the Division of Inspection of the Department of Public Safety designated by the Commissioner of Public Safety to receive the plans and to act officially upon them under the direction of the Chief of Inspections of the department.

Section 15 further provides that such building may not be erected or altered without "sufficient egresses and other means of escape from fire, properly located and constructed." The Supervisor of Plans is also authorized by the statute to require that stairways be enclosed; that they have suitable landings; that they shall be provided with handrails; that egress doors and windows shall open outward and have approved hardware; that places of egress shall be properly lighted and designated; and that proper fire stops shall be provided in the floors, walls, partitions and stairways of such a

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A certificate from the Supervisor of Plans approving the plans and specifications, endorsed by the Chief of Inspections of the department, or a specification of requirements necessary for compliance with Section 15 to 60 of Chapter 143 of the General Laws set forth in detail and so endorsed, must be issued to the person causing the construction or to the architect, and a copy, together with the plans, is then required to be turned over to the Inspector in whose district the building is to be erected or altered. The Inspector is authorized and directed to enforce the requirements of the certificate of approval and the specification of requirements and to supervise the erection or alteration. After a certificate of approval or a specification of requirement has been issued, the law provides that no change may be made in the specification or in the building without the permission of the Supervisor of Plans.

The Inspector to whom this information is turned over is defined in Section 1 of Chapter 143 as an Inspector of the Division of Inspection of the department. The role of the Department of Public Safety with respect to the establishment of building regulations for schoolhouses and the inspection process generally is more fully set out in the Building Regulations for Schoolhouses of the Board of Schoolhouse Structural Standards, a board established by Chapter 675 of the Acts of 1955, as amended, within the Department of Public Safety. This code and other related code matters are fully treated in Chapter III-8 of this report. Under present law, powers of the Board of Schoolhouse Structural Standards will cease and those powers will be taken over by the Commissioner of Public Safety on November 13, 1973. Interestingly, those powers are to make and from time to time alter, amend and repeal rules and regulations relating to structural safety and prevention of fire in connection with construction, reconstruction and alteration or remodeling of all public and private schoolhouses and also "relating to the standards of materials to be used therein, setting forth alternatives to the materials of the type and method of construction" (emphasis supplied). This authority, contained in G. L. Chapter 143, Section 15A, also provides that such rules and regulations "shall be designed to provide reasonable uniform requirements of safety in relation to the preservation of life and the prevention of fire." The Supervisor of Plans, in issuing his certificate of approval for the erection or alteration of a schoolhouse under Section 15 of Chapter 143, is required to ensure, in addition to the other requirements of Chapter 143, that the plans and specifications conform with the rules and regulations made by the Board of Schoolhouse Structural Standards, as must the specification of requirement provided for in Section 15. There are in Chapter 143 other miscellaneous provisions, such as for fire escapes, seats in aisles, and stairways, which can be interpreted to apply to schools by virtue of the definition of "public building" contained in Section 1 of Chapter 143. In essence, however, the major school building construction requirements are those contained in Chapter 143, Section 15, and most exhaustively in the Building Regulations for Schoolhouses promulgated by the Board of Schoolhouse Structural Standards.

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It is significant to note, particularly in connection with the flexibility which is part of the design of most systems schools, that the interest of the Department of Public Safety under present law does not cease with the granting of the certificate by the Supervisor of Plans. General Laws Chapter 143 provides in Section 52 that no person may use any building as a schoolhouse until a license has been issued by the Commissioner of Public Safety or a certificate issued by an inspector. It also provides that the certificate of the inspector shall be void if, among other things, the building's "interior arrangement is materially altered, any egresses or means of escape from fire from such building are rendered unavailable or are materially changed."

Bidding Laws - The Department of Labor and Industries

The next step in chronological sequence, and a step of equal importance to the planning and design processes controlled by the statutes described in this chapter, involves the provisions under which the architectural and engineering plans for public school buildings must be bid in Massachusetts. The bidding procedures are uniform for every awarding authority whether it be a city, a town or regional school district and are governed primarily by G. L. Chapter 149, Sections 44A through 44L and Chapter 30, Section 39M. These provisions are intended to ensure fair competition for bidders in the construction of all buildings by the Commonwealth or by any governmental unit thereof. The detailed workings of fair competition of the public bidding construction statute, which includes the filed sub-bid law, is the subject of a more detailed analysis in Chapter V-1 of this report. In essence, G. L. Chapter 149, Sections 44A through 44L provide that school building contracts (as all public building contracts) "shall be awarded to the lowest responsible and eligible bidder on the basis of competitive bids" in accordance with the procedures set forth in the statute. The awarding authority, which is the city, town or regional school district, is required by this law to prepare for bidding purposes "a sufficient number of sets of plans and specifications" so that they may be made available without cost to prospective bidders and sub-bidders. The term "lowest responsible and eligible bidder" is defined by the statute to mean "the bidder whose bid is the lowest of those bidders possessing the skill, ability and integrity necessary to the favorable performance of the work and who shall certify that he is able to furnish labor that can work in harmony with all elements of labor employed or to be employed on the work." The awarding authority is authorized to require that essential information be submitted with regard to such qualifications.

The statute requiring fair competition in the choice of a general contractor also requires the specification of numerous sub-trades whose work must, in the plans and specifications, be detailed "in a separate section for each" of certain classes of work. The General Court has from time to time added to the list of trades, so that now there are seventeen specific categories as well as an authorization to add other sub-trades on an optional basis. Each of the separate sections for sub-trades must provide that the awarding authority will receive these bids, in effect, approximately one week prior to the receipt of general bids. As a result, a considerable amount of the

work of the general contractor is
who become subcontractors to the
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work of the general contractor is taken from a list of filed sub-bidders who become subcontractors to the single general contractor. Thus, while the awarding authority itself enters only one contract, the general contract, it must play a vital role in the listing of the numerous acceptable subcontractors prior to the award of the general contract. The significance of this unique Massachusetts procedure for the award of construction contracts as it relates to systems building is discussed fully in Chapter V-1 of this report. Related to the provisions of Chapter 149, Sections 44A through 44L is G. L. Chapter 30, Section 39M, describing mandatory procedures for writing specifications. This section, also discussed in detail in Section V, Chapter 1, provides a definition of equality which requires the acceptance of substitution for a specified item in school and other construction if the proposed substitute:

> ...(1) is at least equal in quality, durability, appearance, strength and design, (2) it will perform at least equally the function imposed by the general design for the public work being contracted for or the material being purchased and (3) it conforms substantially, even with deviations, to the detailed requirements for the item in said specifications...

Minimum wage rates are required to be paid on all public construction projects, including schools. These rates are certified by the Commissioner of Labor and Industries and are part of all public bidding documents.

The many questions which inevitably arise during the progress of bidding a public school building are frequently considered by the city law department or the office of the town counsel, but if they cannot be resolved by those officials, the Commissioner of Labor and Industries has the jurisdiction to enforce the sections of Chapter 149, Section 44A through 44L and of Section

39M of Chapter 30, except for the consideration and determination after contract award of the equality of an item. The Commissioner of Labor and Industries has the authority to institute proceedings in the Superior Court to restrain the award of contracts and the performance of contracts in all cases where, after investigation of the facts, he has found that such an award or performance has resulted in a violation of the applicable sections of the General Laws. The significance of these sections in the entire school building process can be gauged by the large number of litigated cases in the Superior Court and, indeed, by the several which have ultimately reached the Supreme Judicial Court during the last few years.

Miscellaneous Provisions of State and Municipal Law

There are other statutes which give various state agencies other responsibilities in connection with the procedures for building a public school. Thus, the basic requirement that every town shall maintain, for at least the number of days required by the Board of Education in each school year, "a sufficient number of schools for the instruction of all children who may legally attend a public school therein" and the laws prohibiting double sessions under various circumstances, coupled with the power of the Board of Education to suspend the prohibition of double sessions, have effects on school building need. So also do other statutes and regulations of the Department of Education with respect to curriculum and facilities have a direct relationship to the school building process. Many of these regulations are set forth in Chapter 71 of the General Laws and are discussed in Chapter II-4 of this report.

Relationships with other state agencies i
Chapter 143, Section 42, that the Departm
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The role of the cities and towns is set f
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Relationships with other state agencies include the requirement of G. L. Chapter 143, Section 42, that the Department of Public Health approve the site of the school and the provisions of G. L. Chapter 131, Section 40A, granting to the Department of Natural Resources authority to disapprove the site of the school on the basis of interference with wetlands.

The role of the cities and towns is set forth in various sections of Chapter 71 of the General Laws relating to school committees, school building committees and regional school district committees. A general statement of the legislation in this area places upon every city and town the obligation to "provide and maintain a sufficient number of schoolhouses, properly furnished and conveniently situated for the accommodation of all children therein entitled to attend the public schools."

As with all of the state statutory and regulatory requirements, the doctrine of checks and balances continues with respect to agencies in municipal government. Thus, for example, Chapter 99 of the Acts of 1967 requires that the school building committee authorized by a town to provide for the planning and construction of a new school building, which submits a plan to the Department of Education under the School Building Assistance Act, must forthwith notify the selectmen that such a plan has been submitted and must also notify the selectmen of any changes in the plan. Similarly, Section 34 of Chapter 43 of the General Laws requires the Manager of the city to approve the construction as well as the site of the new public school. Even the medical profession is potentially involved, as, under Chapter 71, Section 54, a school physician is authorized to make such examination of school buildings as, in his opinion, protection of the health of pupils may require.

Provisions of the law relating to regional school districts include authority under G. L. Chapter 71, Section 16, to acquire property within the towns comprising the district and to construct, reconstruct, add to or remodel or make extraordinary repairs to equip, organize and operate the school or schools for the benefit of the towns comprising the district and to make any necessary contracts in relation thereto. Under G. L. Chapter 71, Section 16A, the regional school committee is authorized, although not required, to appoint a school building committee and to have such powers and duties relative to the construction, reconstruction, alteration or repair expansion and equipping of school buildings and facilities as the school committee determines.

Thus, by constitutional mandate and history, the Commonwealth plays a significant role in school building planning and construction and shares part of that role with local officials. The system of checks and balances provides additional significant features and is an important theme throughout.

ADMINISTRATION OF THE SCHOOL CONSTRUCTION PROCESS

CHAPTER II - 2

The constitutional and statutory basis for the Massachusetts school construction process is meaningful only when viewed in connection with the actual administration of the laws. Such an analysis will be undertaken from two points of view: first, from a description of the approval procedures developed and refined by the School Building Assistance Commission from 1948-1966 and continued under the State Board of Education; second, from the point of view of local authorities as they strive to meet comprehensive and critical local and state requirements.

From both points of view, the analysis shows that there are no comprehensive guidelines available to local school and municipal officials. As a result of this and the inherent complexity of the planning, design and construction process, the enterprise is uniformly time-consuming and for that reason alone costly.

As part of this analysis, six case studies are briefly described, which exhibit varying degress of success and local planning, in the obtaining of state approvals, and in the vitally important quest for local approval of the two-thirds vote to authorize bonding so as finally to construct the school.

From the beginning of the depression in 1929 until the end of World War II in 1945, there was a dearth of school construction in the nation.* The surge of births following World War II caused additional needs for school facilities. To take care of this emergency situation in Massachusetts, the General Court (Legislature) enacted Chapter 645 of the Acts of 1948 establishing a temporary commission, known as the School Building Assistance Commission, with authority

* George J. Collins, National Inventory of School Facilities and Personnel, Washington: United States Office of Education, 1963.

to make special grants to cities and town[s]
districts, when they constructed new scho[ols]

The provisions of Chapter 645 were origin[ally]
1951. However, the Legislature extended
recent extension continues to provisions
as amended until June 30, 1976.*

From 1948 until February 1966, the Commis[sion]
With the passage of the Willis-Harrington
1965), the School Building Assistance Com[mission]
duties transferred. All of the provision[s]
to state aid for school construction rema[in]
Act merely transferred the powers of the
to the State Board of Education. In 1966
the Division of School Facilities and Rel[ated]
Education and placed the School Building
Division. The Bureau now administers th[e]
Division is under the responsibility of a
tion, and the School Building Assistance
tor and an assistant administrator.

Purpose of Chapter 645 of the Acts of 194[8] Enabling Act

The legislative intent of the Enabling Ac[t]
Building Assistance Bureau, Chapter 645 o[f]
the planning and construction of school [...]

* Chapter 645 with amendments to 1970
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HE SCHOOL CONSTRUCTION PROCESS

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of 1948 establishing a temporary
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to make special grants to cities and towns, then later to regional school districts, when they constructed new schools or additions to existing schools.

The provisions of Chapter 645 were originally intended to expire on June 30, 1951. However, the Legislature extended the law five times. The most recent extension continues to provisions of Chapter 645 of the Acts of 1948 as amended until June 30, 1976.*

From 1948 until February 1966, the Commission was an independent state agency. With the passage of the Willis-Harrington Act (Chapter 572 of the Acts of 1965), the School Building Assistance Commission was highly praised and its duties transferred. All of the provisions of Chapter 645, however, relating to state aid for school construction remained unaffected. The Willis-Harrington Act merely transferred the powers of the School Building Assistance Commission to the State Board of Education. In 1966, the State Board of Education created the Division of School Facilities and Related Services in the Department of Education and placed the School Building Assistance Bureau (SBAB) in the Division. The Bureau now administers the provisions of Chapter 645. The Division is under the responsibility of an Assistant Commissioner of Education, and the School Building Assistance Bureau is directed by an administrator and an assistant administrator.

Purpose of Chapter 645 of the Acts of 1948 - A School Building Assistance Enabling Act

The legislative intent of the Enabling Act creating what is now the School Building Assistance Bureau, Chapter 645 of the Acts of 1948, was "to promote the planning and construction of school buildings and the establishment of

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chc ... lities and Personnel,
tic ... .

* Chapter 645 with amendments to 1970 is presented in Appendix, Exhibit 1.

Exhibit I

SBAB-52
R5-9/20/67

Commonwealth of Massachusetts
Department of Education
School Building Assistance Bureau
182 Tremont Street Boston 02111

CHECK LIST

City, Town, Region, County ____________

School ____________

Approval of your school construction project will run smoothly if you use this check list to see that every step has been followed.

		Date Completed
1.	Building Needs Conference	______
2.	Surveys, committee reports, or studies of school plant needs.	______
3.	Educational specifications (filed in this office before scheduling conference)	______
4.	Site (town map, plot plan, topographical map, and Department of Public Health approval of sewage disposal where pertinent)	______
5.	Preliminary drawings (filed in this office before scheduling conference)	______
6.	Preliminary plan conferences (as needed to develop acceptable preliminary drawings)	______
7.	Form F (tentative estimates of cost)	______
8.	Final plans and specifications (filed in this office before scheduling conferences)	______
9.	Final plan conference (written approval of final plans should be obtained before advertising for bids)	______
10.	Conference on grant or reimbursement procedure (usually held at the time of final plan conference)	______
11.	Request for Project Number and Form F (filed in this office when construction begins)	______
12.	Documents for final audit (filed in this office after project has been completed and accepted by the school committee)	______

consolidated and regional schools.
plant facilities for the public s
cost thereof."

When any of the political entitie
school or an addition to an exist
School Building Assistance Bureau
Exhibit I shows SBAB Form 52 R5-9
tion project. Progress for a sch
sively from the needs conference
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in this section. If the project
(on the recommendation of the Bur
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The Approval Process for Cities a

A local school district must firs
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first report to the school commit
ities. If the school committee a
Committee is appointed and author
a school.

Currently the school planning and
steps (Exhibit II). One step is
in Exhibit II and is eliminated i
has skyrocketed costs of building
that preliminary plans and estima

* This procedure is described

consolidated and regional schools, in order to insure safe and adequate plant facilities for the public schools and to assist towns in meeting the cost thereof."

When any of the political entities in Massachusetts intends to build a new school or an addition to an existing school, it makes an application to the School Building Assistance Bureau for a school building needs conference. Exhibit I shows SBAB Form 52 R5-9/20/67, a checklist for a school construction project. Progress for a school construction project advances progressively from the needs conference to final audit and certification of payment by following the twelve items on the checklist, which will be explained later in this section. If the project is approved by the State Board of Education (on the recommendation of the Bureau), the state makes a construction grant to the city, town, regional school district or county involved.

The Approval Process for Cities and Towns

A local school district must first alert the community of the need for school facilities. In most cases the superintendent of schools will provide the first report to the school committee that the district needs additional facilities. If the school committee accepts the report, a School Building Needs Committee is appointed and authorized to initiate the process for constructing a school.

Currently the school planning and approval process is a series of 34 major steps (Exhibit II). One step is optional (0)*. This step follows item 19 in Exhibit II and is eliminated in some school districts because inflation has skyrocketed costs of building in the last five years to such a degree that preliminary plans and estimates have not always provided reliable esti-

* This procedure is described more fully later in this chapter.

Exhibit II

Current School Planning and Approval Process

(Major Steps)

34. STUDENTS USE THE FACILITIES -- 60-100 YEARS
33. TAXPAYERS PAY BONDS FOR 5-20 YEARS
32. SBC AND MUNICIPAL AUTHORITIES DEDICATE FACILITIES
31. STAFF ORIENTATION BEGINS
30. SBC PREPARES ACCOUNTING SYSTEM
29. GC BEGINS CONSTRUCTION
28. SBC AWARDS CONTRACT
27. SBC PRESENTS FORM "F" FOR GRANT TO STATE - SBAB AND EMER. FIN.
26. VOTERS OR MUNICIPAL AUTHORITY APPROVES BONDING WARRANT
25. SBC PRESENTS PLANS AND BID TO VOTERS FOR APPROVAL
24. SBC ACCEPTS GENERAL CONTRACTOR'S BID
23. SBC RECEIVES SUBCONTRACTORS' BIDS
22. ARCHITECT AND SBC REQUEST CONSTRUCTION BIDS
21. SBAB AND DPS APPROVE WORKING DRAWINGS AND SPECIFICATIONS
20. ARCHITECT PREPARES WORKING DRAWINGS AND CONTRACTUAL SPECIFICATIONS
0. VOTERS OR MUNICIPAL AUTHORITY APPROVES PLANS ("O" MEANS COULD BE SHIFTED TO STEP 26.)
19. SBC PREPARES BROCHURE AND MEETS WITH VOTERS FOR NEXT STEP OR STEP 26
18. SBAB, DPS AND DPH APPROVE PLANS
17. ARCHITECT PREPARES PRELIMINARY PLANS AND SUBMITS TO SBAB, DPS, AND DPH
16. SBAB APPROVES "ED SPECS"
15. SBC PRESENTS "ED SPECS" TO STATE SBAB (FORMS 61-R1, 67-R2 and F)
14. SCHOOL COMMITTEE APPROVES "ED SPECS"
13. SBC HAS EDUCATIONAL PROGRAM SPECIFICATIONS PREPARED BY EDUCATIONAL CONSULTANT OR SCHOOL COMMITTEE
12. SBAB AND DPH APPROVES SCHOOL SITE
11 SBC SUBMITS TOPO MAPS AND SOIL TESTS TO SBAB
10. SBC SELECTS SCHOOL SITE
9. SBC SELECTS ARCHITECT AND EDUCATIONAL CONSULTANT
8. CITY OR TOWN APPOINTS SCHOOL BUILDING COMMITTEE, IF NOT ALREADY AUTHORIZED
7. SBAB APPROVES OR ACCEPTS REPORT
6. SBNC/SBC PRESENTS REPORT TO STATE - SCHOOL BUILDING ASSISTANCE BUREAU
5. CITY OR TOWN APPROVES REPORT
4. SBNC/SBC PREPARES REPORT
3. CITY OR TOWN APPOINTS SBNC/SBC
2. SCHOOL COMMITTEE REQUESTS MUNICIPAL AUTHORITY TO APPOINT SCHOOL BUILDING NEEDS COMMITTEE OR SCHOOL BUILDING COMMITTEE
1. SUPERINTENDENT ALERTS SCHOOL COMMITTEE TO NEED FOR NEW SCHOOL FACILITIES

SBC	SCHOOL BUILDING COMMITTEE
SBNC	SCHOOL BUILDING NEEDS COMMITTEE
SBAB	SCHOOL BUILDING ASSISTANCE BUREAU/STATE
DPS	DEPARTMENT OF PUBLIC SAFETY/STATE
DPH	DEPARTMENT OF PUBLIC HEALTH
EF	EMERGENCY FINANCE/STATE
GC	GENERAL CONTRACTOR
0	means OPTIONAL

mates. This step also delays construction of a school by several months, and more districts could take advantage of this economy in time and money.

A more reliable indicator of the cost of a school building is ascertained after contract bids have been received, and on this basis state construction grants are computed.

Construction Grants

Statutes prescribe three methods of computing construction grants for school districts in the Commonwealth. Cities, towns and counties are reimbursed under one formula; a second incentive formula is used for regional school districts or depressed areas which receive a maximal grant.

1. Cities, Towns and Counties

Cities, towns and counties receive construction grants for both new school construction and for reconstruction, remodeling, rehabilitation, and modernization of public school buildings. The Commonwealth utilizes an equalizational percentage of the cost of an approved school project. This percentage cannot be less than 40 percent nor more than 50 percent.* For example, if a city or town constructs a school for $1,000,000, it is entitled to receive a school construction grant which will be no less than $400,000 nor more than $500,000. By this formula, of the 351 cities and towns in Massachusetts, 200 are entitled to 40 percent and 83 are entitled to 50 percent of the cost of a school, while the remaining 68 cities and towns are entitled to receive between 40 and 50 percent.

The exact percentage of the cost of the school to which a city or town is entitled is determined by a rather complicated formula which, however, is less meaningful since amended in 1963 because the equalizational factor

* Sec. 9a. (All section numbers in this chapter refer to Chapter 645 unless indicated otherwise.

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was 50 percent. By passing two
increased the minimal percentag
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city or town in entitled may be

* Sec. 5.

** Chapter 70, Sec. 5.

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varies only 10 percent. When the School Building Assistance Law was enacted in 1948, the minimal percentage was 20 percent and the maximal percentage was 50 percent. By passing two amendments to Chapter 645, the Legislature increased the minimal percentage to 30 and then 40 percent. Therefore, the spread between the percentage of a grant to the highest (poorest district) and the lowest (richest district) for construction grants is more responsive to richer districts than to poorer districts. The formula is based on a theory that a municipality which is comparatively wealthy should receive a lesser percentage than a municipality which is comparatively poor. The yardstick for measuring comparative wealth is prescribed in Sec. 9a and is based on the valuation per pupil of a particular school district as compared to the average valuation per pupil in the entire Commonwealth. The average valuation per pupil in the Commonwealth is determined by the General Court (Legislature) when it apportions the state tax.* In this formula the value of all the taxable real estate in the Commonwealth is divided by the number of children attending the public schools of the Commonwealth.** The valuation of all the taxable property was last determined by the Legislature (see Chapter 660 of the Acts of 1963) at a figure of $10,849,625,000. The last official figure indicating the number of pupils attending public schools in the Commonwealth was 1,060,761. The result of dividing $10,849,625,000 by 1,060,761 is $10,228.15, which represents the average amount of taxable property for each pupil in the public schools of the Commonwealth. This figure of $10,228.15 is compared with the valuation per pupil in the city or town involved. The actual formula for arriving at the percentage to which each city or town in entitled may be expressed as follows:

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* Sec. 5.

** Chapter 70, Sec. 5.

$$\frac{1}{4} \times \frac{\text{Equalized valuation per pupil in the Commonwealth}}{\text{Equalized valuation per pupil in the city or town}}$$

with the proviso that the percentage for a city or town shall not be less than 40 nor more than 50 percent.

2. Regional School Districts

For regional school districts, the minimal grant is also 40 percent of the cost of a school, but the maximal grant is 65 percent. The formula for determining the percentage of a construction grant for a regional district is described in Sec. 9b as follows:

$$\frac{1}{3} \times \frac{\text{Equalized valuation per pupil in the Commonwealth}}{\text{Equalized valuation per pupil in the towns comprising the regional school district}}$$

3. Special Grants for Depressed Areas

If a city or town is in a depressed area, it is entitled to the maximal grant of 50 percent despite the fact that it might otherwise be entitled to a smaller percentage under the formula. A depressed area is defined in Sec. 9a as a city or town which is listed by the United States Department of Labor in the October/November issue of a publication entitled "Area Trends in Employment and Unemployment" or which has "substantial or persistent umemployment."

To encourage the development of more operating school districts, if 60 percent of the member towns of a regional school district are in a depressed or redevelopment area, the district is entitled to a maximal grant of 65 percent. A redevelopment area is defined as a city or town designated by the United States Department of Commerce in accordance with Section 401(a)(4) of the Public Works and Economic Development Act of 1065 (42 u.s.c. 3161).

Computation of the Grant

After a percentage has been determined, percentage to the actual cost of a schoo Bureau makes the final audit of the cons school is constructed and all change ord to the project cost.

This is accomplished by adding together architect's fees in accordance with the of the contract for the construction of invoices, (3) the amount of any change o the original equipment and furnishings,* ment. (See Appendix Exhibit III, "Form these items amounts to $1,100,000 in a p entitled to a school construction grant the grant would be $550,000. It should are not included in construction grants the cost of interest payments on the bon the cost of acquisition of any land for lition of existing buildings. Consequen pay 148 to 168 percent of the cost of a added to the cost of a building.** But w is considered, cost to the school distri

The final approved cost of a school is n

* Since Sec. 5 was amended in 1950.

** Most districts use twenty-year bond ranging from $4\frac{1}{2}$ to $6\frac{1}{2}$ percent. The on 20-year bonds is $10\frac{1}{2}$ times the i The principal of a bond is usually

pupil in the Commonwealth
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l district are in a depressed or
to a maximal grant of 65 percent.
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with Section 401(a)(4) of the
1065 (42 u.s.c. 3161).

Computation of the Grant

After a percentage has been determined, it is then necessary to apply the percentage to the actual cost of a school. The School Building Assistance Bureau makes the final audit of the construction cost of a school when the school is constructed and all change orders and credits have been applied to the project cost.

This is accomplished by adding together five items: (1) the cost of the architect's fees in accordance with the prevailing schedule, (2) the amount of the contract for the construction of the school as supported by actual invoices, (3) the amount of any change orders or credits, (4) the cost of the original equipment and furnishings,* and (5) the cost of site development. (See Appendix Exhibit III, "Form F.") For example, if the cost of these items amounts to $1,100,000 in a particular project and the town is entitled to a school construction grant of 50 percent, the exact amount of the grant would be $550,000. It should be noted that three important items are not included in construction grants from the Commonwealth, namely: (1) the cost of interest payments on the bonds issued by the municipality, (2) the cost of acquisition of any land for the project and (3) the cost of demolition of existing buildings. Consequently, in 1971 a school district will pay 148 to 168 percent of the cost of a school project when interest is added to the cost of a building.** But when the useful service of a building is considered, cost to the school district is less than 2 percent a year.

The final approved cost of a school is not determined until the school has

* Since Sec. 5 was amended in 1950.

** Most districts use twenty-year bonds, and the rates of interest are ranging from $4\frac{1}{2}$ to $6\frac{1}{2}$ percent. The rule of thumb for computing interest on 20-year bonds is $10\frac{1}{2}$ times the interest rate or 48 to 68 percent. The principal of a bond is usually 100 percent.

been completed and until detailed supporting data have been furnished to the School Building Assistance Bureau by the cities, towns, counties or regional districts.

Since 1950 when Sec. 8 was amended, the initial grant payment to a city or town is made on the basis of an estimate which often is derived from the contract bid for construction of the school at the time that the State Board of Education approves the project. If the estimate of the cost of the school is incorrect, the necessary adjustments are made after the final audited cost is determined by the Bureau.

Administrative Procedures for Approval of School Projects

The State Board of Education and the administering agency, the School Building Assistance Bureau, are given wide discretion under the provisions of Chapter 645 of the Acts of 1948 as amended to 1971. A municipality which applies for a state school construction grant does not receive state funds unless the State Board of Education determines that "the proposed construction project is in the best interests" of the municipality. Smaller school districts with less than 2000 students have found strict guidelines applied under the authority of the "best interests" of the city, town, region or county. The State Board of Education has the power to "determine whether the proposed construction is in the best interest of the city, town, region or county with respect to its site, type of construction, sufficiency of accommodations, and otherwise."*

The Bureau has adopted a systematic procedure for determining whether a school project should be approved. This procedure consists of five important requirements.

* Section 7 of Chapter 645.

1. Building Needs Conferences (Iten
This first important conference is he
this meeting, a school committee or l
of "maintaining adequate" school faci
the school district.* The local offi
persons who were appointed by a town
facility needs of the town or to proc
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course, appoint a special committee t
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the building needs conference the loc
long-range plans which they have made
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build a specific school. Exhibit IV
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2. Selecting a School Site
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Bureau a map of the district, a plot
map. There is also a requirement th
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* Chapter 71, Sections 5 and 68.

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1. Building Needs Conferences (Item 1, SBAB 52)

This first important conference is held in the offices of the Bureau. At this meeting, a school committee or local officials charged with the duty of "maintaining adequate" school facilities discuss the building needs of the school district.* The local officials, in the case of a town, are those persons who were appointed by a town meeting either to study the school facility needs of the town or to proceed with plans for the construction of a school building. These officials are usually known as a school building committee. In the case of a city, the mayor and the city council are generally charged with the authority to construct schools. The mayor may, of course, appoint a special committee to assist him. In the case of either a city or town, the superintendent of schools or his designee is a key educational person whom the Bureau requires to be present at all conferences. At the building needs conference the local officials discuss any reports or long-range plans which they have made prior to the conference. A decision is usually made at the end of the conference as to whether the municipality should study its needs further or whether it should proceed with plans to build a specific school. Exhibit IV (Appendix) presents some of the essential elements studied and discussed at a building needs conference.

2. Selecting a School Site

If the decision has been made to build a specific school, local officials suggest certain locations in the district. The staff of the Bureau visits the proposed sites, and the local officials are required to file with the Bureau a map of the district, a plot plan of the site, and a topographical map. There is also a requirement that local officials provide the Bureau with a letter of approval from the Department of Public Health indicating that all state requirements for water supply and sewage disposal are accept-

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* Chapter 71, Sections 5 and 68.

able to public health standards. If the Bureau is satisfied that the site for the proposed school is adequate, it sends a letter of approval for the site to local officials. Exhibit V (Appendix) describes some of the essential elements for evaluating a school site.

3. Preparing Educational Specifications

Educational specifications are furnished by local officials to enable the Bureau to determine whether the proposed school building will provide sufficient accommodations to carry out the educational program offered to the students. For secondary schools the Commonwealth requires the completion of two basic forms which describe in detail the proposed educational program and the instructional spaces required.

The primary objectives of educational specifications are to determine the educational program requirements and to communicate them as a written report to the architectural team. The document is a communication from the school staff and officials addressed directly to the architect and reviewed by the State Department of Education, School Building Assistance Bureau, before approval of a state construction grant is recommended. Exhibit VI (Appendix) presents the essential elements of an educational specification, and the important forms required by the School Building Assistance Bureau: form SBAB-61 R1 for educational programs and SBAB-67 R2 for the square foot areas of educational spaces.

4. Preliminary Plans

The fourth and very crucial requirement by the Bureau is a conference with local officials to review the preliminary plans prepared by a registered architect. The Bureau requires these plans sufficiently in advance of the conference to give the staff an opportun program described in the educational spe SBAB-67 R2, with the preliminary plans s architectural drawings which show the co the arrangement and size of all faciliti changes are needed, the Bureau requires in its office.

A "Form F" (Appendix Exhibit III) must b preliminary plans to provide an estimate with estimating its annual budget reques Governor and the Legislature.

5. Final Plan Conference

The fifth meeting requirement in the app final plan conference. The final plans tural specifications contain the complete contractors to submit bids for the constr requires an architect to secure approval ment of Public Safety before they are se conference is held in order to provide as made all the changes previously agreed up the Bureau and is constructing a school school building needs of the district, th the approved preliminary plans.

The Bureau also requires certain informat the construction cost of a school. A cer

☆ Described in more detail in Chapter

conference to give the staff an opportunity to examine them and compare the program described in the educational specifications, forms SBAB-61 R1 and SBAB-67 R2, with the preliminary plans submitted. The preliminary plans are architectural drawings which show the complete layout of the floor space and the arrangement and size of all facilities in the proposed school. If any changes are needed, the Bureau requires revised preliminary plans to be filed in its office.

A "Form F" (Appendix Exhibit III) must be completed and presented with the preliminary plans to provide an estimate of costs and to assist the Bureau with estimating its annual budget request for the Executive Offices of the Governor and the Legislature.

5. Final Plan Conference

The fifth meeting requirement in the application procedure (Exhibit I) is a final plan conference. The final plans with working drawings and architectural specifications contain the complete information necessary for building contractors to submit bids for the construction of a school. The Bureau requires an architect to secure approval of the plans by the State Department of Public Safety before they are sent to the Bureau.* The final plan conference is held in order to provide assurance that the municipality has made all the changes previously agreed upon by the local officials and that the Bureau and is constructing a school which meets the requirements of the school building needs of the district, the educational specifications and the approved preliminary plans.

The Bureau also requires certain information pertaining to the financing of the construction cost of a school. A certified copy of the votes from the

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* Described in more detail in Chapter III-7.

municipal authority (town meeting, representative town meeting or city council) authorizing the money for a school project must be filed with SBAB and the Emergency Finance Board.*

If the five important requirements outlined above are complied with by local officials, and the project receives the approval of the Bureau staff, then the Bureau recommends that the school project be approved by the State Board of Education. The vote taken by the Board of Education makes the city, town, regional school district or county eligible to receive a state school construction grant. This approval by the State Board of Education must be within the period prescribed by the Legislature so that contract bids may be studied by the city or town before acceptance (currently 30 calendar days exclusive of Saturday and Sunday**).

After the final plans are approved by the School Building Assistance Bureau and the State Board of Education, the Commissioner certifies payments of the construction grants to the treasurer. But, other than an audit of bills, the Bureau of School Building Assistance has no authority and has developed no procedures for reviewing or supervising the construction of a school project. There are no records kept of "as built" or constructed school spaces. Despite numerous change orders in the construction process, the Bureau has faith in the local building committee and in the architect that the approved space requirements will be constructed according to working drawings and specifications.

* The Emergency Finance Board was authorized by Chapter 49 of the Acts of 1933 to review the borrowing of cities and towns for construction of public projects including schools. It is described more specifically in Chapter II and later in this Chapter under the duties of local officials.

** Described in more detail in Chapter II-5.

Implementing a School Building Project fro

From the other end of a school building pr towns look at the administrative procedure the educational needs for school facilitie struct a school facility, school districts dure to determine the number of births, to pare educational programs and to transform a school building project.

To the citizens the general procedures mig

(1) To become aware of a need for school

(2) To determine the scope of the need

(3) To authorize a legal committee to pla building

(4) To prepare a proposal for a specific to legally authorized local approving the voters, representative town membe

(5) To prepare an informational program o of the need for construction and the

(6) To comply with state laws and adminis ting a school which will be entitled state

(7) To supervise the approved project

For each new school the seven general requ converted by the superintendent and his st and countless time diverted from the curre time of the staff and superintendent shoul oping plans for new schools, but in too ma

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Implementing a School Building Project from the Viewpoint of a City or Town

From the other end of a school building project, the citizens of cities and towns look at the administrative procedures or "mechanics" for translating the educational needs for school facilities into bricks and mortar. To construct a school facility, school districts must follow a sequential procedure to determine the number of births, to develop enrollment needs, to prepare educational programs and to transform educational ideas into plans for a school building project.

To the citizens the general procedures might be listed as follows:

(1) To become aware of a need for school facilities

(2) To determine the scope of the need

(3) To authorize a legal committee to plan the construction of a school building

(4) To prepare a proposal for a specific school building project to present to legally authorized local approving agencies or authorities, i.e., the voters, representative town members or a city council

(5) To prepare an informational program designed to educate the citizenry of the need for construction and the appropriation of funds

(6) To comply with state laws and administrative procedures for constructing a school which will be entitled to a reimbursement grant from the state

(7) To supervise the approved project

For each new school the seven general requirements outlined above must be converted by the superintendent and his staff through hundreds of meetings and countless time diverted from the current operation of schools. Some time of the staff and superintendent should be devoted to planning and developing plans for new schools, but in too many instances the process takes unnecessary time. Some of the case studies at the end of this section illustrate the many actions and procedures required to convert the seven general requirements into a constructed school. In too many instances the process takes five years or more. From a study of about 100 school districts, a composite of actions and procedures was developed (Exhibit VII). Some districts must take 135 of the 141 actions and procedures, and then they may repeat many of them several times. This was evident in several of the case studies where unusual delays occurred or where the district did not have a successful two-thirds vote authorizing a bond obligation. A few districts with permanent committees might reduce the number of steps to 110 or 120 actions and procedures.

There is a distinguishing difference in the municipal operations of a city and a town government; and further, between those towns which have a representative town meeting form of government and those which have a general town meeting form of government. Usually, a city charter provides that building and financing are within the province of specific officers or a city council and are not, therefore, subject to direct voter approval. In any event, there is always a procedure to obtain a referendum for the voters in the event the voters want to disapprove the action of the legal representatives who approved a school project. Chapter 43, Section 42 prescribes the procedures for a referendum petition. In this instance twelve percent of the registered voters may protest any measure except a revenue loan order by signing a petition and filing it with the city clerk. Then, at the next city or special election a majority of registered voters must approve the petition to countermand the vote of the city council or school committee.

In the case of a representative town meeting form of government, school approvals are usually decided by the elected town meeting members. In this instance, there are also provisions for a general referendum whereby citizens may, by actual ballot, indicate opposition to act
representatives, usually by the same majority as
school project.

In cities and towns the majority of the approvin
(2/3) of those voting* while in regional distric
than 50 percent is required.**

In many communities the Legislature has delegate
the educational responsibilities of the state to
cess of a general town meeting. This means that
provide educational programs and facilities for
between the ages of 6 and 16, with two notable e
is required until age 21, if necessary, and prog
be provided by 1973.

1. To Determine the Need

This may be accomplished in one of several ways:
school needs study committee; by the school comm
nent building commission which exists in many co
determination must take into account the followi
the enrollment to be housed, based on reasonably
(3) an evaluation of existing facilities to dete
use, including suggestions for any alterations w
the grades to be housed; (4) recommendations for
tion, including the grades to be housed; (5) rec
sites; (6) estimates of cost for acquiring a sit
equipping the proposed new building; and (7) est

* Chapter 44.
** Chapter 71.

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ndum whereby citizens

may, by actual ballot, indicate opposition to action approved by its elected representatives, usually by the same majority as required to approve a school project.

In cities and towns the majority of the approving body must be by two-thirds (2/3) of those voting* while in regional districts a simple majority of more than 50 percent is required.**

In many communities the Legislature has delegated the authority to fulfill the educational responsibilities of the state to local citizens in the process of a general town meeting. This means that local authorities must provide educational programs and facilities for all children and youth between the ages of 6 and 16, with two notable exceptions--special education is required until age 21, if necessary, and programs for kindergarten must be provided by 1973.

1. To Determine the Need

This may be accomplished in one of several ways: by the appointment of a school needs study committee; by the school committee itself; or by a permanent building commission which exists in many communities. In any event a determination must take into account the following factors: (1) births; (2) the enrollment to be housed, based on reasonably projected enrollment data; (3) an evaluation of existing facilities to determine the best (or continued) use, including suggestions for any alterations within the structure or in the grades to be housed; (4) recommendations for new or additional construction, including the grades to be housed; (5) recommendations for potential sites; (6) estimates of cost for acquiring a site and for constructing and equipping the proposed new building; and (7) estimates of cost for financing

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* Chapter 44.
** Chapter 71.

Exhibit VII

ACTIONS AND PROCEDURES FOR CONSTRUCTING SCHOOLS IN MASSACHUSETTS

Constitution
1. assigns "duty of legislatures and magistrates in all future periods of the Commonwealth to cherish...public schools." (Chapter V, Section II)
General Court (Legislature)
2. authorizes State Board of Education to establish minimum educational standards. (Chapter 15, Section 1G)
3. authorizes procedures for financing education with annual tax rate on local property. (Chapter 71, Section 34)
4. requires every town to maintain "a sufficient number of schoolhouses... for the accommodation of all children." (Chapter 71, Section 10) "Keep them in good order...and provide fuel and all things necessary for the comfort of the pupils." (Chapter 71, Section 68)
5. authorizes local and state statutes for financing the construction of school facilities.
6. appropriates state funds annually for School Building Assistance Act. (HR-1)
Superintendent
7. presents need for school facilities to school committee.
School Committee
8. approves recommendation of need from superintendent.
9. notifies municipal officials of need for school facilities.
Mayor/Selectmen
10a. prepares a warrant to appoint School Building Needs Committee.
10b. notifies continuing committee of need for a study.
11. prepares a warrant to fund a study of needs for school facilities.
Council/Electorate
12. votes on a warrant to appoint a committee to study school building needs.
13. votes on a warrant to fund the study of school building needs.
Mayor/Moderator
14. appoints committee for study of school building needs.
SBNC or SBC
15. accepts appointment or assignment to study needs.
16. interviews superintendent
Superintendent
17. provides information to School Building Needs Committee or School Building Committee.
SBNC
18. meets with State School Building Assistance Bureau (SBAB)
19. applies for state reimbursement to study school building needs.
SBAB
20. studies request of SBNC or SBC for funding.
State Board of Education and SBAB
21. approves reimbursement for a study of school building needs.
SBNC or SBC
22. receives approval from SBAB and State Board of Education for funding a study of school building needs.
23a. prepares report of school building needs.
23b. uses superintendent's report of school building needs.
23c. employs a consultant to expedite a report of school building needs.
SBNC
24. mails report of School Building Needs to SBAB.
SBAB
25. receives report of School Building Needs.
SBNC
26. attends a conference with SBAB to discuss report of school building needs.

SBAB
27. approves report of school building need
SBNC
28. receives approval of report of school b
29. notifies municipal officials of need fo
Mayor/Selectmen
30a. prepares a warrant to appoint School Bu
30b. notifies continuing committee of need f
Council/Electorate
31. votes on a warrant to appoint School Bu
Mayor/Moderator/or Regional School Committee
32. appoints School Building Committee.
SBC
33. accepts appointment or assignment to pr
of a school.
34. meets with school committee and superin
Superintendent
35. prepares educational program requiremen
School Building Committee
36a. prepares report of educational program
36b. uses superintendent's report of educatic
36c. employs a consultant to expedite the pre
and space specifications.
36d. notifies municipal authority to provide
Regional SBC
37a. presents request to Regional School Comm
to expedite preparation of program requi
Regional SC
37b. notifies municipal authority to provide
Mayor/Selectmen
38. prepares a warrant to fund the preparati
space specifications.
Council/Electorate
39. votes on a warrant to fund the developme
space specifications.
School Building Committee
40. interviews educational consultant to pre
41. selects an educational consultant.
Consultant
42. prepares educational specifications.
School Committee
43. approves educational program and space s
School Building Committee
44. mails a copy of program and space speci
SBAB
45. receives copy of program and space spec
SBC
46. attends a conference with SBAB on educat
SBAB
47. approves educational specifications.
SBC
48. receives approval from SBAB.
Regional SBC
49a. presents educational specifications to R
approval.

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(Chapter V, Section 11)

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SBAB
27. approves report of school building needs.
SBNC
28. receives approval of report of school building needs from SBAB.
29. notifies municipal officials of need for a school construction project.
Mayor/Selectmen
30a. prepares a warrant to appoint School Building Committee.
30b. notifies continuing committee of need for school facility.
Council/Electorate
31. votes on a warrant to appoint School Building Committee.
Mayor/Moderator/or Regional School Committee
32. appoints School Building Committee.
SBC
33. accepts appointment or assignment to prepare a proposal for construction of a school.
34. meets with school committee and superintendent to discuss requirements.
Superintendent
35. prepares educational program requirements with staff.
School Building Committee
36a. prepares report of educational program and space specifications.
36b. uses superintendent's report of educational program and space specifications.
36c. employs a consultant to expedite the preparation of educational program and space specifications.
36d. notifies municipal authority to provide funds for a consultant.
Regional SBC
37a. presents request to Regional School Committee for approval of a consultant to expedite preparation of program requirements.
Regional SC
37b. notifies municipal authority to provide funds for a consultant.
Mayor/Selectmen
38. prepares a warrant to fund the preparation of educational program and space specifications.
Council/Electorate
39. votes on a warrant to fund the development of educational program and space specifications.
School Building Committee
40. interviews educational consultant to prepare educational specifications.
41. selects an educational consultant.
Consultant
42. prepares educational specifications.
School Committee
43. approves educational program and space specifications.
School Building Committee
44. mails a copy of program and space specifications to SBAB.
SBAB
45. receives copy of program and space specifications.
SBC
46. attends a conference with SBAB on educational specifications.
SBAB
47. approves educational specifications.
SBC
48. receives approval from SBAB.
Regional SBC
49a. presents educational specifications to Regional School Committee for approval.

Exhibit VII (cont.)

Regional SC
49b. notifies municipal authority to provide funds for employing an architect.
Mayor/Selectmen
50. prepares a warrant to fund architectural planning fees.
Council/Electorate
51. votes on a warrant to fund architectural planning fees.
School Building Committee
52. interviews architects for school project.
53. selects an architect for developing plans to construct a school.
School Building Committee
54. arranges an appointment with Emergency Finance Board (EFB).
55. attends meeting with EFB in Boston.
56. receives approval from EFB to borrow and to use planning funds for architectural payments.
57. studies potential school sites.
58. selects a school site.
59. notifies Department of Public Health to study school site.
DPH
60. studies school site.
SBC
61. obtains approval from DPH for school site.
62. mails information on school site to SBAB.
SBAB
63. receives information on school site.
SBC
64. attends conference with SBAB to discuss school site.
SBAB
65. approves school site.
SBC
66. receives approval of site from SBAB.
Regional SBC
67a. requests approval of site by School Committee.
Regional SC
67b. notifies municipal authority to provide funds for the purchase of a school site.
SBAB
78. approves plans and Form F.
SBC
79. receives approval of plans and Form F.
80. mails plans to Department of Public Safety (DPS).
DPS
81. receives plans.
SBC & Architect
82. attend conference with DPS to discuss plans.
SBC
83. notifies municipal authority to provide funds to have architect prepare working drawings.
Mayor/Selectmen
84. prepares a warrant to fund architectural working drawings.
Council/Electorate
85. votes on a warrant to fund the architectural working drawings.
Architect
86. prepares working drawings and specifications.
87. presents working drawings and specifications to SBC.
SBC
88. approves architectural working drawings and specifications for bidding the construction project.

89. mails working d
DPS
90. receives working
Architect
91. attends conferen
DPS
92. approves working
SBC
93. receives approva
94. mails working d
SBAB
95. receives working
SBC
96. attends conferen
SBAB
97. approves working
SBC
98. receives approval
99. advertises for bi
Contractor
100. computes bids fo
101. submits bids to S
SBC
102. receives subcontr
103. receives general
104. studies bids and
105. selects bid of Ge
Regional SBC
106a. presents bids and
Regional SB
106b. notifies municipa borrowing for con
Mayor/Selectmen
107. prepares a warran
Council/Elect.
108. votes on a warran
SBC
109. notifies SBAB of
SBAB
110. recommends fundin
State Board of Educati
111. approves funding
SBC
112. receives State Bo grant.
113. notifies EFB of e
114. attends conferenc
EFB
115. approves request
SBC
116. receives approval
117. awards contract t
Contractor
118. accepts contract
119. begins constructi
Architect
120. recommends approv

thority to provide funds for employing an architect.

fund architectural planning fees.

fund architectural planning fees.

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or developing plans to construct a school.

t with Emergency Finance Board (EFB).
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EFB to borrow and to use planning funds for archi-

ol sites.

Public Health to study school site.

DPH for school site.
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DPS to discuss plans.

thority to provide funds to have architect prepare

fund architectural working drawings.

fund the architectural working drawings.

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working drawings and specifications for bidding
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89. mails working drawings and specifications to DPS.
DPS
90. receives working drawings and specifications.
Architect
91. attends conference with DPS to discuss working drawings.
DPS
92. approves working drawings and specifications.
SBC
93. receives approval from DPS.
94. mails working drawings and Form F.to SBAB.
SBAB
95. receives working drawings and Form F.
SBC
96. attends conference with SBAB to discuss working drawings.
SBAB
97. approves working drawings.
SBC
98. receives approval of working drawings from SBAB.
99. advertises for bidders to construct a school.
Contractor
100. computes bids for construction project.
101. submits bids to SBC.
SBC
102. receives subcontractor's bids 3 weeks from advertising for bidders.
103. receives general contractor's bid for construction of school.
104. studies bids and alternates with architect.
105. selects bid of General Contractor for constructing school.
Regional SBC
106a.presents bids and contracts to Regional School Committee for approval.
Regional SB
106b.notifies municipal authority to prepare warrant for electorate to approve borrowing for construction.
Mayor/Selectmen
107. prepares a warrant to authorize bonds for construction payments.
Council/Elect.
108. votes on a warrant to fund the construction of school facilities.
SBC
109. notifies SBAB of bid contract and completes Form F.
SBAB
110. recommends funding project to State Board of Education.
State Board of Education
111. approves funding of school project.
SBC
112. receives State Board of Education approval for School Building Assistance grant.
113. notifies EFB of electorate approval to borrow.
114. attends conference with EFB in Boston.
EFB
115. approves request for borrowing.
SBC
116. receives approval of EFB.
117. awards contract to school.
Contractor
118. accepts contract to construct school.
119. begins construction.
Architect
120. recommends approval of contractor's payments.

Exhibit VII (cont.)

SBC
121. approves contractor's payments recommended by the architect.
122. prepares accounting system for construction.
Architect
123. notifies field inspector of DPS to check construction.
Contractor
124. submits changes required for construction.
SBC
125. approves all changes recommended by architect for construction.
DPS Field Inspector
126. inspects construction.
SBC
127. receives approval from DPS Field Inspector.
Municipal Treasurer
128. employs bond counsel.
129. chooses certifying bank.
130. compiles financial figures for notice of sale.
131. approves prospectus for sale of bonds.
132. receives bids on bonds.
133. awards bonds to successful bidder.
134. prints and delivers bonds.
135. budgets annual payment for coupon interest and principal.
136. pays fee for coupon interest.
Contractor
137. completes construction.
State Board of Education
138. notifies State Treasurer to pay semi-annual grant for life of bond issue (usually 40 payments).
Municipal Treasurer
139. receives state grant.
SBC/Architect
140. orients staff to new school facilities.
SBC
141. presents school facility to school committee.

a proposal, including the impact on the tax rat

2. To Authorize a School Building Committee

This is accomplished by a vote of the town meet the specific individuals who will serve on such the moderator to make the appointments.

The committee consists primarily of laymen, som of the local school committee. Although it is ent to serve as a member of a building committe the role of educational advisor to the committe have sufficient funds to enable it to prepare a for final review by the voters. There are two funding a building committee.

a. The first is to supply the committee with tect and preparing preliminary drawings or of final costs can be made. With this est committee returns to the voters at a town appropriation of a sum sufficient to cover construction and financing. With authoriz and the town voters, the building committe to prepare final working drawings and bid hopes that the bids will come in within th town meeting.

b. A second method, and one that is increasin mittees in light of swiftly spiraling cos initially to acquire a site, engage an ar working drawings and out to bid. With a committee can then return to the town mee the architect.

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a proposal, including the impact on the tax rate in the community.

2. To Authorize a School Building Committee

This is accomplished by a vote of the town meeting which will either name the specific individuals who will serve on such a committee or will authorize the moderator to make the appointments.

The committee consists primarily of laymen, some of whom are usually members of the local school committee. Although it is permissible for a superintendent to serve as a member of a building committee, more often he serves in the role of educational advisor to the committee. The committee should also have sufficient funds to enable it to prepare a reasonably detailed proposal for final review by the voters. There are two commonly accepted methods for funding a building committee.

a. The first is to supply the committee with funds for engaging an architect and preparing preliminary drawings or sketches on which an estimate of final costs can be made. With this estimate in hand, the building committee returns to the voters at a town meeting and requests the appropriation of a sum sufficient to cover the cost of the estimated construction and financing. With authorization from the state agencies and the town voters, the building committee then directs its architect to prepare final working drawings and bid documents, goes to bid, and hopes that the bids will come in within the figure authorized by the town meeting.

b. A second method, and one that is increasingly favored by building committees in light of swiftly spiraling costs, is to request enough money initially to acquire a site, engage an architect, proceed through final working drawings and out to bid. With a firm bid in hand, the building committee can then return to the town meeting and present its proposal based on actual construction bid figures. The advantage of the latter procedure is that the town meeting, at the time it votes approval of the project, knows the actual cost as submitted by bid. In a competitive, spiraling market of the last few years estimates were not reliable, and warrants for a second and third bonding authority had to be used. Consequently, building committees are increasingly adopting this second method of securing a sound, defensible proposal for town action.

3. To Prepare a Proposal

This requires all of the elements outlined in Paragraph 1, "To Determine the Need." The building committee will begin with the educational program to be offered. This was previously referred to in great detail as educational specifications (Exhibit VI). To avoid developing building designs before the important issues of program are determined, the key person in educational discussions is the chief school administrator (superintendent or superintendent-director for vocational schools). He is in the best position to advise the committee at the very outset as to program needs, objectives and goals. In some cases the superintendent requests the assistance of an educational consultant.

The duties of an educational consultant can be broad in scope as outlined in Exhibit VIII (Appendix) or limited by the time, the availability of staff, and the complex requirements of school officials.

With the enrollment data and educational program established, the committee is then in a position to give attention to the matter of selecting a site, engaging an architect, and proceeding to preliminary drawings. Building committee members usually visit similar new school projects in neighboring towns and states to apprise themselves of current practices of new school construction. At the state level, much information can be secured from the staff of

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At the national level, in addition to t
source of school building guidance is t
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West Woodruff Avenue, Columbus, Ohio 43

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the School Building Assistance Bureau in the State Department of Education. At the national level, in addition to the U.S. Office of Education, a prime source of school building guidance is the Guide for Planning Educational Facilities, published by the Council for Educational Facility Planners, 29 West Woodruff Avenue, Columbus, Ohio 43210 ($7.50 per copy).

The amount of research and self-education devoted to each school project depends upon the building committee experience with school projects. In many cases, citizens who have served on previous building committees are appointed to serve again and can readily direct and supervise a project. In most cases, the committee may be citizens who are exposed to the task for the first time and usually need more help. The experience of and assistance provided to the committee affects the time needed to prepare a proposal for action at a town meeting. Time delays under current market conditions is money added to the cost of a building project.

4. To Prepare an Informational Program

Concurrent with the study and preparation of a specific building proposal, a committee must prepare the necessary information and data to be submitted to the voters for considered evaluation. This includes some of the basic materials prepared initially to determine the need for a project, i.e., births, expanding enrollments, utilization of existing facilities (including any alternations or expansion required or desired) and proposed new school construction. Based on the educational program prepared by the superintendent, together with preliminary estimates of needed space and preliminary designs of the architect, the committee will be in a position to indicate the probable range of costs involved in the proposed project. This can then be translated into the financial impact on the town in terms of construction, operational and financing costs to the taxpayer.

In the event that the committee decides to get firm bids on the project, the actual contract bids will be made available to the voters at the time an appropriation is requested. In any case, the building committee will undoubtedly prepare a brochure of informational materials for distribution to the voters in sufficient time to make an evaluation prior to voting for a bond appropriation.

5. To Comply with State Laws

First, it is axiomatic to assume that a community will seek state aid for construction of new school buildings. The agency legally designated by the Legislature with power of approval of such projects is the State Board of Education, on recommendation of the School Building Assistance Bureau. As soon as a community indicates a need for new school construction, communication should begin with the Bureau and a date should be scheduled for the purpose of holding a building needs conference. At this conference, staff members of the Bureau outline the procedures and services available through that office, including limited assistance for evaluating existing facilities, selection and approval of sites, and assistance in preparing educational specifications. Through reviews, however, more assistance is provided before approval of building needs, educational specifications, preliminary plans, final plans and specifications and audited expenditures for the project. Legal assistance and advice on the proper methods for requesting reimbursement on approved projects are also available in the Bureau. It is important for the school building committee to obtain the review and approval by the Bureau for state reimbursement before it makes its presentation to the town or city for final approval.

Additional assistance and approval must be secured from the State Department of Public Safety and from the State Department of Public Health, each of which must approve the plans for new school construction. Most architects

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building committee is usually relieved of the
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Finally, to finance a project when a district
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6. To Supervise the Approved Project

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practicing in Massachusetts are familiar with these requirements, and the building committee is usually relieved of the details of this procedure, but not the responsibility for seeing that all requirements are adhered to and satisfied.

Finally, to finance a project when a district must borrow beyond the debt limitation authorized by the General Court, approval must be obtained from the State Emergency Finance Board. Most cities and towns require approval from the Emergency Finance Board, because the limitations for borrowing established decades ago have not kept pace with the cost of construction and have consequently been exceeded. Approval of final plans by the School Building Assistance Bureau is required before approval for borrowing can be obtained from the Emergency Finance Board. Approval must also be obtained from the Emergency Finance Board if planning money for preparing the architectural documents and working drawings will be borrowed or included in the school bond issue which will be submitted to the voters.

6. To Supervise the Approved Project

When the voters are satisfied with the need and the financial feasibility of the proposal as advanced by the building committee, authorization for funds may be approved, and the committee is prepared to award a contract for construction. Here the procedure is again complicated. Within thirty calendar days the committee must obtain approval from the State Board of Education and the Emergency Finance Board before the contracts may become official documents for a construction grant or for borrowing outside the debt limit. The main responsibility of the school building committee will be to ensure the proper and specified construction of the project. The committee disperses funds on approval of the architect to protect the interests of the town. To a large degree, the architect and the committee are assisted in this effort by the employment of a Clerk of the Works who acts as the personal representative of the committee on the construction project. His major responsibility is to see that the project proceeds with a minimum of delays (barring those beyond foreseeable control) so that the interests of the school children may best be served by the availability of needed school facilities. In the final analysis, a judgment of acceptability will be rendered by the local school committee, who will be asked to accept the school officially at a dedication, when it is satisfied that all specifications have been met and a "punch" list of deficiencies prepared with the assistance of the architect have been corrected or differences resolved.

Payments to Cities and Town

Assume that a district begins construction of a school whose final cost finally edited by the School Building Assistance Bureau is $1,100,000 and that it is entitled to a construction grant of 50 percent of the cost of the school, or $550,000. The state, however, does not send a check in the amount of $550,000 to the district. The law requires the Commonwealth to pay the grant in equal annual payments over the same number of years as the term of the bonds issued by the district for the construction of the school, but no fewer than five annual payments*. A majority of the districts borrow for a period of twenty years, the maximum permitted under the law. In the example cited, if the borrowing is for twenty years, the grant of $550,000 would be paid over a period of twenty years and the district would therefore receive an annual payment of $27,500 for twenty years, beginning when the first payment of principal becomes due.**

An exception to this rule is possible, but less probable, that the bond issue might be for a shorter term. Under Chapter 645, if a bond issue is for less than five years, the grant is paid in five equal annual payments beginning in the calendar year in which the first payment of principal became due.*

* Section 9d.

** Sections 8 and 9d.

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A Financial Savings To Cities And

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* Section 9d.

** Report of the Massachusetts Bu
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Council on Education, December

*** Ibid., p. 41.

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Rarely, when a city or town has a very small school project, it may decide to finance it from available funds without resorting to a bond issue. In this case the state grant is also paid in five equal annual payments, beginning in the calendar year when the construction commences.*

A detailed discussion of the entire process by which school construction is financed is presented in Chapter II-3.

A Financial Savings To Cities And Town

One method of financing school construction could result in a sizeable savings of the total construction cost. Cities and towns are permitted under Section 5B of Chapter 40 of the General Laws to create a stabilization fund and then to appropriate money from the fund for the purposes of Chapter 645 or for any other purposes for which the town may issue bonds. In fact, a much larger part or all of the construction could be appropriated from the stabilization account and no interest cost would be required. The Report of the Massachusetts Business Task Force for School Management, a study of the Massachusetts Advisory Council on Education, indicates that a city or town could save almost 70 percent of the total cost** by reducing interest charges. This is possible by earning interest on the appropriations in the stabilization account as well as reducing the interest charges. On a statewide basis the task force estimated a savings to taxpayers of $70 million annually.***

* Section 9d.

** Report of the Massachusetts Business Task Force for School Management. Chairman Carl H. Nordstrom, Boston, A Study of the Massachusetts Advisory Council on Education, December 1970, p. 40.

*** Ibid., p. 41.

Special Grants for Studies Made by Municipalities

Since 1954, Section 6A of Chapter 645 provided a method to encourage local municipalities to make studies of school building needs, including studies of the actual physical condition of school facilities. Section 6A provides in part as follows:

> Any city, town or regional school district may apply to the commission for reimbursement, in whole or in part, of any expenses incurred...for surveys made of school building needs and conditions, the contract for which has been approved by the commission. The said commission may, upon completion of the survey, certify to the comptroller for payment to the city, town or regional school district such amount, not exceeding such expenses, as it may deem proper, and the state treasurer shall forthwith make the payments so certified from any funds appropriated therefor.

Under the provisions quoted above, a municipality may engage especially trained persons (an educational consultant; Exhibit VII) to study its complete school building problems, including a complete examination of the physical conditions of school facilities. The purpose of the law is to enable cities and towns to solve problems in school facilities by engaging specialists who will give an unbiased appraisal of needs. The Board of Education has discretionary authority to determine "in whole or in part" the amount of reimbursement it will grant to cities and towns for this purpose. At the present time the policy of the Board is to reimburse the municipality in part by making a payment of not less than 40 nor more than 65 percent of the amount expended by the municipality for the cost of the survey. The exact percentage between 40 and 65 percent which a city or town receives is the same as the percentage to which it is entitled for school reimbursement grants for an approved construction project. For many years the limit of reimbursement was $2000; it was increased to $10,000 in 1969; and the limit was removed in March of 1971 by the State Board of Education to encourage planning.

Grants for Reconstruction, Remodeling, Rehabilit

From the inception of the school building assist of the Legislature had been to permit school rei new construction, which also includes additions 1949, an amendment of Chapter 645 Section 5 perm receive state grants if it enlarges a schoolhous defined as "the construction of additional build classroom, cafeteria, gymnasium, auditorium, uti special activity room." It was never expressly to provide construction grants for any type of r In the latter part of 1968, however, the General requires construction grants, under certain circ remodeling projects. The pertinent provision de follows:

> "Approved school project" shall also m the reconstruction, remodeling, rehabi tion of any schoolhouse in lieu of whi of the present educational facilities structure replacement....

The words "in lieu of which, proper utilization facilities would require complete structure repl confusing to the Board of Education, the Departm School Building Assistance Bureau.* The Bureau projects under this so-called rehabilitation law guidelines for obtaining a grant were mailed to response to special legislative appropriations m session of the General Court to provide funds ar this program. Therefore, it is expected that gr rehabilitation projects.

* See Case Study III below for an example.

<u>Grants for Reconstruction, Remodeling, Rehabilitation and Modernization</u>

From the inception of the school building assistance program, the statutes of the Legislature had been to permit school reimbursement grants only for new construction, which also includes additions to existing schools. Since 1949, an amendment of Chapter 645 Section 5 permits a municipality to receive state grants if it enlarges a schoolhouse. An enlargement is defined as "the construction of additional building space for use as a classroom, cafeteria, gymnasium, auditorium, utility room, boiler room, special activity room." It was never expressly stated in Chapter 645 to provide construction grants for any type of remodeling.

In the latter part of 1968, however, the General Court enacted a law which requires construction grants, under certain circumstances, to be made for remodeling projects. The pertinent provision defines these projects as follows:

> "Approved school project" shall also mean any project for the reconstruction, remodeling, rehabilitation and modernization of any schoolhouse in lieu of which, proper utilization of the present educational facilities would require complete structure replacement....

The words "in lieu of which, proper utilization of the present educational facilities would require complete structure replacement" have been somewhat confusing to the Board of Education, the Department of Education and the School Building Assistance Bureau.* The Bureau had not approved any projects under this so-called rehabilitation law, but in April of 1971 guidelines for obtaining a grant were mailed to all school districts in response to special legislative appropriations made specifically in the 1970 session of the General Court to provide funds and staff in the Bureau for this program. Therefore, it is expected that grants will soon be made for rehabilitation projects.

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* See Case Study III below for an example.

Construction or Acquistion of Structures for Use as Central Food Production Facilities

At the end of the 1970 session of the Legislature, Chapter 871 amended Chapter 645 and now permits the Bureau to make school construction grants for the construction or acquisition of central food production facilities. The amendment was passed as part of a law which makes it compulsory for all communities to make school lunches available to all children by September, 1973. This 1970 law adds a sentence to the definition of an "approved school project."

Planning Grants for Regional School Districts

Although the main provisions of law relating to the establishment of regional school disctricts are contained in Chapter 71 of the General Laws, the School Building Assistance Act specifically provides that the state should participate in the planning and establishment of regional school districts. Section 4 reads in part as follows:

> The commission is hereby specifically authorized to make contracts for surveys or other technical services within the scope of its duties, to provide legal, architectural or other tecnnical advice and assistance to cities and towns or to joint committees thereof in the planning and establishment of regional or consolidated schools....

By 1971, the Bureau had actively participated in the formation of 71 regional school districts in Massachusetts, 51 of which are "academic" regional school districts and 20 of which are "vocational" regional school districts. The 51 academic districts include 154 towns in Massachusetts. The 20 vocational districts include 127 towns and 16 cities, with 36 of the 127 towns also in "academic" regional school districts.*

* The Massachusetts Advisory Council on Education will release a study on regional school districts in 1971.

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Education will release a study

Regional school districts are entitled to construction grants ranging from 40 to 65 percent of the cost of a school. There is also another special form of state aid that is given to regional school districts. Under Section 6 of Chapter 645, the Bureau is authorized to reimburse regional school districts in full for "educational, engineering and architectural services incidental to the planning of a regional school." The architect's work, customarily performed before the construction of a school, includes "preliminary studies, preliminary plans, working drawings and specifications, estimates and all other work customarily performed by an architect prior to the execution of the construction contract by the awarding authority." This means in practice that the state reimburses the regional school district in full for about 75 percent of the architect's work. The reimbursement payment is made to a regional district after the architect completes his work and after the district has paid for the architect's services. The balance of 25 percent of the architect's fee is included in the regular school construction grant and usually includes the supervisory work connected with the construction of his plans and specifications.

Grants for Reducing or Eliminating Racial Imbalance

The Legislature enacted Chapter 641 of the Acts of 1965 which declared the policy of the Commonwealth to encourage all school committees to promote racial balance and to correct racial imbalance in public schools. A school was declared imbalanced in the Act when the percent of nonwhite students "is in excess of fifty percent of the total number of students in such schools."

1. Prohibition of Grants

Under Chapter 15, Section 11 of the General Laws, the Board of Education shall not approve any project for school construction for such city, town or regional school district under Chapter 645 as amended when the schools are racially imbalanced and they have not submitted a plan to eliminate the imbalance.

2. Incentive Grants

Any approved construction project for new schools or additions which reduce or eliminate racial imbalance are reimbursed at 65 percent of the cost of construction.

By 1971, Boston and Cambridge have received construction grants under this act. Springfield and New Bedford have submitted construction plans which make them eligible for a grant under Chapter 641 and 645.

In summary, the administrative procedures and laws of Massachusetts for school building assistance responded to a need, assisting local communities by providing state supervision and review of projects and by providing a number of required services and acts as incentive monetary inducements to implement Legislative policies. Regulations for the administration of the acts are not published by the Department of Education, but most local districts find their way through the maze of administrative requirements by asking persons in other districts who went through the experience. The checklist from the School Building Assitance Bureau and the laws are available in the offices of the Bureau. A school building needs conference does help with highlighting some of the state administrative requirements. The six case studies illustrate the fact that the process is long. Inexperienced school building committees (and most are inexperienced) and new superintendents are confused and delayed in planning school construction projects. The six case studies show that delays cause added expenses to taxpayers in an inflationary economy. Several hundred persons in all parts of the Commonwealth told the study team at eleven regional conferences that the process is too long and should be shortened. The following case studies

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show the diversity of actions and local committees in attempting to complete a successful school construction project.

Six Case Studies with Varying Delays in Constructing a School

The current procedures developed by state agencies and local municipalities are complex and difficult to understand. With no comprehensive guidelines in the Commonwealth, cities and towns use a variety of procedures and delaying actions before starting on the right track to a successful school construction project.

About one hundred cities and towns were studied to determine a range of time necessary to complete a school project. Six school projects were selected as case studies to illustrate the current procedures which result in successful school construction, less successful school construction and unsuccessful school projects. Each of these selected case studies represents the difficulties many cities and towns must experience under current statutory and administrative procedures for constructing a school in 1971. The range in time from notification of a need by the superintendent of schools to completion of a school project is anywhere from three and a fraction years to ten years or, as in one case study, twelve years. Then, unfortunately, there are many towns which have not successfully completed a school project under the present procedures. In fact, the need for schools is greater in 1971 than in any time in the history of the Commonwealth. Chapter III-13 on School Building Needs documents the tremendous lag in construction (10,697 instructional rooms) evident in 1971 under the existing procedures. Yet some cities and towns have developed fairly successful procedures for constructing a school. In the last five years 5,447 instructional rooms were constructed.

CASE I. SUCCESSFUL SCHOOL CONSTRUCTION
(1 to 2 years late)

This town increased in population from 44,550 to 62,250 between 1960 and 1970. From 1955 to 1970 the school population increased 140 percent with annual increases ranging from 400 to 700 students. The town has an area of nearly 26 square miles, and the population increase in less settled parts of the town required new streets, utilities, sewers and schools. Consequently, the planning process had to provide new schools when they were needed and also at the best locations for new facilities.

During the fifteen-year period, the citizens of the town authorized bond issues for about $23 million to construct:

Four (4) additions to elementary schools

Six (6) new elementary schools

Two (2) new junior high schools

Two (2) new senior high schools

In 1971, one item--the two senior high schools -- would most probably cost $23 million. The project procedures developed by the citizens and school and municipal officials were economical for taxpayers, and the schools were available for the education of children and youth without long delays.

The essential elements of a plan for the construction of a school provide responses to the following questions:

How many additional students will need new school facilities?

When will additional facilities be necessary?

What kind and number of instructional spaces will be required?

Where should the new facilities be located?

The cooperation among school an
that the current system can wor
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1961 With the School Committee

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1962 With the Citizens

A formal statement of the
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(2) construct a junior hi
(3) construct a senior hi

A site was selected.

1964 Notification of Town Board

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1965 During the first six month
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On June 22, the school com
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A second special town meet
following issues:

(1) To procure by purchase
7.76 more acres

(2) To appropriate $24,000

(3) To appoint a building
equipment for a secon

The cooperation among school and town officials and town committees shows that the current system can work successfully when people make special and persevering efforts to construct a school. The results are an example of tax economy and appropriately provided facilities for students without too long a delay. A brief description of key actions follows:

1961 <u>With the School Committee</u>

After the spring pre-school census figures were combined with the actual enrollment figures of Oct. 1, 1961, it was evident that new secondary space would be needed by September, 1967, or September, 1968, at the latest.

1962 <u>With the Citizens</u>

A formal statement of the need was given to the citizens by the superintendent in his annual report which was released in March, 1962.

There were three alternatives open to satisfy the need:

(1) add to existing building
(2) construct a junior high school
(3) construct a senior high school

A site was selected.

1964 <u>Notification of Town Boards</u>

The town has a Capital Budget Committee. This committee was notified in December, 1964, that the school committee would need a junior high school in 1967 or 1968. They were also told that additional land would be needed. Since more land was required for this project, the Land Acquisition Committee was also notified of the need for additional acreages. A full explanation was given to each committee and approval was received.

1965 During the first six months of 1965 a public understanding program was carried out.

On June 22, the school committee requested a special town meeting to approve the new school. The article was defeated and referred back to the school committee.

A second special town meeting was held on December 7 to decide the following issues:

(1) To procure by purchase, by right of eminent domain or otherwise, 7.76 more acres

(2) To appropriate $24,000 for this purpose

(3) To appoint a building committee to plan for construction and equipment for a secondary school to accommodate 1500 pupils

(4) To appropriate $134,000 to obtain working plans for this school

1966 A School Construction Committee was appointed about February 1, 1966.

An architect was employed in the spring.

In the fall of 1966, final plans and specifications were developed and approved by the School Building Assistance Bureau and the Department of Public Safety without unusual problems or delays.

1967 Bids were advertised on January 13 and opened on February 15.

A special town meeting on February 27 appropriated $5,525,000 for erecting and equipping the new junior high school.

The Emergency Finance Board approved borrowing above the debt limit on March 16 without any problems or delays.

A contract was signed with the general contractor for completion by December, 1968, or possibly by September, 1968. The building was not ready until the spring of 1969. Since the town had been using newly constructed elementary space to house some of the junior high school pupils, the school committee decided not to open the new school until September, 1969.

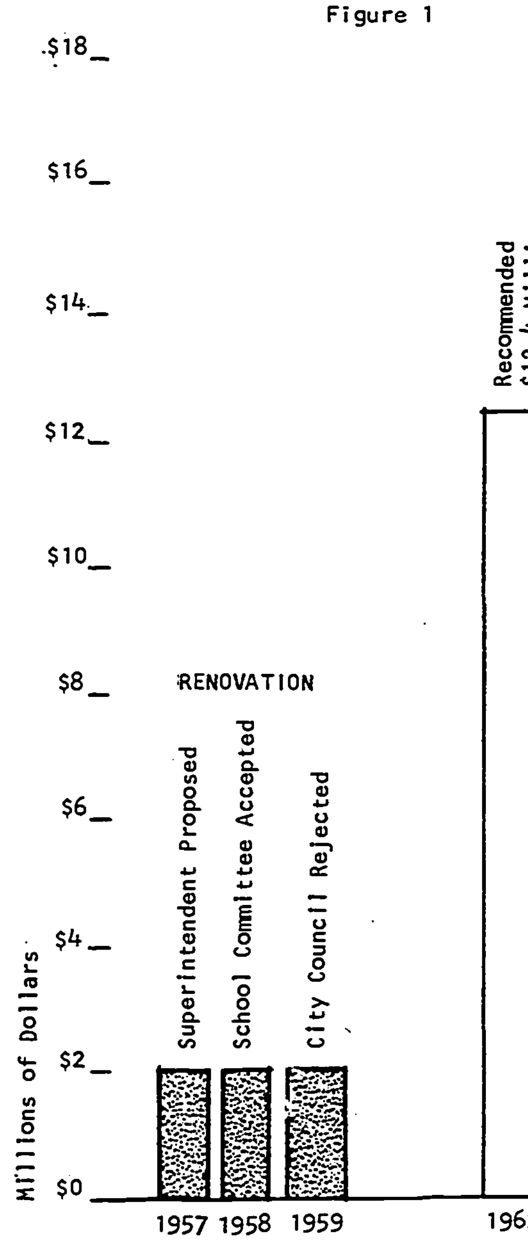
1969 In September, the new junior high school was in full operation---one to two years after the planned need.

CASE II. SUCCESSFUL SCHOOL CONSTRUCTION BUT LATE (12 years late)

This School District has a population which increased from 72,800 in 1960 to 87,450 in 1970. In 1957, a former school superintendent alerted the school committee to the lack of space and poor physical condition of the existing high school. The senior high facilities had space for 2,000 students and over 4,000 would need to be accommodated by 1970. The original structure was built in 1904 and an addition was completed in 1916.

CASE II SUCCESSFUL BUT L

Figure 1



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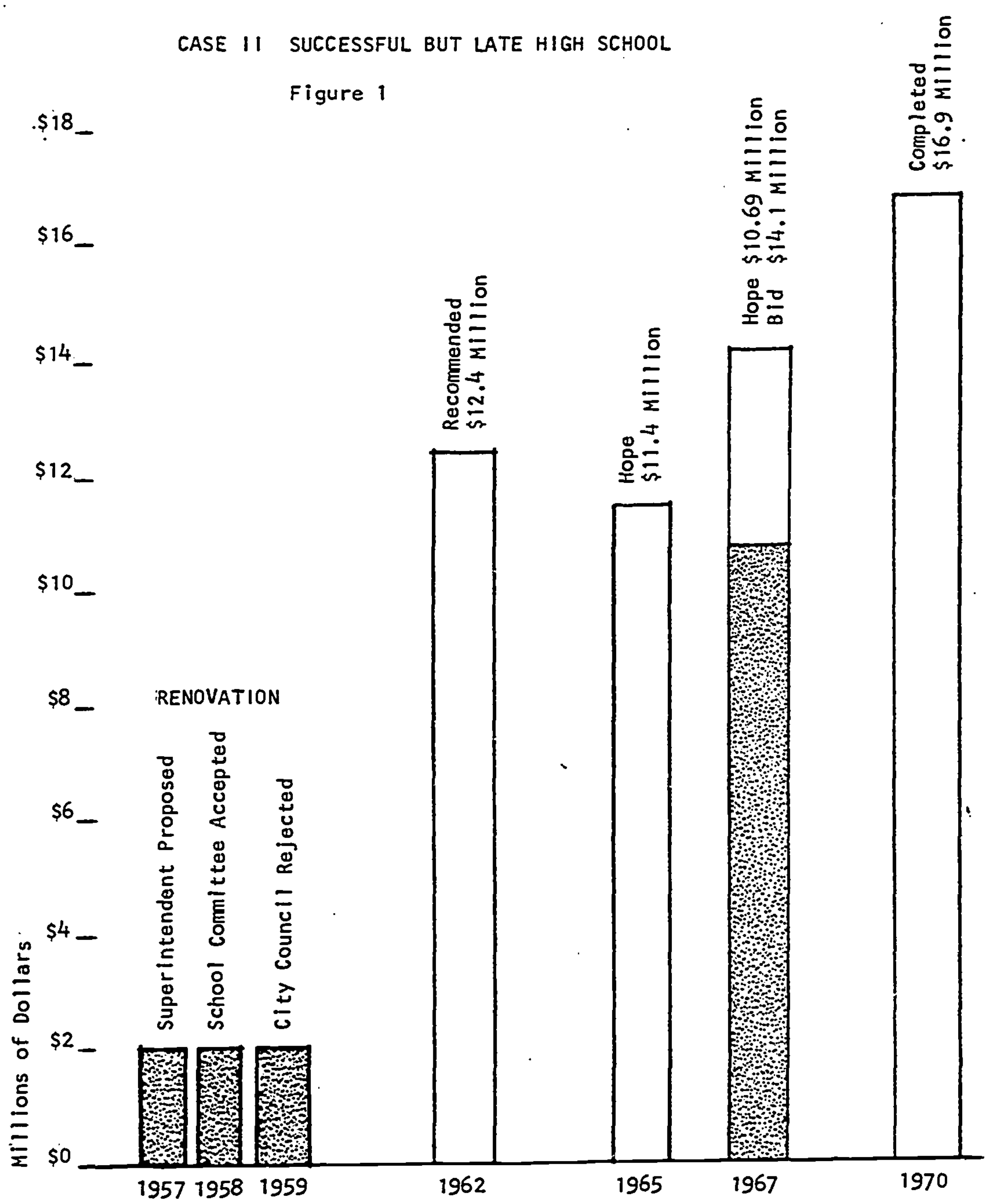
CASE II SUCCESSFUL BUT LATE HIGH SCHOOL

Figure 1



The school committee authorized studies by the school department and an architectural firm. In 1959, the two studies confirmed the need for space. The architectural report recommended additions and renovations, but this approach was rejected by the city council a year later in 1959.

In August, 1962, the School Building Assistance Commission approved educational specifications prepared by the school administration for an 1,800 student high school. The Harvard University Center for Field Studies was requested to review the entire educational program in this school district and to prepare recommendations. The Harvard Report was submitted in July, 1964, again confirming the urgent need for new facilities and recommended that:

(1) The older high school should be razed.

(2) The newer facilities of the high school should be renovated for elementary school use.

(3) One new comprehensive high school (for grades 9-12 and vocational programs) should be constructed to open in the fall of 1966 with a capacity of 3,000 students and should be capable of expanding to accommodate approximately 4,500 students.

A second architectural evaluation in 1964 concluded that it would not be economically feasible to renovate the 1904 facilities in the high school and suggested various options:

(1) To demolish the older section, renovate and remodel the new section of the present high school. Build additions required so that the result will be a 4,000 pupil high school.
Total estimated cost - $5,920,000

(2) To build a new 4,000 pupil high school
Total estimated cost - $6,991,000

(3) To construct two new 2,000
Total estimated cost - $8,1

The school committee decided that one
educational advantages than two small
impending racial imbalance problems.

In 1965, an architect was selected to
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This facility is one of the finest in
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CASE III LESS SUCCESSFUL SC
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A member of the School Building Committ
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(3) To construct two new 2,000 pupil high schools
Total estimated cost - $8,130,000

The school committee decided that one large building would offer more educational advantages than two smaller schools and would also eliminate impending racial imbalance problems.

In 1965, an architect was selected to design a comprehensive high school for 4,800 pupils, based on revised enrollment projections. The projected cost was estimated at $11.4 million. Site work began August, 1966. The new school was formally opened in September, 1970. Four years later the new high school cost $16.9 million, including almost $3 million in new equipment. Figure 1 shows how this cost increased graphically as the project was delayed. In spite of the large cost, the cost of construction per student was lower (about 20 percent) than the average in Massachusetts for school construction at that time, and lower than the average cost per square foot for high school and vocational facilities. (Total cost per square foot: $30.90. Construction cost per square foot: $20.00.)

This facility is one of the finest in the nation for senior high (9-12) and vocational students.

CASE III LESS SUCCESSFUL SCHOOL PLANNING
(10 years late)

The need for new facilities for high school and vocational programs was reported by the superintendent of schools in 1962. Some persons, however, thought that the existing school facilities (1906) should be renovated as an economy to taxpayers of the city.

A member of the School Building Committee of the Parent-Teacher Association summarized the time table of events by an oral and written report at a meeting of the school committee at 8:30 PM on November 25, 1968:

.....Some people have estimated that rising construction costs equal approximately 1% of the new construction total per month. Others estimate that each month of delay in the construction of the high school is costing the taxpayers $100,000. In the light of these delays, I think it is pertinent here to remind the school committee of certain details of remote and recent history concerning the high school. These historic events are as follows:

(1) The spirit of the educational specifications for the high school was spelled out in 1964; 1964

(2) The details of the educational specifications were spelled out in 1967, and agreement on these specifications and their relationship to the physical facilities -- that is, the new high school -- was reached on July 29, 1967, between the School Department, the Mayor, the Public Building Committee of the Board of Aldermen, and perhaps others attending the meeting. 1967

(3) The present Board of Aldermen on August 12, 1968, agreed to a maximum cost figure of 15.4 million dollars for the new high school; and 1968

(4) The Mayor, the Board of Aldermen and the School Committee have expressed repeatedly their willingness to expedite construction of the high school according to these agreements.

If financial justification alone were the problem, the loss in dollars to the community -- due to delays in construction -- would have more than paid for the cost of such "in-house" consultants by this time. Unfortunately, the delay is measured not only in monetary terms but also in the number of months that school children will not have the physical facilities available. We are concerned with this aspect of the delay as well as the financial cost to the community. In response to the question of one of the school committeemen as to whether or not "in-house" or external consultant help would be preferable at this time, we responded that at the moment the latter might have more advantages than the former. In either event this help should be promptly obtained.

We remind the school committee, although it is probably unnecessary to do so, that it has very definite responsibility with regard to the planning of school construction. A portion of Section 23 of the City Charter was quoted, namely, "no schoolhouse shall be located, built, or materially altered until the school committee shall have been consulted as to the proposed location and plan and has full opportunity to set forth its requirements." This quotation appears on page 6 of the Rules and Regulations of the School Committee dated October 10, 1966. We believe it is the obligation of the school committee to meet this responsibility by a continuing review of the progress which

the School Department is making. It is the
responsibility to make sure that the spirit
the letter of the educational specification

On May 13, 1968, an architectural firm had c
Study of the High School. They proposed two plan
high school (referred to as Alternative or Plan D
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major inequities of Alternative D and concluded t
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(1) Majority of educational space is remode
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(2) Technical/vocational students would be
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(3) Majority of space in remodeled building
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"Therefore, this alternative cannot be consi
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The Taxpayers' Association, Inc., performed
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An unusual "condition precedent" in the Act
for the State Department of Education. Chapter 7
and towns could receive from 40 to 50 percent of
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third of the expenditures for new construction f

> the School Department is making. It is the committee's responsibility to make sure that the spirit as well as the letter of the educational specification is followed.

On May 13, 1968, an architectural firm had completed a Development Study of the High School. They proposed two plans: remodel the existing high school (referred to as Alternative or Plan D) or construct a new high school (Alternative or Plan A). The report stated the following major inequities of Alternative D and concluded that this alternative could not be considered as meritorious either educationally or economically.

(1) Majority of educational space is remodeled construction without the flexibility or adaptability which would be built into new construction.

(2) Technical/vocational students would be still housed in least desirable facilities.

(3) Majority of space in remodeled buildings will have relatively high maintenance costs.

"Therefore, this alternative cannot be considered as particularly meritorious either as an educational facility or as an economical structure for the City."

The Taxpayers' Association, Inc., performed a public service by calling attention to a new state law (Chapter 754 of the Acts of 1968) which under certain circumstances might reimburse cities and towns for renovation and remodeling work on existing physical facilities.

An unusual "condition precedent" in the Act caused some confusion for the State Department of Education. Chapter 754 indicated that cities and towns could receive from 40 to 50 percent of the cost for renovating and remodeling, but the condition precedent read: "...not to exceed one third of the expenditures for new construction for the previous year..."

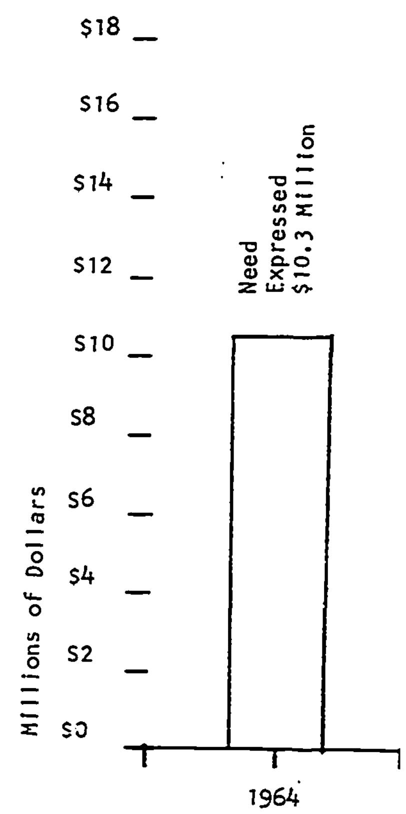
The confusion arose when an interpretation was required to determine "one third" of whose new construction for the previous year -- the city or town or the state.

Nevertheless, the report of the Taxpayers' Association extracted the cost figures from pages 32 and 33 of the architectural report <u>Development Study of the High School</u> and recalculated the net cost to taxpayers.

<u>Alternative A</u>	All new construction	
	No revision in cost estimate	
	Cost to the City less State Aid	$7,411,600
Alternative D	Renovate Buildings II & III	
	Previous estimate of rehabilitation cost to City reduced by 40% or $1,356,480	
	Cost to the City was	$8,130,320
	less	1,356,480
	Net Difference in favor of Alternative D	$ 637,760

Under Chapter 754, the Commonwealth's share of rehabilitation cost is not to exceed one-third of new construction expenditure in the previous year. One interpretation of this law would require the city to spend $4,069,440 in new construction in order to obtain a state reimbursement of $1,356,480.

Moreover, Plan A would give the city a high school constructed in 1970 in replacement of a rehabilitated 1906 model of Plan D. Another way of comparing the plans highlights the economical advantage of obtaining an additional 156,100 square feet of new construction.



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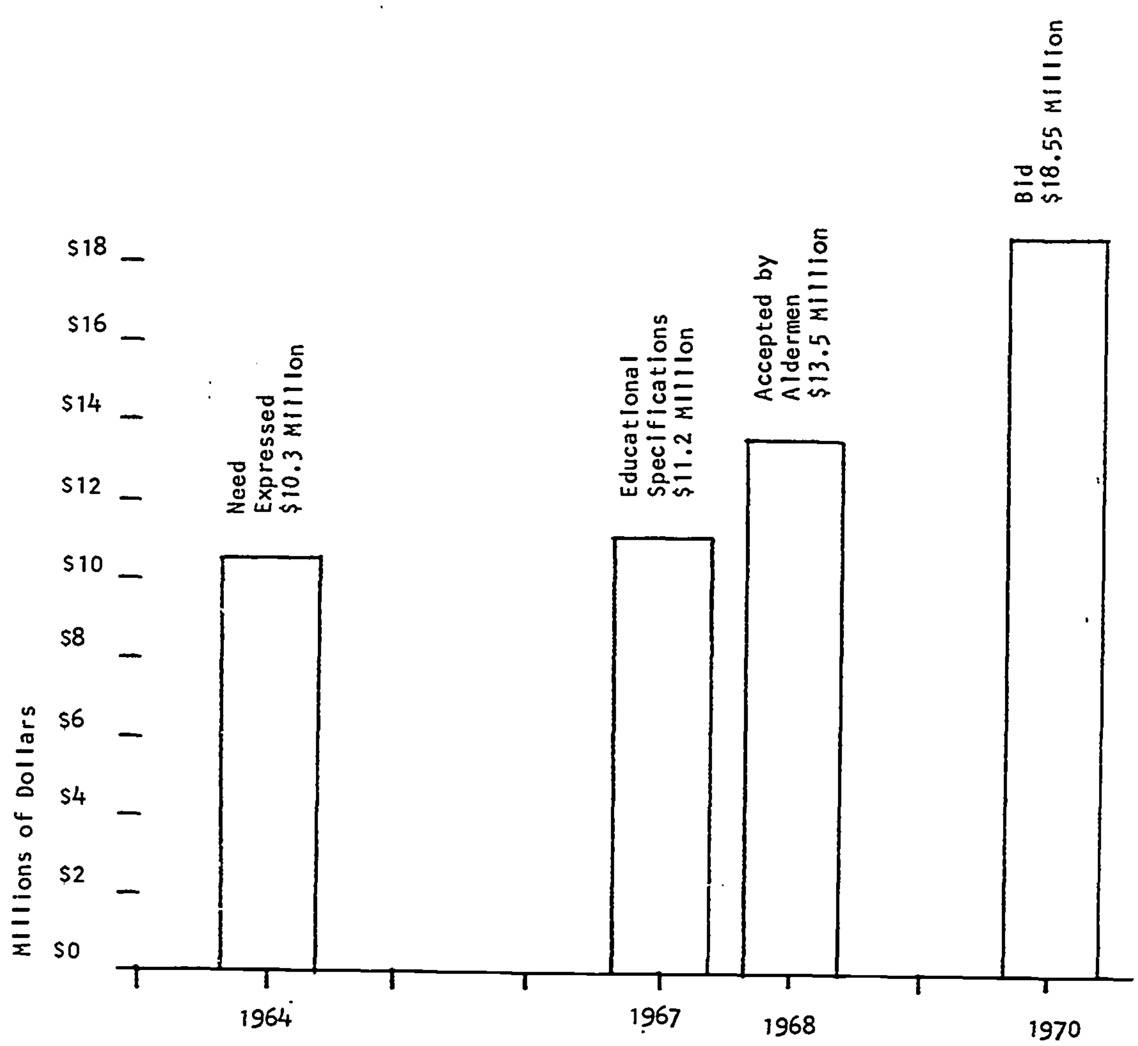

CASE III UNSUCCESSFUL BUT COMING

Figure 2

	Estimated Cost	New Gross Sq. Ft.
Plan A New construction	$ 7,411,600	437,000
Plan D Renovate & Add	6,773,840	280,900
Difference	673,800	156,100

Thus it would appear contrary to the interests of taxpayers to remodel because Plan A would provide 156,100 square feet at an estimated investment of $4.09 per square foot.

The Taxpayers' Association report ended with the following conclusions:

> The need has long been recognized for corrective measures at the High School and is generally accepted. We have had the diagnosis for many years, but still we delay in starting the recommended and essential treatment. This is not fiscal prudence, this is gross malpractice.
>
> The ultimate irony in the situation is that much of this delay has been in the name of economy yet this very delay has already cost the taxpayers several million dollars and at this time is costing us approximately $100 to $200 for every day we delay the start of the new High School. We firmly believe in the following equation:
>
> Fiscal Responsibility: False Economy = Plan A: Plan D

(That is: Fiscal Responsibility was new construction, False Economy was renovate and add.)

The mayor and the board of aldermen approved the construction of a new high school, and this school is now under construction. However, the estimated costs which were based on comparable labor and material costs have increased more than 1 percent a month as indicated by a member of the Parent-Teacher Association in 1968. New estimates of construction in 1971 indicate that the cost will double all previous estimates because during that period of delay the inflationary increases in the cost of building and remodeling increased more than in any other period in history.

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In the fall of 1966 the faculty was requeste specifications.* By April, 1967, the prelim

* At regional meetings throughout the state need for guidelines or a computerized mod tions to expedite the process.

CASE IV. LESS SUCCESSFUL SCHOOL CONSTRUCTION
(10 Years Late)

As early as 1961 some members of the central staff of the school district and some parents recognized that there was a need for new facilities throughout the school system. This need was particularly evident at the junior high school and high school levels.

If built at that time, the junior high school would have represented the most pressing area of need. The school which had been designed for approximately 500 students already had 600 students. Projections showed a need to accommodate 700 students by 1967.

In 1962 the mayor selected an architect to study the remodeling of the junior high. In 1963 the Mayor's Advisory Committee changed the study to include possible new construction and site changes. The report was submitted in July, 1965, with two plans--three years later.

Plan One proposed $813,000 in alterations and $840,000 in new construction, for a total of $1,653,000.

Plan Two proposed construction of a new building at a cost of $2,093,000.

However, after state reimbursement, the cost to the taxpayers would be $1,337,000 under Plan One and $1,267,000 under Plan Two. The educational investment in Plan Two was superior for students, teachers and taxpayers.

In the fall of 1966 the faculty was requested to prepare educational specifications.* By April, 1967, the preliminary statement was completed.

* At regional meetings throughout the state, many persons expressed the need for guidelines or a computerized model of educational specifications to expedite the process.

At that time the overcrowding prompted the purchase of six temporary classrooms to be located on the playground. In September, 1967, a new mayor appointed an architect to begin preliminary architectural drawings.

From interviews with taxpayers, staff, and the architect, it was learned that the city was uncertain of what it really wanted. Inability to finalize the educational specifications and define the scope of the project caused the architect to submit a total of twenty-six different design schemes resulting in a great loss of time, money and use of the school by students.

In March, 1969, the architect was still working without a contract, but with a letter of intent. The plans were still up-in-the-air, and the Department of Education (School Building Assistance Bureau) had not approved some of the space allocations.

A report of the Building Committee of the PTA Council School (June 5, 1969) stated: "It is appalling that suddenly 12 of the 31 schools are found to be overcrowded and inadequate. The recent report to the School Committee on the status of school buildings dramatically underscores the fact that the building and maintenance of school facilities is a problem which concerns citizens in all parts of the city, not just those in one particular school district. Coordinated planning and action by the mayor, the School Committee, and the Board of Aldermen are imperative if this grave city-wide problem is to be solved."

Similarly in a statement for the Charter Review Commission on April 7, 1971, it was stated, "Early in this study it became painfully apparent that there is no comprehensive, long range program for renovating or replacing school buildings as they become obsolete. Neither is there a comprehensive program of preventive maintenance for school buildings...."

However, on April 5, 1971, it was repo
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CASE V. UNSUCCESSFUL SCHOOL
(5 Years P

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However, on April 5, 1971, it was reported that ground had been broken for a new junior high school. The expected date of occupancy is early 1972 with a cost of $5.2 million for essentially the same building originally suggested in 1965 at a cost of $2.3 million -- interest charges for $5.2 million will also be more than doubled during this interval.

Ten years after a need to eliminate overcrowding was evident, delay of the building project had more than doubled the cost to taxpayers (local and state) for facilities and interest costs.

CASE V. UNSUCCESSFUL SCHOOL CONSTRUCTION (5 Years Plus)

This town, with a 1960 total population of 14,100, lies twenty miles southwest of Boston, on the outer ring of the Boston Metropolitan area. It is primarily a residential community; however, its manufacturing and commercial concerns are vital to the economic well-being of the town.

The senior high school was originally constructed in 1908. Since then two additions have been added, one in 1928 and one in 1955. The result is a rambling structure with poor internal relations of spaces. The site occupies 14 acres, an extremely small site for a modern senior high school.

In March, 1965, the superintendent of schools alerted the school committee and selectmen that in 1972 there would be a pressing need for space in grades 10-12. This was obvious from a simple analysis of enrollments which clearly pointed to a population of well over 400 students in each of the three top grades or 1,300 students in 1974 for facilities designed for 1,010. In addition to student accommodations, new programs (especially in occupational education) and advanced courses which would require new types of learning spaces were unavailable in the present high school facility. In 1966, the School Building Assistance Bureau was informed of the need for a new high school.

In March, 1967, the chairman of the school committee told the annual town meeting of the need for planning a new facility, and as a result a School Needs Committee was appointed.

In 1968, a consultant was hired to do a School Building Needs Study and the town hired a city planner to update the town's master plan. In April, 1969, the verdict was in -- the warning given by the superintendent in 1965 was coming true. In addition to high school space, there was a need for elementary school space as well as space to provide programs for kindergarten by 1973.

The consultant recommended a new high school building on a new site as well as some additions and alterations for a total of $11,522,000. "The consultants have recommended against an addition to the pr[illegible]nt structure. The site is too small. The original structure and the first addition are of non-fire resistive construction and would pose a hazard to any new fire-resistive addition. Educationally speaking, the building is inadequate for a modern high school program." This report was accepted by the school committee.

The School Needs Committee felt that the present facility should remain a high school and they proposed an addition. They estimated a cost for their plan of additions and alterations to various schools to be $7,750,000.

In December, 1970, the matter was put before the town meeting. Feeling the general economic pinch, two-thirds of the voters did not authorize the purchase of general obligation bonds.

It is now six years since the space problem was first recognized. The school department conscientiously sought to undertake a comprehensive study of the school community interface. They realized the need for a master plan with specified goals, objectives, zoning, land use and assessment; but, in the end, the money for a comprehensive study was not provided. What is more important,

another year was lost in constructing nee
construction continues to rise.

CASE VI. UNSUCCESSFUL SCHOOL C(
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population	1,121	9
enrollment	939	1

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If past history is any guide, it seems
"immediate action to provide adequate s
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another year was lost in constructing needed facilities, and the cost of construction continues to rise.

CASE VI. UNSUCCESSFUL SCHOOL CONSTRUCTION
(10 Years Plus)

In many respects, this town typifies a number of Massachusetts communities. Its population is largely residential, with professional, white collar and blue collar workers commuting to the nearby industrial cities. Population and school enrollment have grown steadily in the past two decades, but the rate of growth declined significantly in the 1960's:

	1950	1960	1970	1975 (est.)
population	1,121	9,916	12,525	--
enrollment	939	1,905	2,608	2,827

For nearly a decade, this town has attempted to construct new school facilities. Since November, 1965, five separate town meetings have failed to vote the necessary two-thirds approval of general obligation bonds. With each successive year, the situation has grown more serious. Since 1967, the high school, originally built for 640 pupils, has required double sessions to accommodate its present enrollment of 1,271 pupils. In 1970, an evaluation of the high school reported that "the existing school plant lacks adequate facilities for a comprehensive and contemporary program of studies. The community must take immediate action to provide adequate space for a high school program meeting the needs of today's society..." In 1971, the high school faces imminent loss of its accreditation.

If past history is any guide, it seems unlikely that the town will take "immediate action to provide adequate space..." The superintendent of schools first identified the need for new school facilities in 1962. After extensive study, a school building committee recommended approval of a $2.6 million junior high school for 800 pupils. Although the proposal gained a majority of votes at the town meeting in 1965, it fell short of the required two-thirds by a narrow margin. Two weeks later, a reconsideration failed to gain even a majority.

The town moderator then assembled a second school building committee. In 1968, this committee reported that the town should build a new four-year high school for 1,000 pupils and convert the existing high school building into a junior high school. The estimated cost was $3.8 million. Again, the town meeting rejected the recommendation, refusing to vote a majority approval.

A third school building committee was then appointed by the town moderator. Past defeats had taken their toll, however. The superintendent of schools, who had served as educational consultant to the two previous committees, declined to act in this capacity for a third time. Working with an outside consultant, the building committee recommended town approval of plans for a new middle school and an addition to the existing high school. The committee estimated cost at $3 million. Although the plans had not received approval from the School Building Assistance Bureau, because of lack of an adequate site, the committee took their recommendations to the town meeting in July, 1970. Again, the proposal gained a majority, but failed to win the two-thirds vote required for approval.

Thus, in a five-year period the town has rejected successive proposals for a new junior high school, a new high school, and a new middle school with an addition to the high school. The school building committee is now considering construction of additions to two existing schools, a solution which the superintendent of schools finds totally unsatisfactory. But, as one parent charged, "The town officials just will not accept an addition to the present school and

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the taxpayers will not accept a new school." Her remarks were echoed by the vice-chairman of the school building committee who observed that "We have presented enough multi-million dollar schools and the only thing the people want is additions."

On the surface, this impass results from the town's unwillingness to pay for the cost of a new school. A "voter fact sheet," distributed before a recent town meeting, claimed that the proposed middle school would add $9.20 to the existing tax rate. Warning that "this may be your last chance to save your home," this fact sheet urged voters to reject the middle school proposal. But in fact, the town's tax rate is not very high -- roughly $25 based on full assessment. It is a far lower rate than neighboring cities and towns. Furthermore, the town is not poor although it has been affected by recent unemployment. Median family income in 1960 was nearly $6,000, almost $1,000 more than a nearby large city.

The town's unwillingness to solve its school facilities crises has attracted the attention and concern of the School Building Assistance Bureau. But, as one SBAB official recently noted: "... the question of what direction the educational program takes in Town must be determined at the local level. The citizens of Town are responsible for providing equal educational opportunity for their children, and this is accomplished at the ballot box."

The superintendent of schools, remembering five defeats at the ballot box, replied: "I agree with SBAB. But I feel there is a point where this philosophy ceases to be effective. We're past this point now."

In summary the general characteristics of the case studies indicate that:

(1) Needs are identified early but without evidence of organized planning or consistent and effective leadership.

(2) Methods of identifying the need for school facilities are unstructured, i.e., none of the towns studied had developed a system for making long-range educational plans reflect or adjust to subsequent needs.

(3) Multiple demands for tax dollars cause delaying studies upon studies to avoid commitment to major action.

(4) Initial presentation of school needs in each case was neither clearly nor adequately defined or prepared. Several or most of the following necessary elements were lacking:

- educational objectives
- programs to support objectives
- relation with other elements in the system
- site location
- impact on annual operating budget
- impact on tax rate
- relation to other elements of community services, i.e., library, recreation, police, fire, traffic, etc.
- contribution to improvement of community life
- cost of delay to taxpayers

In view of the first principle of the Constitution described in Chapter II-1, some children are not receiving "equal educational opportunities" under the complex statutes and administrative procedures which have been developed in state agencies and the municipalities. The impact of additional taxes for schools on the property tax has caused people to act contrary to the best interest of children and future taxpayers in the Commonwealth. The schools in the case studies should not be so long in the administrative process. Any delay in construction beyond a year is creating unnecessarily higher taxes for school construction grants in future state budgets for state taxpayers.

The current procedures then are imprudent for local taxpayers, for the same people as state taxpayers, and for the children and youth of the Commonwealth who will be future local and state taxpayers.

FINANCING THE SCHOOL CONSTRUCTION PROCESS

CHAPTER II - 3

Solvency as a Basic Principle

Solvency is the basic principle of municipal finance law. The officials of a city or town are forbidden by law from saddling a municipality with debt for operating expenses. Without explaining the details of the municipal finance law, it may be stated that the solvency of cities and towns is guaranteed by the use of certain standard procedures. All the departments of a municipality are required to prepare operating budgets for the forthcoming fiscal year. The city council or town meeting appropriates the money necessary for the operating expenses of the municipality for the fiscal year. The assessors, after taking into consideration the appropriations and the amount of income to be received by the municipality from the state, federal government and other sources, fix the tax rate for the fiscal year. The assessors are required to fix the tax rate so that the tax yield will guarantee that the municipality will have no outstanding debt for operating expenses at the end of the fiscal year. Furthermore, no department may expend any money in excess of the appropriation.

Borrowing for Capital Improvements

From time immemorial, there has been one important exception to the municipal finance law. The Legislature has always recognized the general principle that it is perfectly proper for a municipality to incur debt over a long period of time in order to pay for capital improvements. The construction of schools, of course, falls within this category. Even a fairly large community, which intends to construct a school at a cost of $5,000,000 for

instance, might find it difficu
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Borrowing for School Constructi

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instance, might find it difficult to raise the money from current taxation. If it did raise the money from current taxation, there would be a dispro-portionate rise in the tax rate for that particular year. Consequently, the Legislature allows municipalities to borrow money over a period of years in order to construct schools and to make certain other capital improve-ments.

Cities and towns may borrow money for a period of up to twenty years for the construction of a school. Borrowing may be accomplished under Chapter 44 of the General Laws or under Chapter 645 of the Acts of 1948 (the School Building Assistance Law). Borrowing under Chapter 44 of the General Laws is known as borrowing "within the limit of indebtedness," while borrowing under Chapter 645 of the Acts of 1948 is known as borrowing "outside the limit of indebtedness."

Borrowing for School Construction under Chapter 44 of the General Laws

Borrowing for a school under Chapter 44 means that a town may authorize a bond issue for the construction of a school merely by a two-thirds vote of the voters assembled at a town meeting without any approval of a state agency. A city may authorize a bond issue by a two-thirds vote of the city council without any approval of a state agency. There is, however, one important restriction involved. No city may borrow more than $2\frac{1}{2}$ percent of its equalized valuation and no town may borrow more than 5 percent of its equalized valuation. For example, if a city has an equalized valuation of $100,000,000, it may borrow $2\frac{1}{2}$ percent, or $2,500,000. If a town has an equalized valuation of $10,000,000, it may borrow 5 percent, or $500,000.

Another provision of Chapter 44 states that borrowing may be doubled if the city or town receives the approval of the state's Emergency Finance Board.

This board was created during the depression (1933) for the purpose of acting as a watchdog over municipal borrowing. If a city receives the approval of the Emergency Finance Board, it may borrow up to 5 percent of its equalized valuation and a town may borrow up to 10 percent of its equalized valuation.

What is meant by equalized valuation? The equalized valuation of a city or town is the total value of all its taxable property, more than 95 percent of which consists of real estate, taken at its full fair market value. Equalized valuation is not the assessors' valuation, since assessors do not always assess property at its full value. Equalized valuation means the aggregate amount of all taxable property in a city or town as determined by the State Tax Commission. This Commission is required by law to establish by December 31st of each even-numbered year the equalized value of all the taxable property in each city and town in the Commonwealth. From long years of experience, the State Tax Commission has been able to determine with a reasonable degree of accuracy the full fair cash valuation of real estate in cities and towns.

Borrowing for School Construction under the School Building Assistance Law

The type of borrowing described above is known as borrowing within the limit of indebtedness under the provisions of Chapter 44 of the General Laws. Comparatively little borrowing for school construction is done under Chapter 44 because of limitations on the amount which may be borrowed. Furthermore, when any borrowing is done under Chapter 44, it is necessary to subtract from the borrowing capacity any previous authorized borrowings which are still outstanding.

Shortly after the School Building Assistance Law came into existence, a new

and more practical method was establ
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Referendum Provisions for Voting on

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School Building Assistance Law

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and more practical method was established for school borrowing. This method is known as borrowing for schools outside the limit of indebtedness. This means that if a city or town authorized debt by a two-thirds vote, as previously described, there is no limit to the amount which may be authorized. If a municipality wishes to authorize the borrowing of $20,000,000 for a high school, it may do so without regard to the amount of taxable property within the municipality. However, there are two important safeguards in the law. Even though the municipality may vote to authorize the borrowing of money without limitation, no money at all may actually be borrowed unless the prior approval of the State Board of Education and the Emergency Finance Board is obtained. Approval will be given by the State Board of Education if the board is of the opinion, after careful review of the plans, that the proposed school construction is in the best interest of the municipality. The approval of the Emergency Finance Board will be given if the board is of the opinion that the amount of the loan is warranted, after taking into consideration the actual financial position of the municipality. This procedure for borrowing money for school construction has been very beneficial to the municipalities involved.

Referendum Provisions for Voting on Bond Issues

In Massachusetts, a city council may legally authorize the borrowing of money for school construction. There is no mandatory requirement that the vote authorizing debt be submitted to the general voting public. However, in many of the 39 cities in Massachusetts there are certain provisions of law or certain provisions in city charters permitting voters at large to approve or disapprove the action of a city council which has authorized a bond issue for the construction of a school. The procedure is quite complicated and cumbersome. For example, if a city has accepted Section 8A of Chapter 44 of the General Laws, then 12,000 or 12 percent of the registered voters, whichever is less, may file a petition that the question of upholding a bond issue be submitted to the general electorate. A referendum is held and the voting public will either pass or defeat the bond issue.

Length of Time of Bond Issue

In Massachusetts, school loans, whether made inside or outside the limit of indebtedness, may be authorized for any length of time not in excess of twenty years. However, if a school loan is made for twenty years, this does not mean that the municipality can wait twenty years before it makes any payments on the loan. In Massachusetts, municipalities issue what is commonly known as serial loans. A part of the principal must be paid back each year to the bondholders. The payments on account of principal are often made in equal payments each year over the life of the bond issue. For example, if a city sells bonds for $20,000,000 to construct a high school, the city could issue 4,000 bonds, each in the denomination of $5,000. The bonds would be numbered from 1 to 4,000. The first series, numbered 1 to 200, would amount to $1,000,000 and these would be payable in one year from date. The bonds numbered 201 to 400 would be payable in two years from date. Proceeding in this manner, the entire principal would be paid back at the rate of $1,000,000 a year, and the entire loan would be paid off in 20 years.

It should be noted that it is not necessary to issue the bonds in such a manner that the principal is payable in equal annual installments. The principal payments may be made in unequal installments. However, there is an important restriction if this is done. The law requires that the first payment of principal on a loan for 20 years must be equal to at least 1/20th of the entire loan. Using the example above, the first payment could be

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for $1,000,000 or more. Every payment made in any subsequent year must be less than the payment in the previous year. This system is called a system of diminishing payments. The purpose is to prevent a municipality from repaying small amounts of principal in the early years and large amounts in the latter years of the bond issue.

Interest Payments

When bonds are sold, the purchasers of the bonds turn over the full face value of the bonds (plus any premiums) to the municipality. The municipality has full use of the money from the date of issuance of the bonds. As with any other loan, the city or town must not only pay annually on the principal, but also pay interest on any outstanding bonds. Interest is paid twice a year, computed at the annual rate. Let us assume that a municipality issues $1,000,000 worth of bonds for 20 years, with 1/20th of the principal becoming due annually. If the bonds sold at 6 percent, the interest at the end of one year would be 6 percent of $1,000,000, or $60,000. However, at the end of the second year, the interest would be 6 percent of $950,000, or $57,000, since the municipality paid the bondholders 1/20th of the $1,000,000 principal, or $50,000, at the end of the first year. Continuing in this manner, the interest decreases by $3,000 each year.

In the example cited above, where the municipality issues bonds for 20 years with a provision that the principal is to be paid back in equal installments over the life of the bond issue at an interest rate of 6 percent, the total interest paid during the life of the bond issue is $630,000, or 63 percent of the principal. If the same issue of bonds matured in 15 years instead of in 20 years, the total amount of interest would be $480,000, or 48 percent of the principal. If the same issue matured in 10 years, the total amount of interest would be $330,000, or 33 percent of the principal.

There are simple formulas for determining exactly how much the interest payments will be on any particular bond issue, assuming that the principal is to be repaid in equal annual installments. All that is necessary to know is the length of the bond issue and the interest rate. If the bonds are issued for 20 years and the interest rate is 6 percent, 6 percent is multiplied by 10.5 and the result is 63 percent. The interest, therefore, is 63 percent of the principal. If the interest rate were 5 percent, 5 percent would be multiplied by the same 10.5 and the result would be 52.5 percent. This formula applies to all 20-year bond issues in which the principal is repaid in equal annual installments. There are other formulas for issues of 19 years, 18 years, and so forth which may be obtained from any bank dealing in municipal bonds.

In Massachusetts, there are no legal limits on the amount of interest which a municipality may pay on a bond issue. The municipality, in offering its bonds for sale, could put a limit on the highest amount of interest it will pay. However, this is rarely done. The usual procedure of the municipality is to engage the services of a bank to take care of advertising the bond sale and to invite bids from dealers in municipal bonds. The dealer who offers to buy the bonds at the lowest rate of interest is given the award.

State School Construction Grants

Under the School Building Assistance Law, every city and town which constructs an approved school receives a state school construction grant of not less than 40 percent nor more than 50 percent of the cost of the school. For regional school districts, the range is from 40 to 65 percent of the cost. The exact percentage of the grant is determined by a formula. If the school

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Temporary Borrowing in Anticipation of a

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costs $1,000,000 and the municipality is entitled to 50 percent, the grant will be 50 percent of $1,000,000, or $500,000. The cost on which the grant is based includes the amounts the municipality pays the contractor, the architect and the suppliers of the original equipment and furnishings. Site development is also included. However, the cost of land and all interest payments are excluded.

If a city or town builds a school at a cost of $1,000,000 and receives a construction grant of $500,000, the construction grant is not paid to the city or town at one time. The construction grant of $500,000 is paid in equal payments over the life of the bonds issued by the munici ality. If the bonds are for 20 years and the construction grant is $500,000, only 1/20th of the construction grant, or $25,000, will be paid by the Commonwealth annually to the community involved. Each payment is made so that it will be received before the principal on the bond payment is due in each year.

Temporary Borrowing in Anticipation of a Bond Issue

When a municipality is legally authorized to sell bonds for school construction, it may temporarily raise funds for the construction of the school without actually selling the bonds. This process is known as temporary borrowing in anticipation of the money to be derived from the sale of bonds. Cities, towns and districts may go to a bank and borrow up to the full amount of the bond authorization, but such loans may not be made in excess of one year in the aggregate. This method is sometimes used to permit the municipality to defer the sale of bonds temporarily until there is a more favorable market for the sale. It is sometimes used to provide sufficient funds quickly to pay an architect or general contractor pending the advertising and sale of the bonds. Of course, the temporary loan must be paid from the sale of the bonds and any balance remaining from the temporary loan. Furthermore, the time within which the original bond issue was to become due may not be extended by reason of such a temporary loan beyond the time fixed in the vote authorizing the issue of the bonds.

Architectural Services for Constructing a School

After a district has decided that it intends to build a school, the next significant step is to engage the services of an architect. The services which he will perform before the contractor commences construction of the school consist of designing and preparing the plans for the school, including the final working drawings and complete bid documents required in order for contractors to submit bids for construction. Commonly about 75 percent of the architect's fee is earned up to this point. The remainder of his fee covers the work he performs in connection with selecting the general contractor and supervision of the construction of the school.

Prior to 1969 it was not possible for a city or town to borrow money solely for the purpose of employing an architect; it was necessary to take the money from current taxation receipts. The law has since been changed to allow a city or town to borrow money "for the cost of architectural services for plans and specifications for any proposed building for which a city or town is authorized to borrow, if authorized separately from any other debt relating to said building." There are three qualifications in this law. First, the loan can not be for more than five years. Second, the city or town is required to raise 10 percent of the amount to be borrowed from available funds or current revenues. Third, no such loan may be authorized unless the city or town owns the land on which the proposed school is to be constructed. The 1969 law has enabled municipalities to borrow funds in order to contract with an architect for central planning and development services.

The Sale of Bonds

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3. the annual amount of principal years from the date of issue
4. the law firm which will provid
5. a brief description of the fin or school district
6. a statement to the effect that obligations of the city, town o property therein will be subjec taxes to pay both the principa
7. the percentage of state aid to bond issue. State aid covers o cost of the original school equ Board of Education.

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The Sale of Bonds

When a municipality is ready to sell its bonds, the city or town treasurer usually engages a bank with a municipal bond department to take care of the details of the sale. The bank chosen for this purpose is commonly known as the certifying or fiscal agent for the city or town involved.

Next, the treasurer receives notification from the building committee for the required amount of the bond obligation needed to construct the school project. Assuming all approvals are obtained (Department of Public Health, State Board of Education, Department of Public Safety and the State Emergency Finance Board), the treasurer prepares a notice of sale for the bonds. This notice must contain the following pertinent facts concerning the bond issue:

1. the total amount of bonds to be issued and the date the bonds are to be sold
2. the bank which will certify the bonds and act as paying agent for the bonds as the coupons and principal become due
3. the annual amount of principal to mature each year, not to exceed twenty years from the date of issue
4. the law firm which will provide the legal opinion approving the bond issue
5. a brief description of the financial facts and figures of the city, town or school district
6. a statement to the effect that the bonds constitute valid general obligations of the city, town or school district and that all taxable property therein will be subject to the levy of unlimited ad valorem taxes to pay both the principal of and interest on the bonds
7. the percentage of state aid to be paid annually over the life of the bond issue. State aid covers only the cost of construction and the cost of the original school equipment and must be approved by the State Board of Education.

The procedure for the actual sale of bonds is comparatively simple. The bank sends out an invitation to the persons most likely to bid on the bonds. The prospective purchasers of municipal bonds are for the most part brokerage houses dealing in municipal bonds and also banks which deal in municipal securities. The invitation to bid which is sent out by the fiscal agent is an invitation to the various brokers and banks to send in proposals for the purchase of the bonds. The award is given to the prospective buyer who is willing to purchase the bonds at the lowest rate of interest. The invitation to bid requests bidders to name one rate of interest in a multiple of 1/4 or 1/10 of 1 percent. If two or more bidders name the lowest interest rate, the award is usually made to the bidder offering the highest premium. The broker or bank which purchases the bonds becomes the owner and pays the full amount of the bonds to the fiscal agent of the municipality.

The Cost of Recent Bond Issues in Massachusetts

A special computer listing of outstanding indebtedness was prepared by the Department of Education, Division of Research and Development for this study. The Division received reports of 1528 obligations for bonded indebtedness caused by construction of schools in the twenty years between 1950 and 1970. In the Commonwealth, 286 cities and towns and 70 regional districts reported an outstanding indebtedness (principal only) of $795,062,161. The annual payment of principal was $70,865,436 for the fiscal year ending June 30, 1970. About 45 percent of this amount or about $30 million is reimbursed to school districts for construction grants under Chapter 645, the School Building Assistance Act.

An additional $29,639,155 was paid by the cities, towns and regional districts for annual interest. This payment is additional to the cost of the bond issue itself, which covers only the project cost of a new school. It therefore adds to the burden on local property taxes.

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For twenty-year bonds this will add 22 p
for the average city, town or regional s
1967 the highest rate paid was 4.50 and
or 2.10 percent. The median for the 37
was 4.10 which is comparable to the 1967

The conclusion from the analysis of 1528
Department of Education, Division of Res
interest rates have increased as much as
years. In the last four years (1967-70)
bonds in this survey increased from 4.10
of about 50%. (Exhibit II).

Consequently, the total charge to the cities and towns reporting in this first survey of indebtedness was $100,504,591 for principal and interest, less state reimbursements which were about $30 million. Therefore, the annual impact of all indebtedness was about $70 million on the local property taxes and about $30 million on state tax resources.

The most salient generalization that can be discerned from this survey is the large increase in interest in the last twenty years. Many districts sold bonds for interest rates of 1.40 (Westwood) to 2.00 percent 18 to 20 years ago. In 1969 and 1970 three districts paid as high as 6.70 percent (Easton, Hudson and Southern Worcester County Vocational School), and several districts paid 7 percent (Southwick and Nauset). The median district (50th percentile) paid 5.80 percent to borrow money in 1969 and 6.20 in 1970.

In the last four years (1967-70) the lowest interest rates for twenty-year bonds increased from 3.40 to 5.90 percent. Exhibit III shows that the median (50th percentile) increased from 4.10 to 6.20 percent or 2.10 percent. For twenty-year bonds this will add 22 percent to the cost of borrowing money for the average city, town or regional school district. At the extremes, in 1967 the highest rate paid was 4.50 and it increased in 1970 to 6.70 percent or 2.10 percent. The median for the 37 bond sales of less than twenty years was 4.10 which is comparable to the 1967 rate.

The conclusion from the analysis of 1528 bond obligations reported to the Department of Education, Division of Research and Development is that interest rates have increased as much as 300 percent in the last twenty years. In the last four years (1967-70) the interest rate on the median bonds in this survey increased from 4.10 to 6.20%, or an increase in rates of about 50%. (Exhibit II).

EXHIBIT II

Interest Rates for 1967-70
Massachusetts School Debt

20-Year Bonds	Number in sample	Low	Median	High	Difference Between Low and High
1967	45	3.40%	4.10%	4.50%	1.10%
1968	51	3.40	4.50	4.75	1.35
1969	30	4.70	5.80	7.20	2.50
1970	9	5.90	6.20	6.70	0.80
Increase in rates (1967-70)		+2.50%	+2.10%	+2.20%	+3.30%
Interest rates for bonds for less than 20-years (1967-70)	37	3.00%	4.10%	5.75%	2.75%

Factors Affecting Interest Rates

The rate of interest which a municipality is required to pay on its bonds is of great concern to the city or town involved. In recent years, long term interest rates have jumped to record highs. As previously shown, if a municipality issues $1,000,000 in bonds at the rate of 6 percent and if the principal on the bonds is paid in equal annual installments, the total amount of interest paid by the municipality is $630,000 or 63 percent of the principal amount. If the interest rate is only 1 percent, the total amount of interest is $105,000, or 10.5 percent of the principal. The following list shows the amount of interest payable on 20-year bonds at various rates:

Amount of Bonds	Interest Payable	To
$1,000,000	1%	$1
$1,000,000	2%	$2
$1,000,000	3%	$3
$1,000,000	4%	$4
$1,000,000	5%	$5
$1,000,000	6%	$6
$1,000,000	6 1/2%	$6
$1,000,000	7%	$7

1. The Market*

Although many factors affect interest important factor is the general condi the interest rates on municipal bonds high and low brackets ranging as low cent. In the 1950's the range increa reached 4 percent. In the 1960's the interest rates. Through 1965 very fe than 3 percent interest yield, and th to 3 3/4 percent.

In 1967, 1968, 1969 and 1970, there w yield for municipal securities. In 1 yielding from 3 1/2 to 4 1/2 percent. from 4 to 4 1/2 percent (except for D sharp break in the market and the int as high as 6.72 percent in December o another sharp rise and municipal bond high as 6.80 percent.

* The figures cited in this part of pal bonds sold for less or more t

1967-70
ɔl Debt

High	Difference Between Low and High
4.50%	1.10%
4.75	1.35
7.20	2.50
6.70	0.80
+2.20%	+3.30%
5.75%	2.75%

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Amount of Bonds	Interest Payable	Total Amount Interest	Interest of Percentage of Principal
$1,000,000	1%	$105,000	10.5%
$1,000,000	2%	$210,000	21.0%
$1,000,000	3%	$315,000	31.5%
$1,000,000	4%	$420,000	42.0%
$1,000,000	5%	$525,000	52.5%
$1,000,000	6%	$630,000	63.0%
$1,000,000	6 1/2%	$682,000	68.25%
$1,000,000	7%	$735,000	73.5%

1. The Market*

Although many factors affect interest rates on municipal bonds, the most important factor is the general condition of the market. In the 1940's, the interest rates on municipal bonds showed the usual variations, with the high and low brackets ranging as low as 1 percent and as high as 2 1/2 percent. In the 1950's the range increased somewhat, but the high range never reached 4 percent. In the 1960's there was a distinct change in prevailing interest rates. Through 1965 very few municipal bonds were sold with a less than 3 percent interest yield, and the high yields were from 3 1/2 percent to 3 3/4 percent.

In 1967, 1968, 1969 and 1970, there was a sharp increase in the interest yield for municipal securities. In 1966 and 1967, municipal bonds were yielding from 3 1/2 to 4 1/2 percent. In 1968, the lows and highs were from 4 to 4 1/2 percent (except for December 1968). In 1969, there was a sharp break in the market and the interest yields varied from 5 percent to as high as 6.72 percent in December of 1969. In 1970, the market took another sharp rise and municipal bonds were yielding from 6 percent to as high as 6.80 percent.

* The figures cited in this part of the chapter are averages. Some municipal bonds sold for less or more than the figures cited.

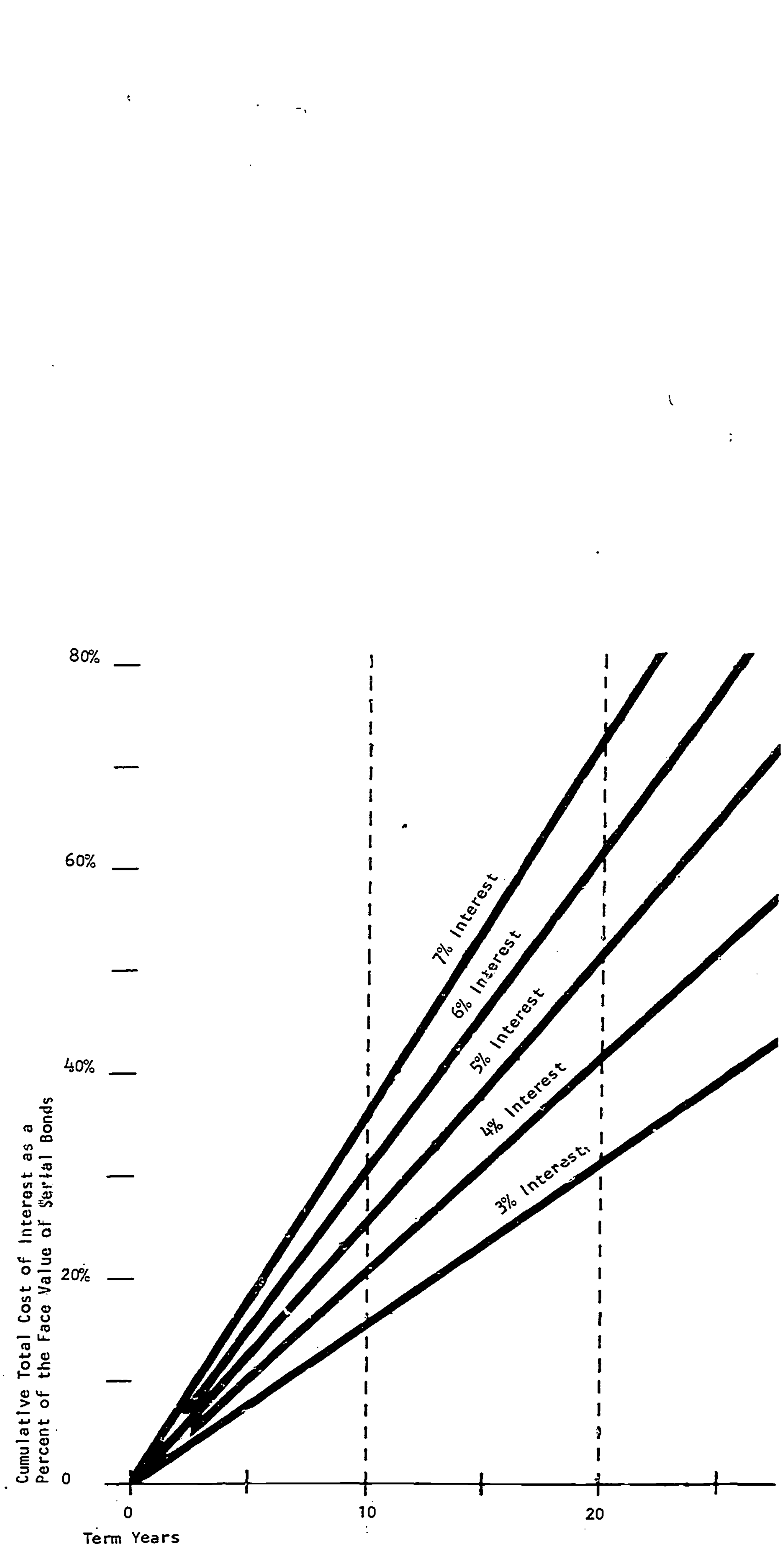

CHART I - CALCULATION OF CUMULATIVE COST OF INTEREST ON SERIAL BONDS

In 1971, the market has been more favo
low of 4.80 and a high of 5.75 percen

2. Ratings of Municipalities

The interest charge that a particular
chusetts depends mostly on general mar
factors which influence the interest r
Moody's and Standard and Poor, assign
Moody's rates municipalities as follow
Massachusetts municipalities all come
Aaa, Aa, A, and Baa. Sometimes Moody
four groups. A rating may be Aa-1.
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> Aaa--Bonds which are rated Aaa ar
> They carry the smallest degree of
> referred to as "gilt edge." Inte
> large or by an exceptionally stab
> While the various protective elem
> changes as can be visualized are
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> Aa--Bonds which are rated Aa are
> standards. Together with the Aaa
> known as high grade bonds. They
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> there may be other elements prese
> appear somewhat larger than in Aa

> A--Bonds which are rated A posses
> and are to be considered as highe
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> elements may be present which su
> sometime in the future.

> Baa--Bonds which are rated Baa ar
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> Interest payments and principal s
> but certain protective elements m
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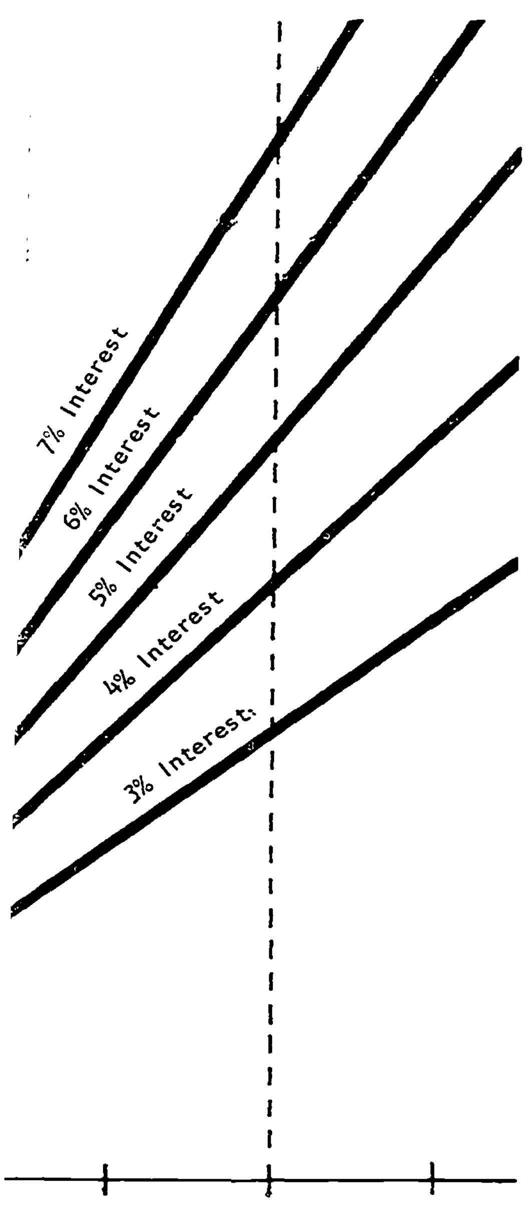

ST OF INTEREST ON SERIAL BONDS

In 1971, the market has been more favorable. Bonds have been selling at a low of 4.80 and a high of 5.75 percent.

2. Ratings of Municipalities

The interest charge that a particular municipality pays on bonds in Massachusetts depends mostly on general market conditions. But there are other factors which influence the interest rate. Certain publishers, such as Moody's and Standard and Poor, assign credit ratings to municipalities. Moody's rates municipalities as follows: Aaa, Aa, Baa, Ba, B, Caa, Ca, C. Massachusetts municipalities all come within the first four ratings, namely, Aaa, Aa, A, and Baa. Sometimes Moody adds a number to the rating in these four groups. A rating may be Aa-1. The figure "1" indicates that Moody's believes that the bonds of that municipality possess the strongest investment attributes.

Moody's describes its highest four ratings as follows:

> Aaa--Bonds which are rated Aaa are judged to be of the best quality. They carry the smallest degree of investment risk and are generally referred to as "gilt edge." Interest payments are protected by a large or by an exceptionally stable margin and principal is secure. While the various protective elements are likely to change, such changes as can be visualized are most unlikely to impair the fundamentally strong position of such issues.
>
> Aa--Bonds which are rated Aa are judged to be of high quality by all standards. Together with the Aaa group they comprise what are generally known as high grade bonds. They are rated lower than the best bonds because margins of protection may not be as large as in Aaa securities or fluctuation of protective elements may be of greater amplitude or there may be other elements present which make the long-term risks appear somewhat larger than in Aaa securities.
>
> A--Bonds which are rated A possess many favorable investment attributes and are to be considered as higher medium grade obligations. Factors giving security to principal and interest are considered adequate, but elements may be present which suggest a susceptibility to impairment sometime in the future.
>
> Baa--Bonds which are rated Baa are considered as lower medium grade obligations; i.e., they are neither highly protected nor poorly secured. Interest payments and principal security appear adequate for the present but certain protective elements may be lacking or may be characteristically unreliable over any great length of time. Such bonds lack outstanding investment characteristics and in fact have speculative characteristics as well.

There is some question as to the exact effect which the various ratings from publishers have on the interest which a Massachusetts municipality pays. Some bankers guess that the difference between the Aaa and Baa rating could result in the bonds selling for 5 1/2 percent instead of 4 1/2 percent in a particular case.

A reduction in interest rates may be possible if school bonds could be issued with the full faith and credit of the Commonwealth, which would give bonds a better rating than that of the average district in the state. Some districts now receive lower bond bids, but in general the state should receive better bids than the local districts. The regional districts with names that do not reflect known areas are particularly vulnerable to higher rate bidding.

Term of Bonds

Although most bonds in the last two decades were for 20 years, it is noteworthy that some were for less, and that these in many cases paid lower interest rates. A listing of 26 bonds issued by cities, towns, and school districts for time periods of five to fifteen years shows a reduction in the rate of interest through the use of shorter term bonds (Exhibit I in Appendix). The range for shorter term bonds is from 3.00 to 5.75 percent. The range in rates was 3.40 to 7.20 percent for 20-year bonds (Exhibit II in Appendix).

Several districts (see Exhibit III) purchased long and short term bonds within a short period of time which provides an opportunity to compare interest rates where the credit ratings are about the same. This evidence may not be regarded as conclusive, however, because all of the (20 year) bond obligations are for much larger amounts of money than are the short term bonds. Another problem with the comparison is that two of the larger bond issues were bid at a later period of time; one however was earlier.

The average difference in interest rates was
comparisons and 0.71 if Westborough although
On a ten-year bond issue this could be a reduc
interest.

Although ten-year bonds are currently obtainir
bonds, the market has varied in the past and c
The probabilities, however, are more appropria
bonds would receive lower bids most of the tin

EXHIBIT III

Comparison of Interest Rates for
Term Bonds in Massachusetts (

Town	Year of Issue	Term (Years)	Amoun
Billerica	1968	5	$ 67.
	1968	20	1,800.
Holden	1966	20	1,405,
	1968	5	120,
North Reading	1969	10	45.
	1969	20	1,225,
Stoughton	Aug.1968	5	90,
	Dec.1968	20	1,400.
Triton	1969	4	300.
	1969	20	7,555,
Westborough	1968	4	247.
	1969	20	1,830.

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the Aaa and Baa rating could
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20-year bonds (Exhibit II in

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money than are the short
n is that two of the larger
c ver was earlier.

The average difference in interest rates was about 0.53 percent for five comparisons and 0.71 if Westborough although a year later, is included. On a ten-year bond issue this could be a reduction of about $2\frac{1}{2}$ percent in interest.

Although ten-year bonds are currently obtaining lower bids than twenty-year bonds, the market has varied in the past and could change in the future. The probabilities, however, are more appropriate to conclude that ten-year bonds would receive lower bids most of the time.

EXHIBIT III

Comparison of Interest Rates for Long and Short Term Bonds in Massachusetts (1968-1969)

Town	Year of Issue	Term (Years)	Amount	Interest Rate	Difference in Rates
Billerica	1968	5	$ 67,900	4.25%	
	1968	20	1,800,000	4.60	0.35%
Holden	1966	20	1,405,000	4.25	
	1968	5	120,000	3.25	1.00
North Reading	1969	10	45,000	4.90	
	1969	20	1,225,000	5.00	0.10
Stoughton	Aug.1968	5	90,000	4.10	
	Dec.1968	20	1,400,000	4.60	0.50
Triton	1969	4	300,000	4.10	
	1969	20	7,555,000	5.40	1.30
Westborough	1968	4	247,000	3.90	
	1969	20	1,830,000	5.50	1.60
				Average	0.71%

Stabilization Funds

Massachusetts no longer uses sinking funds to pay off funded indebtedness because the law requires cities and towns to pay off debt service annually. Municipalities may, however, save money so that they can have some capital on hand when they are ready to incur debt. For example, if a municipality is planning at some time in the future to build a school or any other public work, the law allows the city or town to place money in a special fund. When the municipality is ready to build, it can take the money out of the special fund and thereby reduce the amount which it would otherwise borrow when it is ready to construct the public work. Interest payments are thus also reduced.

The fund described above is known as a stabilization fund. In any year a city or town may appropriate money to be placed in the stabilization fund, but it may not, without the approval of the Emergency Finance Board, appropriate in any one year more than 10 percent of the tax levy for the preceding year. Although a city or town may systematically put money away annually, the total or aggregate amount in the stabilization fund cannot at any time exceed 10 percent of the equalized valuation of real estate and tangible personal property in the city or town involved. The treasurer of the municipality is the custodian of the fund and he may invest the proceeds in various banks and in certain securities.

Under the stabilization law, a town can withdraw money from the stabilization fund only at an annual town meeting and with a two-thirds vote. There is one important exception to this rule. A town may appropriate money from the stabilization fund at a special town meeting if the town intends to use the money for construction of a school.

In the case of a city, the money may be withdrawn
city council. The money can be withdrawn for an
or city may borrow money.

A city or town may save a little interest under t
Building Assistance Law. As explained earlier, o
construction grants are paid over the life of the
municipalities for the construction of a school.
exception to this provision. The School Building
a method whereby a comparatively small part of th
may be paid immediately by the state, while the r
the life of the bond issue.

This method may be explained by a simple example
town wishes to construct a school estimated to c
state construction grant will be $500,000. The
its stabilization fund, provided that the amount
not less than $75,000. Assuming that the town v
the state will match the exact amount taken from
will send a check for this amount to the town.
amount of the state check be more than $100,000.
will not need to borrow $1,000,000 for the schoo
row $800,000 because it will have appropriated $
fund and will have received an advance payment o
the sum of $100,000. The town thereby saves a g
because it borrows $200,000 less than it would n
should be noted that the state construction gran
is entitled is not increased by this method. In
matching stabilization fund payment is then dedu
grant and the remaining $400,000 state grant is
the life of the bond issue.

In the case of a city, the money may be withdrawn by a two-thirds vote of the city council. The money can be withdrawn for any purpose for which the town or city may borrow money.

A city or town may save a little interest under the provisions of the School Building Assistance Law. As explained earlier, practically all state school construction grants are paid over the life of the bond issued by the local municipalities for the construction of a school. There is one important exception to this provision. The School Building Assistance Law provides a method whereby a comparatively small part of the grant ($75,000 to $100,000) may be paid immediately by the state, while the remaining part is paid over the life of the bond issue.

This method may be explained by a simple example. Let us assume that a town wishes to construct a school estimated to cost $1,000,000 and that the state construction grant will be $500,000. The town may vote money out of its stabilization fund, provided that the amount voted out of this fund is not less than $75,000. Assuming that the town votes $100,000 from the fund, the state will match the exact amount taken from the stabilization fund and will send a check for this amount to the town. In no case, however, can the amount of the state check be more than $100,000. In the case cited, the town will not need to borrow $1,000,000 for the school. It will only have to borrow $800,000 because it will have appropriated $100,000 from the stabilization fund and will have received an advance payment on its construction grant in the sum of $100,000. The town thereby saves a great deal of money in interest because it borrows $200,000 less than it would normally have borrowed. It should be noted that the state construction grant to which the city or town is entitled is not increased by this method. In the example cited above, the matching stabilization fund payment is then deducted from the $500,000 state grant and the remaining $400,000 state grant is paid in equal payments over the life of the bond issue.

Reliability of Municipalities in Repayment of Bonds

In Massachusetts, because there has never been a default by a city or town in the payment of a bond issue, investments in school bonds are considered safe investments. It has never been necessary to pass legislation requiring the state to guarantee to bondholders the payment of funded indebtedness of cities and towns.

There are many reasons why school bonds in Massachusetts are safe investments. Even though a city or town may borrow for up to twenty years, it has already been explained that the municipality cannot wait twenty years before it begins to repay the principal and interest. A payment on principal is required annually and the payment in any one year can never be more than the payment in a previous year. As previously stated, this requirement prevents municipalities from paying small amounts of the principal in the early years and large amounts in the latter years of a bond issue.

Furthermore, municipalities are required to include in the tax rate the amount of principal and interest which is due in that particular tax year. It is incumbent on the city auditor, the town accountant or town treasurer to notify the board of assessors of the amount of debt falling due during the current fiscal year. The board of assessors then has the obligation to make sure that provision is made in the tax levy to take care of the payment of the debt. Thus the taxpayers are required to pay all outstanding bonds and the interest thereon in the year in which they fall due. There is no "tax limit" in Massachusetts; that is, there is no provision in the law which states that the tax rate cannot exceed a certain amount. Consequently, the tax rate must be sufficient to pay any principal and interest which may become due on funded indebtedness.

Another provision of the law which assures that bonds and notes are relatively secure is the requirement that all school bond loans which are made outside

the limit of indebtedness
This board has an excellent
various municipalities in
of loans.

Bonds

a default by a city or town
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ssachusetts are safe investments.
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n they fall due. There is no
is no provision in the law
a certain amount. Consequently,
rincipal and interest which may

that bonds and notes are relatively
ond loans which are made outside

the limit of indebtedness must be approved by the Emergency Finance Board. This board has an excellent knowledge of the financial condition of the various municipalities in Massachusetts and is very careful in its approval of loans.

SPACE NEEDS AND THE CURRICULUM PLANNING PROCESS

CHAPTER II - 4

The rapidly rising costs of school construction greatly alarm Massachusetts citizens. Their attitude is understandable for as local and state taxpayers they will be sharing the payments for a new school for twenty years. A well-designed and well-constructed school building, however, should serve the community for sixty, eighty, or more years. Thus, it is imperative that each community plan and construct new schools which will remain educationally, structurally, and architecturally sound for as many years as possible.

This chapter will review some of the current practices in planning a school facility which will meet present educational space requirements and also adapt to future changes. Six schools constructed in the last few years are described at the end of the chapter as examples of the quality and effectiveness of the educational environment provided for Massachusetts students.

The need for school facilities is determined from a number of socio-economic factors reflecting the unique combination of circumstances for each school district. The most important elements for planning a new school are: (1) the number of students, (2) the type of educational program and (3) the methods of teaching and learning. From these essential elements the size, type and kind of instructional spaces are determined.

Determining the Need for Student Accommodations

Schools must be planned to accommodate a required number of students and specified groups of grades. The basic information for determining the number of students and the grades comes fr projected enrollments and the capacity of exis a district. Construction projects are planne of the student capacity needed for the project

Preparing projections of future enrollments is planning new facilities. The essential eleme jecting school membership in cities or towns a enrollments, (2) historical cohorts* on grade births to residents, (4) planned housing star for new housing units and (6) economic condit

Table 1 provides an example of a projection f historical growth of the last three years. caution -- this caution must be emphasized -- reliable the day after they are prepared. In completely invalid, and a new series should b latest conditions in a city or town. Anytim because by then births and housing starts fro and a more stabilized enrollment preferably a ready for calculating new cohorts and project town.

The projection in Table 1 shows that enrollme elementary grades (1-4) because the number of to 199. Therefore, the existing facilities

* Cohorts are the relation between the number the next grade over a period of time, i.e., three years, five years or ten years.

CURRICULUM PLANNING PROCESS

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the number of students and the grades comes from a comparison of the projected enrollments and the capacity of existing school facilities in a district. Construction projects are planned to accommodate part of all of the student capacity needed for the projected enrollment.

Preparing projections of future enrollments is risky but essential for planning new facilities. The essential elements for estimating and projecting school membership in cities or towns are: (1) present school enrollments, (2) historical cohorts* on grade to grade progressions, (3) births to residents, (4) planned housing starts, (5) availability of land for new housing units and (6) economic conditions.

Table 1 provides an example of a projection for one town based on the same historical growth of the last three years. There is, however, one large caution -- this caution must be emphasized -- <u>projections become less reliable the day after they are prepared</u>. In one year (January) they are completely invalid, and a new series should be prepared reflecting the latest conditions in a city or town. Anytime after January is appropriate because by then births and housing starts from the previous year are available, and a more stabilized enrollment preferably at the end of September is also ready for calculating new cohorts and projection parameters for a city or town.

The projection in Table 1 shows that enrollments will begin to decline in elementary grades (1-4) because the number of births decreased from 239 to 199. Therefore, the existing facilities do not need to be increased.

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* Cohorts are the relation between the number of students in a grade and the next grade over a period of time, i.e., grade 1 to grade 2 for three years, five years or ten years.

Table 1
Estimates and Projections for Enrollment - 3-year Cohorts

Public Schools

Births	Actual 1970	Cohorts	Projected 1971	1972	1973	1974	1975	1976	Estimates 1977	1978	1979	1980
(-6)	232	(1.47)	239	222	203	184	217	199	200	200	200	200
(K-5)	296	(1.33)	295	270	245	289	265	266	266	266	266	266
1	371	(0.97)	351	326	298	270	319	293	294	294	294	294
2	329	(1.03)	360	340	316	289	262	309	284	285	285	285
3	315	(1.04)	339	371	350	325	298	270	318	293	294	294
4	340	(1.03)	328	353	386	364	338	310	281	331	305	306
K-4	1651		1673	1660	1595	1537	1482	1448	1443	1469	1444	1445
5	321	(1.05)	350	338	364	398	375	348	319	289	341	314
6	303	(1.00)	337	368	355	382	418	394	365	335	303	358
7	322	(1.05)	303	337	368	355	382	418	394	365	335	303
8	404	(1.06)	338	318	354	386	373	401	439	414	383	352
5-8	1350		1328	1361	1441	1521	1548	1561	1517	1403	1362	1327
9	352	(0.95)	428	358	337	375	409	395	425	465	439	406
10	287	(0.90)	334	407	340	320	356	389	375	404	442	417
11	273	(1.02)	258	301	366	306	288	320	350	338	364	398
12	291		278	263	307	373	312	294	326	357	345	371
9-12	1203		1298	1329	1350	1374	1365	1398	1476	1564	1590	1592
K-12	4204		4299	4350	4386	4432	4395	4407	4436	4436	4396	4364
S.E.	59	(0.016)	64	65	66	66	66	66	67	67	66	66

In the middle grades the enrollment will
existing school with a student capacity c
addition to accommodate about 400 to 500
the housing developments that might be ar

Finally, the old high school with a stude
an addition to accommodate about 800 stud
expected to reach about 1600 by 1980.

Determining Space Requirements

There exists a direct relationship betwee
a school district develops and the requir
tional program has its unique space requir

Recently the State Department of Educatio
titled Minimum Curriculum Standards (June
program of studies and prescribes activit
(K-6), junior high (7-9) and senior high
first program listed, requires opportunit
electives in grades 9-12 and to use media
by painting, sculpture,ceramics and fabric
program requirements to the design and fu
apparent. Minimally, the art space needs
and fabricating and an area for dusty acti
ceramics. The number of spaces for each
(1) the number of students taking art clas
available, (3) the number of times each cl
of teaching and scheduling.

rollment - 3-year Cohorts

ols

1976	1977	1978	1979	1980
	Estimates			
199	200	200	200	200
266	266	266	266	266
293	294	294	294	294
309	284	285	285	285
270	318	293	294	294
310	281	331	305	306
1448	1443	1469	1444	1445
348	319	289	341	314
394	365	335	303	358
418	394	365	335	303
401	439	414	383	352
1561	1517	1403	1362	1327
395	425	465	439	406
389	375	404	442	417
320	350	338	364	398
294	326	357	345	371
1398	1476	1564	1590	1592
4407	4436	4436	4396	4364
66	67	67	66	66

In the middle grades the enrollment will increase until 1976, so the existing school with a student capacity of 1052 students must have an addition to accommodate about 400 to 500 students, depending again on the housing developments that might be anticipated in the district.

Finally, the old high school with a student capacity of 812 students needs an addition to accommodate about 800 students because enrollments are expected to reach about 1600 by 1980.

Determining Space Requirements

There exists a direct relationship between the educational program that a school district develops and the required space needs. Each instructional program has its unique space requirements.

Recently the State Department of Education issued a working draft entitled Minimum Curriculum Standards (June, 1971). It describes a minimal program of studies and prescribes activities by grade groups for elementary (K-6), junior high (7-9) and senior high (9-12). Art, for example, the first program listed, requires opportunities for all students to take electives in grades 9-12 and to use media in developing manipulative skills by painting, sculpture,ceramics and fabrication. The implications from program requirements to the design and functions of space are immediately apparent. Minimally, the art space needs a clean-air area for painting and fabricating and an area for dusty activities such as sculpture and ceramics. The number of spaces for each activity is directly related to: (1) the number of students taking art classes, (2) the number of courses available, (3) the number of times each class meets and (4) the methods of teaching and scheduling.

Exhibit I presents three of the four essential facts and indicates that, based on the number of students, a space for arts and crafts would require 25 teaching stations or periods. A space for 30 teaching stations of graphics and a space for painting and general art would also be required in this school.

Educational Program Specifications

An education program specification, required by the School Building Assistance Bureau, takes many forms and in some cities and towns is used as a delaying technique to avoid construction. Local participants in the first series of Regional Conferences for this study want and need help in preparing educational specifications. They wish the process could be computerized.

In developing and maintaining any instructional program, a district should have educational program specifications on file, that could be reviewed periodically to incorporate changing concepts, ideas and methods of instruction and learning. A school district could also use a checklist for determining future maintenance programs and new facilities. In the Appendix, Exhibit II briefly describes so[illegible] of the general requirements for art spaces. Exhibit III shows a comprehensive checklist for evaluating art facilities. Exhibit IV presents a summary of instructional and service areas. There are 18 instructional areas listed and 24 supporting spaces for a secondary school. Each would be described as art is described in Exhibit II.

Establishing Student Capacities

In Massachusetts there are no standards for establishing student capacities.

Exhibit I

Detailed Schedule of the Propos[illegible]
using SBAB Form

	Antici-pated Enroll-ment	Subject I	P[illegible]
ART			
Arts and Crafts 10-12	85	2	
	40	2	
	15	2	
Sculpture I	35	3	
Sculpture II Arts 11,12	15	5	
Graphics I	16	10	
Graphics II	40	10	
General Art	150	3	

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Exhibit I

Detailed Schedule of the Proposed Educational Program
using SBAB Form 61 RI

	Antici- pated Enroll- ment	Subject [1]	Proposed [2]	No. of Sections	Teaching Stations Required	Spaces
ART						
Arts and	85	2	24	4	8	
Crafts	40	2		2	4	
10-12	15	2		1	2	
Sculpture I	35	3	20	2	6	
Sculpture II	15	5	20	1	5	
Arts					25	1
11,12						
Graphics I	16	10	20	1	10	
Graphics II	40	10	20	2	20	
					30	1
General Art	150	3	24	7	21	1

Exhibit I, Chapter II-2, shows Form SBAB-61 RI, which describes a proposed educational program and determines the number of instructional spaces required for a program. There can be a variety of results from this form, if basic factors are increased or reduced. For example, note the change in requirements (3.7 to 5 rooms) if class size is increased (30 students) or decreased (25 students) but the number of periods in a week is held constant at 30 for room or space use.

Educational Program	Anticipated Enrollment	Subject Period/wk	Proposed Class Size	No. of Sections	Teaching Stations Required	Instr. Spaces
English I	600	5	20	30	150	5.0
English I	600	5	25	24	120	4.0
English I	600	5	28	22	110	3.7

Another factor that could increase or reduce the number of instructional spaces is the number of periods the space is available in a week. Most secondary schools have 6, 7 or 8 periods in a day, usually extending for 40 to 70 minutes. Some are experimenting with modular scheduling of 15, 20 or 30 minutes. Consequently, the number of potential periods to meet the State Board of Education regulation of $5\frac{1}{2}$ hours of instruction for each student increases from 11 for 30 minute "mods" to 22 for 15 minute mods.

For the majority of schools a 6- or 8-period day provides a 30- to 40-period week. Therefore, the final computation in spaces would change, for example as follows:

Teaching Stations Required	Instructional Spaces	
	6 Periods	7 periods
150	5.0	4.3
120	4.0	3.5
110	3.7	3.2

In modular scheduling, one purpose
students to schedule blocks of tim
would take place in the much large
schools provide a variety of class
hear a lecture or demonstration fo
groups of 12 or 15 students might

This varies the use of a space or
students, teachers, and subject an
factor for the determination of st
"utilization factor" is 80 or 90 p
for example as follows:

Teaching Stations Required	100 percent		
	6	7	[illegible]
150	5.0	4.3	[illegible]
120	4.0	3.5	[illegible]
110	3.7	3.2	[illegible]

Consequently, the spaces vary from
has a certain amount of flexibility

Exhibit V shows a complete school
acceptable or "optimal" capacity of
it could accommodate 3178 students

It is reasonable to assume that the
be utilized for more "optimal" sche
20 percent saving in space. Econo
would be about one-half of a senior

ich describes a proposed
nstructional spaces
f results from this form,
xample, note the change
increased (30 students)
ds in a week is held

No. of Sections	Teaching Stations Required	Instr. Spaces
30	150	5.0
24	120	4.0
22	110	3.7

umber of instructional
able in a week. Most
usually extending for
dular scheduling of 15,
tential periods to meet
s of instruction for each
22 for 15 minute mods.

rovides a 30- to 40-period
s would change, for

ctional ces 7 periods
4.3
3.5
3.2

In modular scheduling, one purpose is to provide more opportunities for students to schedule blocks of time for individual study. This study would take place in the much larger library resource center. Some schools provide a variety of class groups so that 150 students might hear a lecture or demonstration for one period a week and later small groups of 12 or 15 students might discuss the demonstration.

This varies the use of a space or the ability to arrange scheduling of students, teachers, and subject and highlights a third and important factor for the determination of student capacities. If the use or "utilization factor" is 80 or 90 percent, more space or rooms are needed, for example as follows:

Teaching Stations Required	100 percent		80 percent		90 percent	
	6	7	6	7	6	7
150	5.0	4.3	6.3	5.4	5.5	4.7
120	4.0	3.5	5.0	4.4	4.4	3.9
110	3.7	3.2	4.6	4.0	4.1	3.5

Consequently, the spaces vary from 3.5 to 6.3, so that a school facility has a certain amount of flexibility by changing programs and schedules.

Exhibit V shows a complete school designed for 2140 students with an acceptable or "optimal" capacity of 2713 (125 percent) and in an"emergency" it could accommodate 3178 students (or 133 percent).

It is reasonable to assume that the planning of secondary schools could be utilized for more "optimal" scheduling and somewhere approximating a 20 percent saving in space. Economics for middle or junior high schools would be about one-half of a senior high, or 12 to 16 percent. Elementary schools are not utilized at nearly 100 percent capacity. In view of the fact that most of the larger enrollments for Massachusetts will be entering secondary schools in the next five years, an average of 10 percent of the space submissions might be a conservative estimate of economy in school planning.

Methods of Teaching and Learning

A most significant determinant of initial design and function of a school facility depends on the methods of teaching and learning. At the two extremes are self-contained classrooms and open-space classrooms which resemble an architectural supermarket. In some cases, sad to say, architecture leads educators; this is contrary to the primary principle of school planning which prescribes "from the school program to the school plant." The flexibility of design and the logic of individualized learning have encouraged architects to use open-space plans.

Partially open space, convertible, expandable, adaptable and dual-use space are also prevalent in school construction. Educators are changing at variable rates, and the design of new facilities must be capable of accommodating new demands and converting back to older plans.

In summary, the educational space requirements for a school are determined by the process of projecting future school enrollments, the method of converting student choices for courses of study into types of instructional spaces, and the description of the objectives and activities required by the educational program. These known, foreseeable and sometimes subtle factors guide administrative decision makers and architects in planning an acceptable school facility.

Exhit

Space Requirements ar

2140 Stu

Subject	Spaces	Educ.
ART (3)	3	24
Photography	1	-
BUSINESS (9)		
Typing	5	30
Office Prac.	1	15
Large Group	1	25
Discussion	4	12
Sales	1	25
Remedial	1	5
Prod. Center	1	25
HOME ARTS (5)		
Cooking/Sewing	2	16
Cooking	1	16
Sewing	1	16
Family Apart.	1	16
Seminar	2	10
Resource Center	1	10
INDUSTRIAL ARTS (5)		
Metal	1	16
Print	1	16
General	1	16
Wood/Constr.	1	16
Mech. Drawing	1	20
MUSIC (2)		
Instrumental	1	25
Vocal	1	25
Ensemble	1	4
Practice	1	1
PHYSICAL EDUCATION (6)		
Field House	5	35
Auxiliary	1	35
Body Mech.	1	35
SCIENCE (15)		
Labs	12	24
Lg. Group Instr.	1	25
Seminar	3	10
Gen. Class	1	25
Resource Center	1	20
Project Area	2	-
Plant Room	1	-

In view of the
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capable of accom-
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the method of
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Exhibit V

Space Requirements and Student Capacities

2140 Students

Subject	Spaces	Educ.	Opt.	Emerg.	Student Capacities Educ.	Opt.	Emerg.
ART (3)	3	24	24	28	72	72	84
Photography	1	-	5	5	-	5	5
					72	77	89
BUSINESS (9)							
Typing	5	30	40	40	150	200	200
Office Prac.	1	15	15	20	15	15	20
Large Group	1	25	50	75	25	50	75
Discussion	4	12	12	12	48	48	48
Sales	1	25	25	28	25	25	28
Remedial	1	5	5	10	5	5	10
Prod. Center	1	25	25	25	25	25	25
					293	368	406
HOME ARTS (5)							
Cooking/Sewing	2	16	20	20	32	40	40
Cooking	1	16	20	20	16	20	20
Sewing	1	16	20	20	16	20	20
Family Apart.	1	16	16	20	16	16	20
Seminar	2	10	10	12	20	20	24
Resource Center	1	10	16	20	10	16	20
					110	132	164
INDUSTRIAL ARTS (5)							
Metal	1	16	20	20	16	20	20
Print	1	16	20	20	16	20	20
General	1	16	20	20	16	20	20
Wood/Constr.	1	16	20	20	16	20	20
Mech. Drawing	1	20	25	25	20	25	25
					84	105	105
MUSIC (2)							
Instrumental	1	25	25	28	25	25	28
Vocal	1	25	25	28	25	25	28
Ensemble	1	4	4	4	4	4	4
Practice	1	1	1	1	3	3	3
					57	57	63
PHYSICAL EDUCATION (6)							
Field House	5	35	30	40	175	150	200
Auxiliary	1	35	30	40	35	30	40
Body Mech.	1	35	30	40	35	30	40
					245	210	280
SCIENCE (15)							
Labs	12	24	28	28	288	366	366
Lg. Group Instr.	1	25	50	75	25	50	75
Seminar	3	10	10	12	30	30	36
Gen. Class	1	25	25	28	25	25	28
Resource Center	1	20	20	25	20	20	25
Project Area	2	-	10	12	-	20	24
Plant Room	1	-	4	6	-	4	6
					388	485	530

Subject	Spaces	Student Capacities					
		Educ.	Opt.	Emerg.	Educ.	Opt.	Emerg.
ENGLISH (14)							
Colloquium	1	75	100	112	75	100	112
Discussion	12	12	12	15	144	144	180
Writers Lab.	1	20	20	25	20	20	25
Reading Lab	1	15	15	20	15	15	20
Resource-media	1	20	20	25	20	20	25
General	3	25	25	28	75	75	76
					349	374	418
LANGUAGES (8)							
General	6	25	25	28	150	150	168
Seminar	4	12	12	15	48	48	60
Lab	1	25	25	28	25	25	28
Resource Center	1	20	20	25	20	20	25
					243	243	281
MATHEMATICS (11)							
Lg. Group Inst	1	25	50	75	25	50	75
General	9	25	25	28	225	225	252
Lab-Resource	1	25	40	50	25	40	50
					275	315	379
SOCIAL STUDIES (15)							
Large Grp. Inst.	1	25	50	75	25	50	75
General	12	25	25	28	300	300	336
Lab-Resource	2	25	40	50	50	50	50
					375	400	461
ASSEMBLY	1	-	50	75	-	50	75
Dining (235 Seats)	1	-	50	75	-	150	225
LIBRARY							
Reading	1	-	100	150	-	100	150
Viewing AV	1	-	20	25	-	20	25
Prod. Lab.	1	-	15	20	-	15	20
Conference	4	-	6	10	-	24	40
Student Work	1	-	10	15	-	10	15
						169	250
SPECIAL EDUC. (2)	2	15	15	18	30	30	36
ADMINISTRATION							
Office Prac.		-	10	15	-	10	15
GUIDANCE							
Offices	8	-	6	8	-	6	8
Library	1	-	3	5	-	3	5
Test/Conf.	2	-	8	15	-	8	15
						17	28
					2521	3162	3739
Utilization 85%					2142	2713	3178

Communities in Massachusetts h
enactment of the School Buildi
ing the date of construction,
planning, design and construct
to future changes because new
learning will impose demands o
students and teachers. Fortu
schools in Massachusetts are a
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similar to those in schools co

Despite their quality and adapt
were not completed until well a
discovered. The delay usually
most schools requiring roughly
tion of need to occupancy of th
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can be shortened without a redu
contract bids for two recent pr
10 percent of the construction
quality.

Unfortunately, "quality" can be
study team recognized that its
of systems schools to equal, or
ventionally constructed. Acco
six recently constructed school

...udent Capacities Emerg.	Educ.	Opt.	Emerg.
112	75	100	112
15	144	144	180
25	20	20	25
20	15	15	20
25	20	20	25
28	75	75	76
	349	374	418
28	150	150	168
15	48	48	60
28	25	25	28
25	20	20	25
	243	243	281
75	25	50	75
28	225	225	252
50	25	40	50
	275	315	379
75	25	50	75
28	300	300	336
50	50	50	50
	375	400	461
75	-	50	75
75	-	150	225
150	-	100	150
25	-	20	25
20	-	15	20
10	-	24	40
15	-	10	15
		169	250
18	30	30	36
15	-	10	15
8	-	6	8
5	-	3	5
15	-	8	15
		17	28
	2521	3162	3739
	2142	2713	3178

An Evaluation of Six School Instructional Facilities

Communities in Massachusetts have constructed superior schools since enactment of the School Building Assistance Act in 1948. Considering the date of construction, these schools represent excellence in planning, design and construction. Schools, however, must be adaptable to future changes because new inventions and research on education and learning will impose demands of unprecedented complexity on adults, students and teachers. Fortunately, many of the recently constructed schools in Massachusetts are adaptable and provide flexibility in open-space planning and clusters of spaces. They include several features similar to those in schools constructed with integrated subsystems.

Despite their quality and adaptability, these recently built facilities were not completed until well after the need for new schools was first discovered. The delay usually ranges from three to fourteen years, with most schools requiring roughly four to five years from initial recognition of need to occupancy of the new building. Under a systems approach to construction planning and management, the design and construction time can be shortened without a reduction in quality. For example, the contract bids for two recent projects in Massachusetts reveal that about 10 percent of the construction cost can be saved without a reduction in quality.

Unfortunately, "quality" can be an imprecise and subjective notion. The study team recognized that its Report must objectively document the ability of systems schools to equal, or better, the quality of the schools conventionally constructed. Accordingly, members of the study team selected six recently constructed schools, located in cities and towns across the state, and evaluated the quality of each instructional space in the school. The schools include two elementary schools, one regional junior high school, two senior high schools, and one regional vocational-technical school. In past years, a 1000-point rating instrument was used to rate school facilities, but the study team determined that this instrument would yield a superior rating, in the high 900's, for each of these six schools without appropriate description and differentiation of quality.[1] Thus, a lengthy survey instrument was developed which evaluated a greater number of items than the previous instrument and which defined educational requirements more appropriate for the twenty-first century. The six buildings evaluated for this survey represent some of the best educational facilities in use today, and buildings constructed in the future with integrated subsystems must equal or exceed the quality of these schools as identified by this instrument.

The completed instruments for each school are available in the working papers of the study; however, brief summaries of the evaluations for each school follow:

School A - Elementary School (1970)

This elementary school, constructed in 1970, three years after its need was first identified, is a rectangular structure with eight small interior courts. The school accommodates 700 students in six open-space quadrangles. Each quadrangle, in turn, is subdivided by partitions and furniture into four teaching spaces. The six quadrangles flank two sides of a

[1] Older schools, constructed before 1920, usually rate below 500 on this 1000-point instrument, and should be replaced. Facilities which have been remodeled or rehabilitated usually rate above 500. The six schools in this survey would rate in the high 900's, providing too little variation or range to establish qualitative standards.

modern, well-equipped instructiona
curricular and materials workrooms
kindergarten, boys' gym and girls'
shop, a cafeteria which may be div
rooms, and several guidance, healt

On the whole, this school receives
has many excellent characteristics
the heating and air conditioning c
able furniture and equipment, the
of its interior partitions, and it
materials center deserves special
building and very accessible to al
number of books and periodicals, s
body, well-equipped study carrels,
instructional rooms, a comprehensi
room, staff offices and TV studio.

The school is not without several
woodshop areas have poor access to
open and project out from the wall
corridor. Most serious is the ab
A sunken pit in the IMC seats only
accommodates 150 to 200 pupils;
the same presentation.

None of these drawbacks is serious
evaluation of this school as an ex
adapt to a wide range of educatio

modern, well-equipped instructional materials center and staff curricular and materials workrooms. There are excellent spaces for kindergarten, boys' gym and girls' gym, special education, art, woodshop, a cafeteria which may be divided into four dining or activity rooms, and several guidance, health and administrative offices.

On the whole, this school receives an extremely superior rating. It has many excellent characteristics: the level and uniformity of lighting, the heating and air conditioning capabilities, the carpeting, the movable furniture and equipment, the aesthetic appeal and acoustical properties of its interior partitions, and its dining areas. The instructional materials center deserves special mention. Located in the center of the building and very accessible to all students, it contains a very large number of books and periodicals, study space for 15 percent of the student body, well-equipped study carrels, a language laboratory, four small group instructional rooms, a comprehensive audio-visual room, curricular workroom, staff offices and TV studio.

The school is not without several minor flaws. Students in the art and woodshop areas have poor access to lavatories, all student lockers are open and project out from the walls, and the lobby is a narrow, confusing corridor. Most serious is the absence of adequate auditorium space. A sunken pit in the IMC seats only about fifty students, and one quad accommodates 150 to 200 pupils; consequently, a "quad" cannot attend the same presentation.

None of these drawbacks is serious enough to detract from the overall evaluation of this school as an extremely superior facility which can adapt to a wide range of educational programs and space needs.

School B - Elementary School (1969)

This open-plan elementary school was completed in 1969, after two years of planning and construction. It is an addition to a modified open-plan building erected in 1960. The addition is designed as one large block housing 450 students in grades K-5. Its core contains an instructional resource center, with interchangeable instructional areas on three perimeters and a small theatre on the fourth. The original building was designed with pairs of classrooms connected by project areas. This concept of pairing instructional spaces was the first departure from the self-contained classroom initiated in the Quincy School of Boston in 1867.

This school has many superior characteristics, particularly in its open-plan addition. The instructional resource center is large, well lighted, and contains 5,500 volumes as well as ample audio-visual equipment. Illumination throughout the addition is excellent. The acoustics, which seemingly would be a problem for an open-plan and instructional space for multiple classes, are surprisingly good primarily because of sound-absorbing carpet. Aesthetic considerations are excellent, expecially in the little theatre, in the art studio, and in the finishes of partitions and floors. In contrast, the original building is far less exciting, but it represents sound design for the time it was built--a decade ago.

Despite the national acclaim given this addition, several characteristics are less than superior. Heating units are exposed and easily damaged by students. Students and staff members complain of the building's poor thermal qualities and lack of air conditioning on warm days; and the ventilation system in several spaces (art room, theatre) has poor acous-

tical properties for large-group instruction. Tr open-plan areas are indistinguishable, and student project into corridors. Glare comes in from corr none of these characteristics is very serious, a c tractive features impair the instructional functic

A notable strength in this school is the close cor building's design and the educational program crea Staff and students make active use of the advantag

School C - Junior High School (1969)

Junior high schools are similar in design and func This regional junior high school, first planned in in 1969, is a rectangular structure with four inte are 59 instructional spaces which can accommodate Each of the instructional spaces has some "superio many "good" ones, some "adequate" ones and several conditions. Overall, the building is an excellen which should provide very satisfactory instruction of this century and a good part of the next.

The superior features include a pool, the separatic areas, the library/instructional materials center, homemaking, shop, and science spaces, book and stuc staff work areas, many fire exits, fire-resistive c site characteristics, and accessibility for handica of these features would not have been possible if t regional school serving several communities.

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n, theatre) has poor acous-

tical properties for large-group instruction. Traffic lanes in the open-plan areas are indistinguishable, and students' lockers open and project into corridors. Glare comes in from corridor windows. Although none of these characteristics is very serious, a combination of distractive features impair the instructional functions of this facility.

A notable strength in this school is the close correlation between the building's design and the educational program created for students. Staff and students make active use of the advantages of open-plan space.

School C - Junior High School (1969)

Junior high schools are similar in design and function to middle schools. This regional junior high school, first planned in 1969 and constructed in 1969, is a rectangular structure with four interior courts. There are 59 instructional spaces which can accommodate about 1200 children. Each of the instructional spaces has some "superior" educational features, many "good" ones, some "adequate" ones and several "poor," although minor, conditions. Overall, the building is an excellent economic investment which should provide very satisfactory instructional spaces for the end of this century and a good part of the next.

The superior features include a pool, the separation of noisy and academic areas, the library/instructional materials center, language lab, art, homemaking, shop, and science spaces, book and student-project storage, staff work areas, many fire exits, fire-resistive construction, general site characteristics, and accessibility for handicapped students. Many of these features would not have been possible if this had not been a regional school serving several communities.

Although the basic architectural design does not reflect a program for open-space teaching, there are nine double classrooms which provide for large group instruction, and two large clusters for social studies which will accommodate individualized, team or open-space learning programs.

The structure has several relatively minor inadequacies, including "hard" acoustics, glare, a few poorly illuminated areas, a shortage of chalkboard space in two of the 59 instructional areas, excessive heat in the library materials center and the interchangeable classrooms, only two instrumental practice room and a lack of essential portable equipment (i.e., exhaust hood for a science room, a fire extinguisher in the art room).

The overall rating of this building is superior for educational programs in the 1970's and well into the 2000's.

School D - High School (1970)

This large high school was completed in 1970, eleven years after its need was first determined. It currently has an enrollment of 3800 students and contains both an academic and vocational program. It is a conventional three-story design that combines lofts, blocks and clusters of instructional space. The overall effect is somewhat confusing, and this confusion is compounded by long corridors and poor overall access. The facility does include a number of outstanding general-use spaces: a large auditorium, three dining areas, two large gymnasia and several smaller auxiliary spaces for physical education, a superior pool, four lecture halls and a large library resource center. The facilities for language lab, science and physical education are impressive. They are well

equipped, large, contain good stora any educational program. Likewise comprehensive and attractive, altho for a student enrollment approachin

Although each of the instructional and architectural features, the bui by some serious flaws. Interchang usually accommodate nearly 35 pupil rooms are air conditioned, and all that are merely adequate. Acousti "hard" in the interior corridors an are designed for less than one-quar always seem crowded. Finally, the lane road) to the building from the for pedestrian sidewalks, parking, accessibility. Despite many adm all rating was not as superior as specific inadequacies and a genera areas. In general the individual standing learning environment, and best secondary schools in the nati

School E - High School (1970)

The need for this large high schoo The facility was completed in 1970 is situated on an 88-acre site and connected by bridges and courts. only exterior walls are permanent equipped, large, contain good storage space and would be an asset to any educational program. Likewise, the library resource center is comprehensive and attractive, although the number of volumes is small for a student enrollment approaching 4,000.

Although each of the instructional areas has many superior educational and architectural features, the building's overall rating is lowered by some serious flaws. Interchangeable classrooms are very small and usually accommodate nearly 35 pupils each. Only the interior classrooms are air conditioned, and all classrooms have illumination levels that are merely adequate. Acoustics are also adequate but are especially "hard" in the interior corridors and science labs. The dining areas are designed for less than one-quarter of the current enrollment and always seem crowded. Finally, there is very limited access (one 2-lane road) to the building from the main road and inadequate provision for pedestrian sidewalks, parking, bus embarkation, and vehicular accessibility. Despite many admirable features, this building's overall rating was not as superior as the other five schools. It has several specific inadequacies and a generally confusing access to instructional areas. In general the individual instruction spaces provide an outstanding learning environment, and the school as a whole is one of the best secondary schools in the nation.

<u>School E - High School (1970)</u>

The need for this large high school was first predicted twelve years ago. The facility was completed in 1970 and serves almost 5,000 pupils. It is situated on an 88-acre site and includes nine separate buildings connected by bridges and courts. It has impressive program flexibility; only exterior walls are permanent while all interior walls are demountable or moveable. The design of the school reflects a flexible and modern educational program and represents excellent functional quality for expenditures.

Paramount among the planning and design strengths is the arrangement of educational functions and the subdivision of facilities; for example, there are four academic houses, a science and business complex, an administrative unit, an arts' complex, a physical education building, a vocational complex, a service building, and a hockey rink provided by the Metropolitan District Commission. There are four cafeterias, each divisible into four dining areas; a central instructional resource center and a decentralized unit for each house, providing a capacity of over 50,000 volumes; and excellent audio-visual equipment for modern educational programming. In addition, the facility contains four modern instructional laboratories (for math, language, social studies, and reading), eight lecture rooms, large audio-visual spaces, and a planetarium. Although this school is very large (5000 students), it is thoughtfully divided or decentralized into smaller, educationally functional units or complexes.

The quality of design and construction is generally superior; however, a few flaws do exist. Many spaces--interchangeable classrooms, for example---are plain and not very imaginative. More storage area is needed in classrooms and labs. Most serious is the noisy ventilation system particularly in the auditorium, little theatre, several interchangeable classrooms and lecture rooms. This flaw, in fact, seriously impedes effective teaching and learning. Illumination and acoustics in interior corridors are also less than superior.

On the whole, however, this faci
both for the design and the qua
While one can dislike schools of
minimizes the handicaps of a hug
careful planning and instruction

School F - Vocational Technical

This regional vocational-technic
five years of careful planning a
the country. Built of modular
modified loft with two interior
and the building occupies only t
building will house about 700 st
only 350 students. An addition
classrooms provide maximal flexi
the highest quality.

The admirable features of the bu
one of its main strengths is the
material. Acoustics, lighting,
superior, as well as the conditi
partitions. Most interior part
for academic instruction flank t
will enable expansion of IMC spa
IMC itself is large, especially
10,000 volumes, a modern audio-v
cent of the student body. The
areas and opens onto an exterior
tional and technical spaces are

ool reflects a flexible and
excellent functional quality

trengths is the arrangement of
of facilities; for example,
and business complex, an
physical education building,
and a hockey rink provided by
here are four cafeterias, each
ral instructional resource
house, providing a capacity
dio-visual equipment for
tion, the facility contains
or math, language, social
s, large audio-visual spaces,
is very large (5000 students),
ed into smaller, educationally

generally superior; however,
rchangeable classrooms, for
ive. More storage area is
ious is the noisy ventilation
ttle theatre, several inter-
This flaw, in fact, seriously
Illumination and acoustics in
erior.

On the whole, however, this facility receives an excellent rating both for the design and the quality of its instructional spaces. While one can dislike schools of this size, this particular school minimizes the handicaps of a huge educational facility because of its careful planning and instructional space affinities.

School F - Vocational Technical School (1970)

This regional vocational-technical school was completed in 1970 after five years of careful planning and visits to other facilities across the country. Built of modular construction, it is a two-block modified loft with two interior courts. The site size is 92 acres, and the building occupies only three acres. At full capacity, the building will house about 700 students, although present enrollment is only 350 students. An addition, however, is currently planned. The classrooms provide maximal flexibility, and the materials used are of the highest quality.

The admirable features of the building are difficult to describe, since one of its main strengths is the skillfully combined effect of space and material. Acoustics, lighting, heating and air conditioning are all superior, as well as the condition and finishes of floors and interior partitions. Most interior partitions are demountable; those designed for academic instruction flank the instructional materials center and will enable expansion of IMC space when the addition is completed. The IMC itself is large, especially for a vocational-technical school, with 10,000 volumes, a modern audio-visual facility, and seating for 12 percent of the student body. The cafeteria is divisible into three dining areas and opens onto an exterior court for outdoor dining. The vocational and technical spaces are very large and well equipped with many panels (kalawall), the student lockers, the ample storage space, and the superior safety zones and other safety provisions.

Finally, this building contains several features not found in other new schools which serve the interests of staff and students very well. The guidance office has a private entrance so parents or students may enter unobserved by other students; the secretarial and teacher work-rooms are designed for great efficiency; the mailroom is separate from the main office; classrooms are very large and quiet; lighting fixtures have a walnut formica case; and interior corridors are very attractive.

It is difficult to find serious fault with the school. Locker rooms and the health suite could be larger; the auditorium only seats 160 students in hard plastic chairs (but the cafeteria is used for large meetings or productions); and the gym has insufficient office space.

The overall impression is a very superior school in almost every respect. Given its sound coordination of the educational program and the space requirements and the high aesthetic quality of the design, this school's rating is the highest possible.

In summary, the six schools surveyed by the study team are superior instructional facilities. The three junior and senior high schools and the vocational school contain every instructional space required for a modern educational program. Likewise, the two elementary schools are facilities well suited to current and future trends in elementary education. However, the short-comings in each school, though usually

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minor, are surprising for schools built in the late 1960's. These short-comings include "hard" acoustics ;in corridors, some spaces which are too small or restricted, uneven illumination, noisy ventilation and occasional lack of flexibility in the three secondary school instructional spaces. As documented in Chapter of this report, systems schools can reduce these shortcomings and equal or exceed the overall quality of these six schools.

Equally important, the study team's proposals for building and financing systems schools through a state corporation can reduce two other serious flaws found in most of the six schools; (1) construction was completed too long after the need for the school was first determined and (2) the cost was more than necessary because of delays in approving bond obligations for construction. Construction of one of the six schools in the survey was delayed more than a decade after municipal officials had acknowledged the need for the school. In that interval, the cost of the building doubled and the interest payments on the debt nearly tripled. Despite these obstacles, that school--and the five other schools surveyed by the study team--now provide instructional spaces of high quality. Massachusetts can take justifiable pride in these six structures, housing nearly 12,000 students, and in the hundreds of other schools completed since the enactment of Chapter 645 in 1948. The state's challenge today is to provide schools of similar or better quality in far less time and for less cost.

THE BUILDING DESIGN AND CONSTRUCTION PROCESS

CHAPTER II - 5

Introduction

The previous chapters have outlined the existing legal, administrative and financial procedures involved in school planning, approval and construction, but largely from the standpoint of the state and municipal bodies participating in the process.

The two main groups of professional participants in the process are the design team, led by the architect, and the construction team, led by the general contractor. Since many of the findings and recommendations found later in this report relate to the work of these two groups, it will be useful to have a working understanding of their procedures and relationships. This chapter is to provide that background for readers who are not already familiar with the process.

It attempts to identify the main steps and central figures only with a particular view to the material to follow. The approach is generally chronological. However, it should be recognized that the process is not linear, so some steps may be concurrent, while others may sometimes be one way and sometimes the reverse way.

Architect Interviews and Appointment

A school building committee, with the assistance of an educational consultant if one is engaged, invites the applications of architects and selects one from those who apply. In some may simply invite a limited number three architects may be interviewe especially in tight economic situa apply for the same job.

In selecting an architect, the tow experience, ability to control cos techniques, experience of the arch aesthetics, and recommendations of of architects are applying for a j all of them, so it may be possible by a systematic and objective comp interviews have reduced this list should visit buildings by these ar their degree of satisfaction with

The other important factor in any of the architect as a person, sinc crucial to a successful working ex

Architects' Fee Schedules

The most common basis for determi the project construction cost. T American Institute of Architects Book" which also explains the ter exceed the minimum, but reduction is grounds for censure by and exp

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one from those who apply. In some cases, rather than advertise, the committee may simply invite a limited number to apply for the job. Thus as few as three architects may be interviewed in some circumstances, while in others, especially in tight economic situations, as many as sixty architects may apply for the same job.

In selecting an architect, the town should consider such factors as school experience, ability to control costs, receptivity to and experience with new techniques, experience of the architect's staff, proximity to the job, aesthetics, and recommendations of past clients. When a very large number of architects are applying for a job, it will not be practical to interview all of them, so it may be possible to reduce the list to a manageable size by a systematic and objective comparison of their written credentials. After interviews have reduced this list to three or four, members of the committee should visit buildings by these architects and talk to users to determine their degree of satisfaction with the building.

The other important factor in any selection is simply a subjective evaluation of the architect as a person, since a good interpersonal relationship is crucial to a successful working experience.

<u>Architects' Fee Schedules</u>

The most common basis for determining architects' fees is a percentage of the project construction cost. The maximum fees are standardized by the American Institute of Architects and are set forth in the A.I.A. "Blue Book" which also explains the terms of engagement. Architects' fees may exceed the minimum, but reduction below them is called "fee cutting" and is grounds for censure by and expulsion from the A.I.A.

The fees attempt to be a realistic reflection of what an architect will need to charge to do a professional job for different kinds of work. They are based on a sliding scale related both to project size (lower percentage for larger jobs) and complexity (lower percentage for less complex work).

Other bases than a percentage of the construction cost are used to determine architects' fees. Depending on the exact circumstances, an architect and his client may agree upon a single lump sum to cover all architectural services, or they may decide on a process in which payments are based on the architects' direct payroll costs of performing the work multiplied by a factor to allow for indirect costs, overhead and profit (so-called "cost-plus").

Payments to architects are commonly phased according to the proportion of work in each phase. The normal fee breakdown is as follows:

Schematic design phase	15%
Design development phase	20%
Construction documents phase	40%
Bidding or negotiation phase	5%
Construction phase	20%

Work in addition to these tasks (such as the construction of a presentation model or site surveys) is customarily charged separately on a time basis.

Educational Program Specifications ("Ed Specs")

"Ed specs," which have already been discussed in detail in Section II, Chapter 2, are the architect's fundamental brief for his work. In some cases, the architect may participate in their preparation. Either way, the allotment of space to various activities and the interrelationships between these spaces should be spelled out in the program and the final size of the building should be a reflection of this. The quality of the building can be no better than the quality of the program.

Site Selection and Approval

The site may be selected by the municipalit selection of the architect. If the archite assist in the site selection.

Factors which should be considered in selec

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- cost and ease of acquisition
- road safety
- topography
- special site conditions (rock, swam
- future road plans
- future town growth
- existence and adequacy of sewers an
- in absence of sewers, soil percolat

The site must then be approved by the Departı acceptability of sewer facilities, the Depar and the School Building Assistance Bureau fo facilities.

Selection and Appointment of Consultants

The architect is assisted in the preparation school building committee and the educationa of engineers and other consultants who may b municipality or by the architect. If they a municipality, the architect's fee is reduced consultant's fee.

The main consultant is the structural engine materials and structural systems and enginee

Site Selection and Approval

The site may be selected by the municipality either before or after the selection of the architect. If the architect is selected first, he can assist in the site selection.

Factors which should be considered in selecting a site are:

- convenience of location to the student population being served
- adequacy of size for the number of students
- cost and ease of acquisition
- road safety
- topography
- special site conditions (rock, swamp, susceptibility to flooding)
- future road plans
- future town growth
- existence and adequacy of sewers and other services
- in absence of sewers, soil percolation capacity

The site must then be approved by the Department of Public Health for acceptability of sewer facilities, the Department of Natural Resources, and the School Building Assistance Bureau for adequacy for the intended facilities.

Selection and Appointment of Consultants

The architect is assisted in the preparation of his plans not only by the school building committee and the educational consultant, but by a number of engineers and other consultants who may be employed either by the municipality or by the architect. If they are employed directly by the municipality, the architect's fee is reduced by an amount related to the consultant's fee.

The main consultant is the structural engineer, who advises on soil capacity, materials and structural systems and engineers the structure of the building.

The mechanical engineer will advise on and design the heating, ventilating and air-conditioning system and other mechanical services. Normally, an electrical engineer is employed for all electric/electronic parts of the project.

Other consultants who may be employed include a cost consultant to provide a continuing control on costs at each stage of design and construction and a kitchen consultant for jobs in which the food service operation is complex.

Cost Estimates

Cost is a crucial factor in any school building project. Each project starts with an explicit or at least implicit budget, and the municipality has a right to demand that the architect work within it. Many school building committees will ask an architect at the interview what he would expect the building to cost. Although that may be premature, the architect should be able to give a realistic estimate of cost at as early a date as possible. If the committee's expectations are unreasonably low, they should know as soon as possible.

Once an architect has made an estimate, his design should not differ substantially from this unless by clear agreement with the committee. A cost consultant can help the architect make a realistic initial estimate and can keep him to this budget as the job progresses by preparing progressively more refined estimates at each step along the way. If at any point the architect's concepts begin to get expensive, the design can be brought back within the limits of the budget before it is too late. This process is known as cost control.

The Design Process

The design process is a probl
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a solution which is functional

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The Design Process

The design process is a problem-solving procedure in which the individual problems of the space needs, the site, and the budget are integrated into a solution which is functional, solid and pleasing to the eye.

The architect is assisted not only by his consultants but by the school building committee, the educational consultant and, in some cases, by the users of the building themselves. All these people continuously give the architect their ideas and their reactions to his ideas, so that the design is very much a joint effort.

The ultimate form of this communal effort is the "squatters" or "charrette" technique, which brings together all the people involved in the process for periods of intense concentrated effort and exchange of ideas. By encouraging everyone to have his say, many mistakes are avoided. The purpose of the process is two-fold. The first is to get the best possible building by maximally involving citizens and other knowledgeable parties. The second is to speed the design process, since the technique short-cuts much of the time-consuming and inefficient individual consultations that characterize most design procedures. A typical charrette procedure is for the architects to be "in residence" in the town which is building the school for periods of a week at a time, alternating with a week or two back in their office to work out some of the questions raised. A series of such visits may result in a nearly final schematic design.

The design process is divided into two phases, progressing from general concepts to more specific details. The schematic design phase starts with "bubble diagrams" which are little more than circles or rectangles on a piece of paper, drawn to a scale related to the areas of spaces listed in the program. From this an arrangement of spaces is developed which recognizes their functional relationships and relates to the site conditions. As the design develops, it gradually begins to define a building. The schematic design is complete when a viable solution has been reached which indicates all rooms in the building, room heights, levels, materials, and the exterior treatment of the building. At the completion of the schematic design, the chairman of the school building committee may sign the drawings to confirm the committee's approval of them.

The design development phase takes the design several steps further to provide a level of detail at which virtually all decisions affecting the function and appearance of the building have been made. All consultants have been deeply involved by this point, and if designs for their particular building function have not been drawn, they have at least been worked out in sufficient detail to ensure that construction drawings will not change them in any significant way and that a close estimate of the cost can be made. At the completion of this stage, the chairman of the school building committee may again sign the drawings.

Plan Reviews and Approvals

One of the two approvals which will have been obtained during the design process is the SBAB review of floor areas, number of teaching stations, special spaces, dining areas, etc. Since the SBAB must approve the design, this should be carried out before the design is so fixed that it cannot be changed without great effort.

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Working Drawings

Working drawings are the construction draw
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the structure, the HVAC plan, and the elec
are provided by the respective consultants
ultimate responsibility for all drawings.

Specifications

The specification is a detailed descriptic
working drawings and a form describing ge

The other plan review is the Department of Public Safety review for compliance with the regulations of the Board of Schoolhouse Structural Standards and other code-setting agencies, departments, and bureaus. It is desirable to discuss plans with the Department of Public Safety before progressing too far, but the official approval of the Supervisor of Plans can only be given to the contract documents, i.e., the working drawings and specifications. Even this approval is only provisional, depending on the findings of later field inspection.

Working Drawings

Working drawings are the construction drawings from which contractors calculate costs and later build. They must show or otherwise explain all details of construction. The more complex the building, the more drawings are needed. If details can be standardized or simplified, the number of drawings can be kept down. In general, contractors submit higher bids on jobs with many drawings. Much of the information can be reduced to schedules with only a few diagrams, the rest of the information being provided by a list of numbers or descriptive data. The working drawings for the structure, the HVAC plan, and the electric/electronic distribution plans are provided by the respective consultants. Nevertheless, the architect has ultimate responsibility for all drawings.

Specifications

The specification is a detailed description of the work. Together with the working drawings and a form describing general and special contractual provisions (frequently the standard A.I.A. Owner/Contractor Agreement form with appropriate modifications), the specifications complete the package of contract documents on which contractors bid and by which the execution of the contract is ultimately governed.

Specifications usually start with a statement of the general conditions of the contract, which deal with the responsibilities of the general contractor. The remainder of the specification is a very careful and detailed description of the construction of all parts of the building, including standards of workmanship and quality. The document supplements the working drawings, taking up where the drawings leave off. The description of work is divided into categories corresponding to those set forth in the Filed Sub-Bid Law as well as into other standard specification divisions.

Product Information

With the tens of thousands of building products in existence, management of the huge body of product data becomes difficult. There are several aids to simplify the process. One is Sweet's Architectural Catalog File. Architects may subscribe to this 13-volume compendium of products. Products are cataloged by Sweet's indexing system. The architect thus has a conveniently cataloged library of ready-to-use product data. Moreover, most architects have their own library of product catalogs, including both solicited and unsolicited literature.

Each of the above assists architects in finding products, but when an architect needs more information, he will turn to product representatives.

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Bidding

The legal implications of the bid
Chapter 1. For our purposes, an

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These salesmen stand ready to provide varying degrees of technical know-how and assistance in using and specifying their products. A knowledgeable representative may often show the architect how best to use his product.

Bidding

The legal implications of the bid procedure are described in Section V, Chapter 1. For our purposes, an outline should illustrate the basic steps:

1. Invitations to bid are published by the school building committee in various trade journals and newspapers.
2. Contractors and subcontractors, upon payment of a small refundable deposit, pick up copies of the full set of contract documents and issued bid forms without cost.
3. Subcontractors file bids on the work in their categories. These are made public and a list is sent to all who have been issued plans. The submission date is usually about three weeks after the invitation to bid.
4. On a prescribed date, a minimum of four days and usually a week later, general contractors submit their bids, which include the cost of all filed subcontracts plus all general contract work. These bids remain in force for 30 working days. The general contractors must name each subcontractor they intend to use. They are not obliged to choose the lowest subcontractor in each field, although generally it is competitively prudent for them to do so.
5. If funds are available, the lowest eligible and responsible general contractor is accepted by the school building committee.

Bond Issue Referendum and Contract Award

Upon accepting the lowest general contractor's bid, the school building committee notifies the municipal authority that the funds must be made available. The mayor or selectmen prepare a warrant or file the necessary papers with the municipal legislative body to authorize bonds for construction payments. The electorate or city council then votes on the matter, usually about three weeks after the receipt of bids. If the referendum is defeated, the project is either shelved or redesigned. If the issue is approved by two-thirds of those voting, then the school building committee notifies the SBAB of the bid contract to receive approval, and subsequently requests the approval of the Emergency Finance Board. Upon receiving these approvals, the school building committee awards the contract to the accepted general contractor.

The General Contractor's Role in the Execution of the Building Contract

Upon contract award, the general contractor takes over the leading role. He is in charge of the on-site operation and is responsible for all construction work. He is financially liable for himself and all subcontractors, but he also has the most potential for profit. He contracts for all sub-trades and controls their work on site.

Scheduling becomes one of his most important operations. The general contractor must coordinate the work of all the different trades with his own building work and with deliveries of materials. This includes ensuring that all the necessary work by one trade is done before the next one begins, or, if they are on site at the same time, coordinating their activities.

The general contractor must also have a good kn
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Construction Process

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its own operators.

The general contractor must also have a good knowledge of prices and time factors (or hire someone who does) in order to submit bids that anticipate pertinent problems regarding weather, labor market, supplies of materials, site problems, and economic outlook. A single bad oversight can throw an estimate off by an amount which could cause serious losses. Not surprisingly, the incidence of bankruptcy among contracting firms is high compared to other kinds of business.

<u>Construction Process</u>

After receiving notice from the building committee to proceed, obtaining the necessary building permits, opening his construction site office and erecting a fence around the work area, the contractor clears the site of all existing buildings, trees and other objects which stand in the way of the new building. The topsoil is then stripped from the working area and stored in a convenient place until it is replaced when the building is complete. Earthmoving equipment, usually crawler tractors, front-end loaders and small hydraulic shovels or hoes, is then brought in to excavate for the building foundations and to do any major grading required to adjust the existing ground contours to the new structure. Because of the relatively low level of investment which most contractors have made in capital equipment, many of these machines, as well as most cranes and other large equipment, are rented from firms specializing in this business, either on a fairly long-term lease or, as is frequently the case with large cranes, by the hour. In the former case, the contractor frequently provides his own operators, so that for all practical purposes the equipment is his own for the duration of the lease, but in the latter case, the equipment comes with its own operators.

Following excavation work the foundations are placed. The building structure is erected immediately after inspection of the completed foundations. Steel and precast concrete structural members can be assembled quite rapidly, since they need only to be fastened into place and then are immediately strong and able to carry loads. Cast-in-place concrete building is a much slower proposition, since formwork must be assembled and steel reinforcing rods placed prior to pouring the concrete, following which a wait of between a day and a week or more is necessary to allow the material to set up and develop strength before the forms and braces can be removed.

As the supporting members are completed, the horizontal decks are installed. Roofing is applied, exterior walls are erected and windows, doors and exterior trim are installed to complete the exterior of the building.

Meanwhile, work on the interior of the structure has been closely following the progress of the structure and enclosure. Piping, electrical conduits and mechanical work begin almost immediately with the structure, and are followed closely by wall and ceiling supports and other "buried" elements. Finish work does not begin in a given area until all the rough and dirty work has been completed, in order to minimize the occurrence of accidental damage to finish parts and materials. Walls and ceilings are installed, lighting fixtures set in, the building is painted and the finish floors are laid. Following exterior grading, paving and landscaping, and an overall cleanup, the contractor turns the completed building over to the school committee for their use.

A SURVEY OF PHYSICAL AND ECONOMIC FACTORS RELATING TO MASSACHUSETTS SCHOOLS

89

YSICAL AND ECONOMIC TO MASSACHUSETTS

iii

LEVEL OF TECHNOLOGY

CHAPTER III-1

In aggregate, the construction industry is one of the largest industries in America. The total volume of new contracts for the year 1969, approximately equal to the annual volume of completed construction, entered into by the four hundred largest firms in the field was on the order of $32 billion, with estimates of the total value of new contracts to all firms running as high as $90 billion. Despite this respectably large total dollar volume, individual construction firms are relatively small when compared to industrial companies: 273 out of the 400 largest firms contracted for less than $50 million each in new work, according to Engineering News-Record figures for 1970, and only 54 undertook new work in excess of $100 million per firm. The ten largest construction firms in the country account for just over $8 billion in new domestic contracts. By way of comparison, the ten largest industrial corporations listed in Fortune magazine's 1970 list of the 500 largest corporations aggregated sales of over $99 billion and 115 posted individual sales total over $1 billion.

The construction industry exhibits a number of unique characteristics in addition to the small size of the typical contracting company. Contractors' work loads vary widely and are extremely sensitive to overall economic conditions. Mobility is low, with most contractors, except for the largest firms, being local operators working within a half-hour to an hour's drive from their main office. This lack of mobility exacerbates the effect of local economic cycles, since a contractor in a stagnant area where little building is taking place is unlikely to be able to seek new work very far

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afield. In order to survive in such an environment, builders have generally opted to keep their capital investment in machinery, equipment and vehicles to a minimum, since labor can in theory be hired and laid off to accommodate changing work loads, while capital equipment continues to incur ownership costs whether used or lying idle. According to Engineering News-Record, in 1970 the average building contractor had an investment in capital equipment equal to only about 2 percent of its annual turnover of work.

Partly a consequence of this situation and partly the cause of it is the nature of most conventional construction. The typical building is assembled from a collection of more or less unrelated parts and materials by a large number of workers, representing as many as forty different contractors, subcontractors and suppliers. The overall process has aptly been referred to as "organized handicraft" and is remarkably similar to the way in which buildings were erected fifty and one hundred years ago and even earlier.

Most of the parts and materials from which buildings are assembled, such as bricks, pipe, wire, concrete, plasterboard, acoustical tiles and so on, are intended to serve generalized functions and are capable of being assembled into endlessly varied combinations to fit the conditions represented by a given building. This method of construction is inevitably labor-intensive. Since few, if any, parts or materials are designed specifically to fit together with any others, assembly of a building becomes a matter of extensive cutting, fitting and patching in order to solve all the interfaces and special conditions which occur. It has been estimated that as a result of this characteristic two thirds of all the labor required to construct a building is performed at the project site.

Working conditions at the typical building site are far from optimal. To give some obvious examples, at least until the building is roofed over and closed in so that it is weathertight, the progress of the work is at the mercy of the weather: too much rain or snow, low temperatures and so on can slow or even halt progress. Temporary enclosures and heating systems brought in to allow construction to proceed during inclement weather are reflected in higher contract prices. Inevitably, quality and efficiency of work are also lower. It is not feasible to work in the field to the same dimensional tolerances which can be obtained in factory situations through the use of precision jigs and closely controlled working conditions. In order to assure the construction of safe and habitable buildings, the designer must make sure that his safety factor or margin for error is great enough to include all the likely variations from his design which accompany field construction. This practice is obviously sound and necessary, but it requires the expenditure of more money to achieve the intended result.

Several factors have been active to prevent any significant change in this situation from occurring. Due to a combination of the inability of contracting firms to tie up available cash in expensive machinery and equipment, and a variety of other factors, the degree of automation in the building industry is comparatively low. Accordingly, it is not surprising that the overall productivity of construction labor has risen far less during the past decade than that of labor in other fields, where large-scale mechanization has enabled major gains in output.

Over a long period of time, an intricate system of craft labor unions and jurisdictions has developed. An idea of the complexity of this system can

be gained from the wage rate tables pub
for a recent school project in Boston,
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school and other public construction do
lost time due to friction between union

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be gained from the wage rate tables published by the Commonwealth, which, for a recent school project in Boston, listed over fifty separate trades and skills. While not all contractors use union labor, most of those doing school and other public construction do, in order to minimize the risk of lost time due to friction between union and non-union labor.

There has been a gradual refinement of the conventional building process over the years, intended to enable the productivity of the on-site labor force to increase. Larger components and subassemblies have been developed which require fewer field operations to install. Concrete block has supplanted brick, reducing the number of pieces in a masonry wall more than twelvefold. The endless list of such components also includes items like lightweight longspan steel joists, plasterboard, packaged rooftop air handling units, and prefabricated chimneys. To a certain extent, this approach has been successful in helping to increase the productivity of field labor. With larger pieces brought to the job site, the amount of field labor required to assemble them is decreased somewhat. As has been previously noted, however, these increases in productivity have not yet been comparable to those in other fields.

For most school construction projects the time required for the contractor to complete the building, from mobilization at the job site to acceptance by the owner of the finished product, runs from one and a half to two and a half years and more. Perhaps surprisingly, there appears to be only a loose correlation between project size and construction time.* A very important influence on the duration of construction is the contractor's skill at scheduling the project and coordinating the work of the various

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* See Appendix 3-1-1, "Rough determination of construction time for 23 new schools opening in September, 1970."

trades and subcontractors. A great deal of the difference between a run-of-the-mill contractor and one who does superior work is determined by this important activity.

Scheduling and coordination is a two-aspected problem. The first aspect is the relatively simple matter of task precedence, the sequence in which operations must be performed, regardless of who does them. To give an example, it is obviously not possible to paint a conventional wall until it has been installed, and it is wise not to paint it at all unless there is no activity in progress nearby which would tend to create dust and dirt. The second aspect is much more complex and involves scheduling the entire project so that two or more trades or subcontractors will never be working in the same place at the same time.* This procedure is necessitated by two major factors: (1) the conventional division of labor into trades, which work optimally when workmen can stay within the bounds of their respective specialties; and (2) the extreme fragmentation of the construction operation itself. The participation of so many subcontracting firms virtually requires that the overall project be broken down into a series of circumscribed tasks, each of which is then assigned to a subcontractor for execution. In order to determine when and how well each of these tasks is completed, it is important to keep each subcontractor as separate from the others as possible. Even when inspection is done informally by the next subcontractor, as is frequently specified,** these intrinsically complex coordination and scheduling problems place a great premium on the general contractor's project management expertise. The

* See Appendix 3-1-2, "An example of a scheduling-coordination problem."

** E.g., "The starting of work in any space will be construed as acceptance of such surfaces as being satisfactory, and any defects in this work resulting from such accepted surfaces will be corrected..." (Typical clause from specification for new Agassiz School in Boston)

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need for improved scheduling techniques can be inferred from the low correlation observed between project size and completion time, and the wide dispersion of finishing times, discussed very generally in Appendix I to this chapter and in more detail in Section III, Chapter 5.

There are available powerful tools, including CPM and PERT-type network analyses, which can greatly facilitate the scheduling and coordination of a job by a contractor.* The value of these tools was dramatically demonstrated in the federal government's development of the Polaris missile-carrying submarines. Of a degree of complexity which would make a mere building look like a kindergarten exercise by comparison, the program to conceive, design and construct a fleet of inertially-guided ballistic missiles and mobile undersea launching vehicles involved several hundred contractors and subcontractors and was carried out in less time than originally

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* CPM (Critical Path Method) and PERT (Project Evaluation and Review Technique), while differing from each other in some details, are both able to show a great deal more information about a project than is possible with conventional "bar chart" scheduling. Each individual task or activity (for instance, "Pour the floor slab in the gymnasium") is presented in relation to (1) all of the activities which must be completed in order for it to begin, and (2) all of the activities which may not begin until it is complete itself. Following estimation of the time required to perform each activity, some simple arithmetical manipulations will yield not only the total time required to complete the project, but also which activities must be done within the estimated time if the entire project is to be completed on time. This chain of activities is known as the "critical path." In practice, CPM and PERT schedules are updated monthly or more frequently in order to give an accurate picture of the progress of the job. Because of the large number of activities (on the order of two hundred) which the master schedule for a typical construction project must take into consideration, the compilation and updating of these schedules is usually performed on high-speed computers by professional consultants. Current prices for CPM service are about $1250 per million dollars of construction contract. These services include preparation of a prebid "outline" activity schedule network, development of the detailed project task schedule with the selected contractor, and monthly review and updating of the schedule until the building is completed. These services are readily available in Massachusetts.

A good introduction to the field is <u>Project Management with CPM and PERT</u>, by J. J. Moder and C. R. Phillips, published by Van Nostrand-Reinhold, New York, 1964.

thought possible, due largely to the ability of the scheduling method (PERT) to describe the progress of the entire job and all the interactions between its various components in a meaningful way. Obviously, such a tool has the potential for wide application to the building industry. It has been used on a number of construction projects, primarily large in scale, and has been very successful whenever all participants took the schedule seriously. The use of CPM and PERT in school construction, however, is comparatively rare.

In order to secure the use of CPM scheduling and similar management techniques, the owner or building committee must require their use as a condition of the contract. This is the approach used by Massachusetts Bureau of Building Construction and is beginning to be applied to public school situations; the two systems schools currently under construction in Boston are an example. Due to the specialized knowledge and data-processing facilities required to prepare and update CPM schedules, outside consultants can perform this function most efficiently. They must be paid for, however, either directly by the building committee or indirectly as part of the contractor's bid price. Consequently, the local building committee must be convinced that the costs of preparing and updating the CPM schedule will be repaid by having the school available for use earlier than would otherwise be possible. Costs due to reduced operating efficiency such as occurs when a needed school building is not available at the beginning of a school year are difficult to assess, making the cost-effectiveness of CPM scheduling hard to determine. Furthermore, even with a carefully prepared CPM schedule, there is no guarantee that the project will be completed on time.

The situation is complex; at the most rudimentary level, the contractor's fixed expenses accumulate at a steady rate whether he has a long project, a short one, or no projects at all. It is reasonable to assume that when a contractor plans to take significantly more time than his competition to

construct a building, his fixed costs will
upward, eventually to the point where he wi
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however, and most contractors doing school
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The core of the scheduling problem is found
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construct a building, his fixed costs will tend to drive his bid price upward, eventually to the point where he will cease to be competitive. The effect of overhead on a contractor's bid price is not overly significant, however, and most contractors doing school work tend to vary from project to project in the lengths of time which they require to perform the work.

The core of the scheduling problem is found in the fragmentation of the design and construction process, which provides a large number of opportunities for delays outside of the contractor's control to occur. Late decisions by the building committee, architect, engineer or other designer; untimely approvals, strikes; slowdowns or other labor disputes at the job; late delivery of needed materials; unacceptable performance by a subcontractor; unforeseen subsurface conditions and inclement weather are only a few of the more common examples of such circumstances. Accordingly, the contractor's control over his schedule is at best incomplete. With such fragmentary control over many of the basic factors affecting the time required to perform a contract, few contractors are able to accept total responsibility for on-time completion and still remain in business.

The size of the typical contracting firm which bids on the construction of new schools within the Commonwealth ranges widely. At one end of the spectrum are the small firms for which a one- or two-million-dollar elementary school is a very large project, possibly one which will require all of the firm's resources. At the other end of the scale are large firms, some of which, according to Engineering News-Record, are among the fifty largest contractors in the country. In general, the larger firms only bid projects which are sufficiently large and complex to allow them to use their more sophisticated management skills to good advantage. Additional expenses, which show up in their overhead costs, are incurred by large contractors as a result of developing and retaining sophisticated managerial skills.

Below a certain project size, which appears to be in the vicinity of $4 to $8 million, the management expertise of these large contracting firms does not return sufficient advantages to offset its greater costs. Consequently, the larger firms have historically tended not to bid public school work, leaving it to the smaller builders whose fixed costs are generally lower. Both the trend toward larger, more complex school buildings and the increasing interest in systems building techniques, with their potential for cost savings through more tightly coordinated and scheduled construction, strongly imply that the demand for professional project management will increase and that an increasing number of contractors with this ability will become involved in the construction of schools.

In summary, the process of making a new school building is fragmented at all stages, and the construction phase is probably the most fragmented of all. The existing situation has offered little incentive or assistance to contractors to modify their working and managerial methods. Accordingly, change and modernization have moved at a slow pace. The potential exists, however, for significant improvement in response to opportunities presented by the widespread introduction of systems building in Massachusetts.

LABOR MARKET AND UNIONS

CHAPTER III - 2

The Status of the Construction Labor Market

Within the construction industry today, many problems exist relative to the construction labor market, including periodic labor shortages, constantly increasing wages without corresponding increases in productivity, and chronic instability of employment. These and other factors have resulted in rapidly escalating construction costs over the last several years. This chapter will describe and analyze some of the factors within the labor market which contribute to these conditions.

Labor Shortages

During recent years, rising volumes and complexity of construction have required larger and more skilled work forces; however, in many trades traditional channels of union labor supply have been inadequate to meet this demand. The industry has made some attempts to cope with this condition by attempting to lengthen the building season, training new workers, utilizing non-union labor where possible, and implementing labor-saving innovations in the process of construction. These attempts to grow and adapt have not, however, changed the basic characteristics of the industry.

Employment remains intermittent, with work lost due to weather conditions, to the ebb and flow of demand in local markets, and traditional industry practices. A special study by the Bureau of Labor Statistics found that,

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Labor Statistics found that,

of thirteen crafts surveyed in four major areas across the nation, in no case did average annual hours worked exceed 1300 hours. It is clear that the industry continues to underutilize the bulk of the available labor force.

Seasonality continues to be a major problem. During most of the winter, a considerable volume of construction activity is either shut down or slowed and unemployment rates among the basic trades rise dramatically. During boom periods of either labor shortage or high construction activity, seasonality tends to lessen, but the construction process during the off-season is more inefficient and costly due to adverse weather conditions.

The problem of seasonality has received the primary corrective attention of government, contractors and unions for several reasons:

1. The higher incidence of adverse weather conditions and of unemployment in the industrialized states of the north and north central regions;
2. The complexity of the problem, involving all of the productive elements of the construction process both in plant and field operations;
3. The long-standing existence of seasonality as a major contributor to unemployment and peak season worker shortages;
4. Very strong and unsettling effects on inflation and economic stabilization.

Annual Employment

The annual average construction employment levels in Massachusetts have remained fairly stable for the past several years, as shown below:

Year	Number of Construction Workers
1967	77,705[1]
1968	78,358[2]
1970	77,500[3]

Note: Although the sources are different, the methods used to arrive at the figures are the same. Figures are not available for 1969.

Sources: 1 1967 Census of Construction Industries

2 1968 County Business Patterns

3 An unpublished survey by the Division of Employment of the Massachusetts Department of Labor and Industries

Approximately one-third of construction workers are employed in the industry during only one seasonal quarter of each year. This is primarily due to the seasonal variations in demand for labor. During the rest of the year, these men work at other trades of similar seasonal nature or are unemployed or on welfare. Short work years, even among the industry's major earners (those who earn all or the major part of their annual earnings in the industry) are symptomatic of many of the problems in this industry.

The annual average employment figures do not, therefore, reflect the full-level capacity of the available labor force. The magnitude of the entire statewide construction labor force is fairly clear, as can be seen in the following table and chart.

MASSAC

Annual Average Cons

by Industry

Industry Group	Establishments
Gen. Bldg Construction	2800
Highway Construction	620
Heavy	320
Plumbing, HVAC	1400
Painting	1300
Electrical	980
Masonry	560
Plast. & Lath.	200
Terrazzo & Tile	150
Carpentry	1000
Floor Work	250
Roof. & Sht Mtl Work	560
Concrete Work	230
Water Well Drilling	68
Str. Steel Erection	50
Glass & Glazing	58
Excavat. & Foundation	390
Wrecking & Demolition	75
Installing Building Equip.	29
Subdividers & Developers	110
Operative Builders	420
TOTAL	12,000

Source: 1967 Census of Constructic rounded to two significant

Note: No current series presents occupational or geographic analysis of the industry. persons with jobs on payro are a relatively insensiti zation.

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MASSACHUSETTS
Annual Average Construction Employment
by Industry Group, 1967

Industry Group	Establishments	Number of Construction Workers	Other Employees	All Employee
Gen. Bldg Construction	2800	21,000	3600	25,000
Highway Construction	620	5,700	780	6,500
Heavy	320	9,300	3600	13,000
Plumbing, HVAC	1400	8,600	1900	10,000
Painting	1300	4,800	300	5,100
Electrical	980	6,300	1000	7,300
Masonry	560	3,000	200	3,200
Plast. & Lath.	200	1,100	73	1,200
Terrazzo & Tile	150	1,000	140	1,100
Carpentry	1000	2,300	100	2,400
Floor Work	250	830	170	1,000
Roof. & Sht Mtl Work	560	3,400	560	4,000
Concrete Work	230	1,500	140	1,600
Water Well Drilling	68	200	48	250
Str. Steel Erection	50	960	84	1,000
Glass & Glazing	58	300	120	420
Excavat. & Foundation	390	1,800	240	2,000
Wrecking & Demolition	75	600	68	670
Installing Building Equip.	29	490	130	620
Subdividers & Developers	110	160	260	420
Operative Builders	420	1,400	560	2,000
TOTAL	12,000	75,000	14,000	89,000

Source: 1967 Census of Construction Industries, U.S. Bureau of the Census, rounded to two significant figures.

Note: No current series presents the employment situation in the occupational or geographical detail required for accurate analysis of the industry. Estimates of the number of persons with jobs on payrolls as of some selected pay period are a relatively insensitive measure of labor fource utilization.

The employment figures are compared to total figures for manufacturing industries by county.

MASSACHUSETTS
Distribution of Building Construction and Manufacturing
Employment by County
(All Figures in Thousands)

County	Building Construction	Manufacturing
Barnstable	2.2	1.1
Berkshire	1.4	24.0
Bristol	3.4	78.0
Dukes	0.2	-
Essex	5.9	93.0
Franklin	0.4	7.5
Hampden	5.5	65.0
Hampshire	0.9	10.0
Middlesex	20.0	170.0
Nantucket	0.2	-
Norfolk	6.7	59.0
Plymouth	2.7	21.0
Suffolk	18.0	84.0
Worcester	5.7	110.0
TOTAL	75.0	720.0

Source: The 1967 County Business Patterns and the 1967 Census of Manufacturers. All numbers rounded to two significant figures.

The following information gives the estimated composition of the building construction union labor force by trade in each county in Massachusetts for 1970:

	Barnstable	Bristol	Berkshire
General	1100	1600	630
Plumbing, HVAC	280	530	210
Painting	110	200	60
Electrical	170	360	260
Masonry	140	80	-
Lath & Plaster	-	40	-
Tile & Terrazzo	-	-	-
Fin. Carpentry	250	150	30
Roofing & Sheet Metal	-	180	120
Concrete	-	-	-
Structural Steel	-	-	-
Glass & Glazing	-	-	-
Excavation & Foundation	-	90	-
Others	150	-	72
TOTAL	2.200	3,200	1,400

	Essex	Middlesex	Nc
General	2200	7300	
Plumbing, HVAC	1200	3200	
Painting	250	1100	
Electrical	650	1700	
Masonry	350	940	
Lath & Plaster	120	570	
Tile & Terrazzo	30	200	
Finished Carpentry	310	990	
Roofing & Sheet Metal	380	910	
Concrete	80	260	
Structural Steel	20	360	
Glass & Glazing	20	150	
Excavation & Foundation	150	420	
Others	85	2000	
TOTAL	5,900	20,000	[illegible]

All numbers rounded to two significant figures.

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	Barnstable	Bristol	Berkshire	Dukes	Franklin	Hampden	Hampshire	Nantucket
General	1100	1600	630	140	150	2400	486	170
Plumbing, HVAC	280	530	210	-	50	790	85	-
Painting	110	200	60	40	60	240	-	-
Electrical	170	360	260	-	50	750	120	-
Masonry	140	80	-	-	-	260	75	-
Lath & Plaster	-	40	-	-	-	-	-	-
Tile & Terrazzo	-	-	-	-	-	-	-	-
Fin. Carpentry	250	150	30	-	-	130	20	50
Roofing & Sheet Metal	-	180	120	-	-	210	-	-
Concrete	-	-	-	-	-	80	-	-
Structural Steel	-	-	-	-	-	180	-	-
Glass & Glazing	-	-	-	-	-	-	-	-
Excavation & Foundation	-	90	-	-	-	120	-	-
Others	150	-	72	-	-	380	-	-
TOTAL	2,200	3,200	1,400	180	320	5,500	790	220

	Essex	Middlesex	Norfolk	Plymouth	Suffolk	Worcester
General	2200	7300	2200	860	6500	2200
Plumbing, HVAC	1200	3200	1600	490	3200	730
Painting	250	1100	380	180	950	240
Electrical	650	1700	730	380	2800	880
Masonry	350	940	290	210	410	290
Lath & Plaster	120	570	110	40	310	220
Tile & Terrazzo	30	200	30	20	330	-
Finished Carpentry	310	990	420	170	610	100
Roofing & Sheet Metal	380	910	240	110	510	300
Concrete	80	260	35	20	400	71
Structural Steel	20	360	25	20	350	-
Glass & Glazing	20	150	25	20	110	-
Excavation & Foundation	150	420	230	80	140	120
Others	85	2000	390	90	1200	190
TOTAL	5,900	20,000	6,700	2,700	18,000	5,300

All numbers rounded to two significant figures.

Seasonal Variations in Construction Employment

In Massachusetts. construction employment fluctuates 25% - 35% between the months of highest and lowest employment in a year. For construction workers, seasonality means unemployment and no earnings during certain months. Peak operations in the summer and fall, as well as high wages, draw workers into the construction labor force who cannot find employment in the industry during the winter.

This pattern normally results in a construction unemployment rate almost double that for the total civilian labor force across the nation or state.

Extent of Seasonal Variation in Building Construction Employment in Massachusetts: 1967

(the annual average employment for each trade - 100)

	March	May	Aug.	Nov.
General Building	78.8	99.9	114.3	101.6
Plumbing, HVAC	92.2	95.9	105.0	101.0
Painting	69.6	100.1	120.6	96.1
Electrical	90.6	93.7	105.9	105.0
Masonry	79.6	100.9	112.3	98.0
Lathing & Plastering	103.5	99.5	101.6	100.9
Tile & Terrazzo	83.3	107.5	118.6	94.0
Carpentry & Floorword	79.4	106.0	103.0	94.3
Roofing & Sheet Metal	80.8	97.2	115.1	100.6
Concrete Work	62.1	114.1	121.6	99.5
Structural Steel	84.9	106.5	118.0	87.5
Glass & Glazing	92.3	95.6	104.9	104.4
Excavation & Foundation	72.7	100.7	115.5	101.0

The differences in seasonal emplo bridges and roads) have been, how construction and about three time These differences, therefore, hav seasonal ranges for all statewide annual employment in heavy constr total. During that year, however struction employment accounted fo August shift.

The extent to which peak construc employment has declined during th across the nation. Most of the de the growth in special trades contr trical work, where seasonal varia rapidly than in other contracting can also be attributed, at least i nonresidential building constructi

In 1968, the President of the Unit federal agencies to seek to reduce In addition, the Congress has adde Act a fourth title, "Seasonal Unem the Secretaries of Labor and Comme special attention to its implicatio other factors, the federal program to which seasonal employment can be in construction costs by means suc yment

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rch	May	Aug.	Nov.
8.8	99.9	114.3	101.6
2.2	95.9	105.0	101.0
9.6	100.1	120.6	96.1
7.6	93.7	105.9	105.0
5.6	100.9	112.3	98.0
3.5	99.5	101.6	100.9
8.3	107.5	118.6	94.0
6.4	106.0	103.0	94.3
3.8	97.2	115.1	100.8
2.1	114.1	121.6	99.5
4.9	106.5	118.0	87.5
7.3	95.6	104.9	104.4
7.7	100.7	115.5	101.0

The differences in seasonal employment in heavy construction (highways, bridges and roads) have been, however, almost twice as severe as in building construction and about three times as great as in special or building trades. These differences, therefore, have affected disproportionately the total seasonal ranges for all statewide construction. In 1967, for example, annual employment in heavy construction was about 20% of the construction total. During that year, however, the seasonal fluctuation in heavy construction employment accounted for more than 40% of construction's February-August shift.

The extent to which peak construction employment has exceeded February-March employment has declined during the last five years in Massachusetts and across the nation. Most of the decline, however, can be attributed to the growth in special trades contracting such as plumbing, HVAC, and electrical work, where seasonal variations are smallest and are diminishing more rapidly than in other contracting groups. The lessening of fluctuations can also be attributed, at least in part, to the increasing importance of nonresidential building construction.

In 1968, the President of the United States issued a memorandum directing federal agencies to seek to reduce the seasonality of work on public projects. In addition, the Congress has added to the Manpower Development and Training Act a fourth title, "Seasonal Unemployment in Construction." This requires the Secretaries of Labor and Commerce to conduct a study of seasonality with special attention to its implications for national manpower planning. Among other factors, the federal program has taken into consideration the extent to which seasonal employment can be reduced without substantial increases in construction costs by means such as:

1. The application of modern techniques to reduce the influence of weather on construction activity;
2. The resolution of technical problems which have not been solved by existing research and development activities;
3. Possible changes in contract procedures and in allocation cycles; and
4. Improved planning and scheduling of construction projects.

Seasonality as an Economic and Social Problem

As an economic problem, seasonality involves underutilization of manpower and other resources. Labor shortages during peak building seasons are followed by unemployment at other times of the year. Short-term labor shortages tend to raise construction costs in peak periods while the seasonal instability of work contributes to demands for a wage scale higher than that of skilled workers in more stable industries. Additionally, the instability of employment acts in many ways to hinder manpower training and development in the industry and it also burdens the community with large socioeconomic pressures.

The seasonal peak in construction activity is normally associated with labor shortages in certain trades and regions. Labor shortages result in higher costs to contractors and owners through:

1. Lower productivity of marginal workers;
2. Payment above the scale;
3. Excessive overtime;
4. Poor quality of work produced;
5. Unanticipated delays in work; and
6. General "make work" and featherbedding practices.

Delays in construction are often ext
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Delays in construction are often extraordinarily costly--to the owner because of extended financing charges and deferred income from an operating facility, and to the contractor through penalty clauses and continuing burdens on his fixed expenses. The concentration of work in the spring and summer months tends to exaggerate the vulnerability of contracting firms to strikes by their employees and thereby to wage and other demands.

The impact of seasonality on manpower development is unfavorable. Seasonality results in a pervasive uncertainty of employment for all union members. This uncertainty is largely responsible for the negative attitudes of journeymen toward increasing the manpower supply through expanded training. Additionally, apprentices are generally laid off first by contractors during the off-season. This tends to limit both their earnings and training.

To counteract seasonality and negative attitudes, such programs as The Boston Plan and laborers' training programs have been instituted and winter work protection laws have been passed in Massachusetts.

The Boston Plan was established in June, 1970. It calls for a level of minority group representation in each of the construction trade unions that will be proportionate to the minority group percentage of the population in the geographic area covered by the agreement. It was designed to provide for the hiring of 2,000 minority members in 24 cities and towns in the Boston area over a five-year period. In addition, the Massachusetts Laborers' Training Trust Fund (one of the 24 training programs jointly administered by local unions and regional councils of the Laborers' International Union and contractor associations and partially funded by the Labor Department) has been training about thirty men a month as laborers. Both of these programs are having difficulty placing graduates into a very limited number of available positions.

Employment in trades which experience the greatest risk of seasonal unemployment is often unattractive to potential apprentices. Seasonality, then, tends to increase the difficulty of recruiting and retraining potential journeymen.

Mechanism of Employment

In many trades, labor organizations operate hiring halls, exclusive or nonexclusive,* to which the discharged worker goes to seek employment. Continuing referral from a pool of workers is the only mechanism by which job security is attainable for many journeymen. For most tradesmen, the hiring hall mechanism is imperfect, especially in periods of labor surplus. The result is considerable intermittency in employment, particularly over the course of several years. Suggestions have been made for work stabilization on a local basis by exercising tighter control over the allocation of jobs than is currently practical. For example, a guarantee might be made by employers as a group to provide minimum annual hours to an eligible group of journeymen. Efficient utilization of manpower resources will require a fresh approach to intermittency of employment. Such an approach might well include some form of work guarantee.

Stabilization of employment in construction depends critically on stabilization of the work flow. This balance can be created only by owners and their representatives. So far, owners have indicated little or no concern for problems of manpower utilization. The process of awareness comes slowly

* An exclusive hall involves a commitment by contractors to seek to hire first through the hall.

through public complaints about labo
and enforced delays of some projects
An alert owner can materially affect
ation and scheduling of large or fre

Availability of Construction Labor i

According to estimates based upon cu
number of construction specialty tra
this decade is projected as follows:

Projection of Massachu
Construction Employment b

General Building
Plumbing, HVAC
Painting
Electrical
Masonry
Lath & Plaster
Tile & Terrazzo
Carpentry
Roofing & Sheet Metal
Concrete Work
Structural Steel
Glass & Glazing
Excavation & Foundation
Others
TOTAL

Note: Estimated on the basis o

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contractors to seek to hire

through public complaints about labor shortages, increased unemployment, and enforced delays of some projects due to high costs or lack of bidders. An alert owner can materially affect the economy through proper coordination and scheduling of large or frequent projects, such as schools.

Availability of Construction Labor in Massachusetts

According to estimates based upon current census data, the approximate number of construction specialty tradesmen that will be available during this decade is projected as follows:

Projection of Massachusetts Total Building Construction Employment by Trade: 1975 and 1980

	1975	1980
General Building	28,500	29,400
Plumbing, HVAC	12,600	13,100
Painting	4,100	4,230
Electrical	9,000	9,360
Masonry	3,100	3,200
Lath & Plaster	1,500	1,550
Tile & Terrazzo	630	650
Carpentry	3,300	3,400
Roofing & Sheet Metal	3,200	3,300
Concrete Work	960	990
Structural Steel	900	940
Glass & Glazing	600	620
Excavation & Foundation	1,400	1,450
Others	4,700	4,850
TOTAL	74,490	77,040

Note: Estimated on the basis of census data.

This work force is not large enough to build what even the lowest projections of need and construction demand indicate must be built in Massachusetts in the next ten years.

The Benefits of Reducing Seasonality in Construction

The advantages resulting from the reduction of seasonality in construction will vary for the owners, contractors, skilled craftsmen and semiskilled construction workers. Expedited construction schedules will benefit owners by reducing interim financing charges and accelerating occupancy. Contractors who are able to minimize construction time should maximize profits and enhance their competitiveness in contract bidding. Stabilization of employment will, of course, benefit skilled craftsmen by providing more hours of work annually. Elimination of the seasonal pattern of work would not necessarily benefit the marginal, partially skilled workers who are now drawn into construction on a seasonal basis during peak periods. The stabilization of construction would reduce the necessity for this type of worker.

Conclusions and Recommendations

1. The construction industry is currently beset by rapidly escalating costs which are caused in part by the instability of construction activity and seasonal labor shortages.
2. Under current conditions, the projected construction work force will not be sufficient to meet the estimated demand for construction in Massachusetts over the next decade.
3. Instability of the construction economy is caused to a great extent by the seasonality of the industry. To correct this instability,

construction "users" and the industry must:

a. Take into account projections of lc in scheduling construction project
b. Through cooperation of constructior tions, and trade unions, implement to provide the basis for maximum jc teed work year";
c. Maximize work during the winter mor as soon as possible through proper systems building techniques;
d. Better coordinate the scheduling o ticularly schools) to level off pe add work to slack periods.

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construction "users" and the industry must:

a. Take into account projections of local labor market conditions in scheduling construction projects;

b. Through cooperation of construction "users," contractors' associations, and trade unions, implement a 12-month construction program to provide the basis for maximum job security through a "guaranteed work year";

c. Maximize work during the winter months by enclosing structures as soon as possible through proper scheduling and utilization of systems building techniques;

d. Better coordinate the scheduling of all public facilities (particularly schools) to level off peak construction periods and add work to slack periods.

BUILDING COSTS AND WAGES

CHAPTER III - 3

Escalation in Construction Cost

The major elements of construction costs are on-site wages, off-site wages, building material prices, overhead and profit. In recent years, the primary factor behind the large construction cost variations among cities has been the variations in local wage rates for on-site construction labor.

The impact of rising wages and material prices has been clearly felt in escalated building costs in Massachusetts as well as the rest of the Northeast region. Computed on the basis of labor and material price changes, the school building cost index given below illustrates the extent of cost escalation in Massachusetts. Through 1967, school building costs in Massachusetts rose at an annual rate in excess of 5%. Between 1968 and 1969, labor and material costs rose 8.2% and a year later they were climbing at a rate of 12% per year. A projection of the escalation which took place in school construction in Massachusetts for the period from 1966 through 1971 is as follows:

Massachusetts School Construction Index, 1965 - 1971

Year	Cost Index	Annual Change (%)
1966	100.0	(Base Year)
1967	106.5	6.5
1968	111.8	5.0
1969	121.0	8.2
1970	135.5	12.0
1971	149.1	10.0

Source: McKee-Berger-Mansueto Index using known wage rates and material prices only. These factors are weighted for the method of construction and type of school projects currently being bu
These cost indices do not take int
labor, competition or full "in-pla

Over the same period, costs for all types
the Department of Commerce Composite Cost
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material prices rose approximately 21%.

Because the wage increments are far more s
much of our discussion of construction inf
focused on wage increases. The other majo
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General Trends in Union Wage Scales

Average hourly earnings of construction wo
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1. Wage scales within each trade vary by
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2. The ratios of journeymen to laborers a
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3. Some workers shift between union and n
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4. Some craftsmen are paid at premium rat
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5 - 1971

Annual Change (%)
(Base Year)
6.5
5.0
8.2
12.0
10.0

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school projects currently being built in Massachusetts. These cost indices do not take into account available labor, competition or full "in-place" indices.

Over the same period, costs for all types of construction, as measured by the Department of Commerce Composite Cost Index, rose only about 31% across the nation. Nationally, construction labor costs increased about 65% and material prices rose approximately 21%.

Because the wage increments are far more significant than other cost factors, much of our discussion of construction inflation in this chapter will be focused on wage increases. The other major element in cost is materials, which comprises over 40% of the construction dollar; however, materials have escalated in cost far less than labor in recent years.

General Trends in Union Wage Scales

Average hourly earnings of construction workers are substantially but not entirely affected by the published level of union wage settlements. These quotations are not totally adequate for determining actual earnings or escalation for the following reasons:

1. Wage scales within each trade vary by area and by city or town and, in some cases, from contractor to contractor.
2. The ratios of journeymen to laborers and apprentices vary by trade and by area.
3. Some workers shift between union and non-union sectors of the industry.
4. Some craftsmen are paid at premium rates higher than the negotiated wage scales.

5. The negotiated wage scales do not reflect the extent of overtime work, which is compensated at premium rates.

The AFL-CIO (American Federation of Labor - Congress of Industrial Organizations) recently defended high construction wage levels on the grounds that workers in the building trades did not work the standard 2,000 hours per year. They stated that construction workers average only 1,400 hours a year. A recent survey by the Bureau of Labor Statistics on union wage scale increases suggests that between April, 1970, and April, 1971, building construction employment dropped 15% from an August-September high to a January-February low. In manufacturing, however, the variation between high and low points was estimated at about 3%.

A Bureau of Labor Statistics survey indicates that hourly union wage scales of skilled workers in building construction were uniformly higher than the average straight-time earnings of workers with the same skills in maintenance and therefore other non-union activities.

The following tabulation shows yearly rates in major trades from 1968 to 1972 for the Boston metropolitan area. Wage scale increases for the area's unionized building tradesmen averaged $ .98 an hour, or 13.8%, between 1970 and 1971. Over the same period, average union wage scales increased only $ .68 an hour, or 10.8%, in New York City. The 1969 wage scale agreements indicated in the table illustrate typical increases in wages of 42% to 52% over 1968 wage levels. The 1971 average rate of $8.06 represents a 14% increase over $7.08 for 1970. This clearly illustrates the recent pattern of rapid wage escalation in the Boston area.

Selected Wage Rates
(1968-1972 As c

Trades	Hourly Wage Rates 1968	1969	1970	1971
Bricklayers	$6.45	$6.88	$7.95	$8.80
Carpenters	5.95	6.55	6.95	7.75
Cem. Masons	6.45	6.85	7.90	8.75
Comm. Labrs.	4.20	4.35	5.15	5.85
Electricians	6.43	6.73	7.67	9.02
Str. Iron Wkrs.	5.99	6.65	7.39	8.15
Lathers	6.00	6.25	6.70	8.05
Painters	5.06	5.46	6.21	7.15
Plasterers	5.85	6.10	6.80	7.60
Plumbers	6.44	6.89	7.39	8.25
Roofers	5.90	6.25	7.00	8.05
Sht. Mtl. Wkrs.	6.19	6.44	7.49	8.49
Stm. Fitters	6.42	6.92	7.40	8.57
Average of 13 Trades	$5.95	$6.33	$7.08	$8.04

Source: MBM Survey (March, 1971)

Note: Fringe benefits are included in all

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Selected Wage Rates - Boston Metropolitan Area
(1968-1972 As of February of Each Year)

Trades	Hourly Wage Rates 1968	1969	1970	1971	1972	% Increase 68-69	69-70	70-71	71-72
Bricklayers	$6.45	$6.88	$7.95	$8.80	Expires	6%	15%	11%	--
Carpenters	5.95	6.55	6.95	7.75	$8.80	10%	6%	12%	14%
Cem. Masons	6.45	6.85	7.90	8.75	Expires	6%	15%	11%	--
Comm. Labrs.	4.20	4.35	5.15	5.85	6.60	4%	18%	14%	13%
Electricians	6.43	6.73	7.67	9.02	9.92	5%	14%	18%	10%
Str.Iron Wkrs.	5.99	6.65	7.39	8.15	Expires	11%	11%	10%	--
Lathers	6.00	6.25	6.70	8.05	8.50	4%	7%	20%	6%
Painters	5.06	5.46	6.21	7.15	8.00	8%	14%	15%	12%
Plasterers	5.85	6.10	6.80	7.60	8.00	4%	11%	12%	5%
Plumbers	6.44	6.89	7.39	8.25	8.95	7%	7%	12%	8%
Roofers	5.90	6.25	7.00	8.05	8.50	6%	12%	15%	6%
Sht. Mtl. Wkrs.	6.19	6.44	7.49	8.49	9.14	4%	16%	13%	7%
Stm. Fitters	6.42	6.92	7.40	8.57	9.00	8%	7%	16%	5%
Average of 13 Trades	$5.95	$6.33	$7.08	$8.04	--	6.4%	11.8%	13.6%	--

Source: MBM Survey (March, 1971)

Note: Fringe benefits are included in all wage rates.

In construction, union workers appear to accept employment in the non-union sectors at less than union wage scales when job opportunities are not available in the union sector. Although ho rly, daily and weekly earnings in non-union employment tend to be lower than those in unionized situations, the acceptance of a temporary non-union job boosts a worker's annual earnings.

On-Site and Off-Site Costs

Although the total labor input may be relatively large, the contribution to the total cost of building construction made by any single trade is small. Under current conventional methods, some substitution of off-site for on-site labor is possible; however, it is rarely possible to completely eliminate the need for a given trade through substitution of factory production.

The proportion of off-site labor to on-site labor is steadily rising across the nation. This is the only trend which appears to have the potential of controlling construction cost escalation.

Construction Expenditures

Figures projected by the United States Department of Commerce and the Massachusetts Department of Labor and Industries indicate that total building construction in Massachusetts in 1971 will approximate $2 billion in volume.

SCHOOL MANAGEMENT Magazine estimates that public school construction completed in 1971 in Massachusetts will equal $175.9 million in value and that new public school projects going to bid in Massachusetts in 1971 will total over $240 million.

Because of the importance of the educational share of total construction

expenditures, the U.S. Bureau of Labor Statisti studies on labor and material requirements for

Labor and Wage Factors in School Construction

At the Massachu etts level of school constructi to the Bureau of Labor Statistics study, approx of labor were required for each $1,000 of schoo 1965. This represents a decline of about 16% f of the estimated total man-hours for each $1,00 was as follows:

Primary Man-Hours, Subtotal

- Off-Site Construction
- On-Site Construction
- Transportation, Trade & Services
- Last Manufacturing Stage

Secondary Man-Hours, Subtotal

- Transportation, Trade & Services
- Other Manufacturing
- All Other Industries

TOTAL

On-site man-hour requirements varied considerably half of the projects studied had man-hour requirei 75 per $1,000 of construction expenditure. Change requirements included the following aspects:

1. An increase in labor productivity was reflect man-hour requirements per square foot of scho 1.19 in 1959 to 1.02 in 1964-1965.
2. The total value of materials used per man-hou over the same period.

expenditures, the U.S. Bureau of Labor Statistics has done a series of studies on labor and material requirements for school construction.

Labor and Wage Factors in School Construction

At the Massachusetts level of school construction expenditures, according to the Bureau of Labor Statistics study, approximately 198 man-hours of labor were required for each $1,000 of school construction in 1964-1965. This represents a decline of about 16% from 1959. The distribution of the estimated total man-hours for each $1,000 of school construction was as follows:

Primary Man-Hours, Subtotal	144
Off-Site Construction	9
On-Site Construction	72
Transportation, Trade & Services	22
Last Manufacturing Stage	41
Secondary Man-Hours, Subtotal	54
Transportation, Trade & Services	15
Other Manufacturing	27
All Other Industries	12
TOTAL	198

On-site man-hour requirements varied considerably among projects, but over half of the projects studied had man-hour requirements ranging from 55 to 75 per $1,000 of construction expenditure. Changes in on-site man-hour requirements included the following aspects:

1. An increase in labor productivity was reflected in a decrease of man-hour requirements per square foot of school construction--from 1.19 in 1959 to 1.02 in 1964-1965.
2. The total value of materials used per man-hour increased about 16% over the same period.

3. A 16% decline in total man-hour requirements for school construction over the 5½-year period indicates an annual reduction of about 2.75%.
4. The proportion of on-site wages to total contract costs remained about the same--around 26%--between the two periods, despite a 16% increase in average earnings.

The reduction in on-site man-hour requirements seems to have been related to three major factors:

1. Increased availability and use of labor-saving equipment.
2. Increased amount of prefabricated components.
3. Increased proportion of skilled workers.

A 16% gain in workers' earnings did not significantly alter the relationship of wage payments to total contract costs (25.8% in 1964-1965 compared with 25.7% in 1959). On-site wages in more than half of the projects studied fell into the range of 22.6% to 27.5% of the contract dollar. Increased wages appear to be offset by lower man-hour requirements. The results of the Bureau of Labor Statistics survey indicate a continuation of this trend in the future.

Recent Developments in Federal Policy

Along with the business downturn across the nation, the slowdown in the volume of construction activity has been widespread, reflecting an easing of inflationary pressures coming from the demand-pull side. The cost-push side of construction inflation has been persistent throughout the industry. The current and anticipated easing of inflation is, therefore, not the result of any structural changes in the industry but rather the result of fewer new construction starts.

This seems to be the implication of President Nixon's guideline policy.

To avoid a resurgence of inflation, costs, the Administration is shiftin of keeping them down, as has been de of the Davis-Bacon Act and by its re management to practice voluntary res

President Nixon issued an executiv "self-regulating system of constra at the same time as he reinstated up a tripartite committee to overs boards which are to pass on the "a fringe increases, using the criter rises with allowance for "equity a entials in some areas.

Despite federal funding and contra relies mostly on voluntary complia nor provide for roll-back of wage need for haste in implementing the measures are not likely to check s construction inflation.

Projection of Future Cost Escalati

As this is written the full effect price freeze of August 15, 1971 ar widely assumed that some type of w to remain in effect after the init of price control to be retained is the rate of escalation within the difficult to predict.

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To avoid a resurgence of inflation, especially from rising wages and other costs, the Administration is shifting toward an apparently active policy of keeping them down, as has been demonstrated by its temporary suspension of the Davis-Bacon Act and by its recommendation to construction labor and management to practice voluntary restraint.

President Nixon issued an executive order that established the so-called "self-regulating system of constraints" to curb construction inflation at the same time as he reinstated the Davis-Bacon Act. The order sets up a tripartite committee to oversee individual labor-management craft boards which are to pass on the "acceptability" of negotiated wage-fringe increases, using the criteria of productivity and cost-of-living rises with allowance for "equity adjustments" to smooth out wage differentials in some areas.

Despite federal funding and contract sanctions for violations, the order relies mostly on voluntary compliance, and does not bar strike-lockouts nor provide for roll-back of wage rates. Although keenly aware of the need for haste in implementing the stabilization plans, the federal policy measures are not likely to check substantially the cost-push side of construction inflation.

Projection of Future Cost Escalation

As this is written the full effects of President Nixon's 90-day wage/price freeze of August 15, 1971 are still largely unknown. It is widely assumed that some type of wage/price administration will continue to remain in effect after the initial 90-day period; however, the degree of price control to be retained is unknown at this time. Therefore, the rate of escalation within the construction industry is extremely difficult to predict.

Although increased labor and material costs account for a major share of escalation of contract bid prices within the industry, these factors do not account for all of the escalation.

The other important factor in building cost escalation is "market conditions"; which includes such considerations as a lack of bidding competition resulting in abnormal profits, labor shortages leading to the necessity for overtime premiums to attract men to a job, and delays which spread the work over a longer period of rising prices, and uncertainties of all types which are reflected in excessive bid contingencies.

Even before the wage/price freeze, market forces were tending to flatten the inflationary cost curve within the industry. In 1971 unemployment in the building trades in Massachusetts has been substantially higher than in recent years. Also more bidders have been competing for school construction work especially in the $5 million and under category. However, a factor that is undeterminable at this point is the effect of the expected long-term wage/price control on the wage rate levels established in current and future labor-management contracts.

It is certainly assumed that some selective, "reasonable" wage increases will be allowed but that the rampant wage increases of recent years will be curtailed. Based upon this rationale it is projected that the total escalation for the calendar year 1971 will be 10% with the escalation reduction to an average 7.5% annually for the period from 1972 through 1976. The total effect of this escalation is projected as follows:

Massachusetts School Construction Cost Index 1971 - 1976

Year	Projected Cost Index	Annual Change (%)
1971	149.1	10.0
1972	160.3	7.5
1973	172.3	7.5
1974	185.2	7.5
1975	199.1	7.5
1976	214.0	7.5

It is noted that the Design and Con
States General Services Administrat
annual rate of escalation of 10% fo
following years which roughly corre
above.

Conclusions

1. For the last five years, increa
Massachusetts have averaged 8.7
in 1970.

2. The major factor in the escalat
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3. A trend toward the substitution
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Annual Change (%)
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It is noted that the Design and Construction Division of the United States General Services Administration is currently projecting an annual rate of escalation of 10% for 1972, 8% for 1973 and 6% for the following years which roughly corresponds to the projection stated above.

Conclusions

1. For the last five years, increases in school construction costs in Massachusetts have averaged 8.7% annually, reaching a high of 12% in 1970.

2. The major factor in the escalation of the cost of school construction has been labor cost. In 1971, average rates in the construction trades in the Boston area increased a phenomenal 14% over those of 1970.

3. A trend toward the substitution of off-site labor for on-site labor has been observed in recent years. This trend appears to be the only means of restraining rapid wage-rate escalation in the industry.

4. Projected actions by the Federal Government in the field of labor are expected to reduce but not control construction cost escalation.

HOW COST IS DEFINED AND MEASURED

CHAPTER III - 4

The cost of the same school building may be any one of several different amounts, depending on what is being measured. As many school building committees have found in trying to draw meaningful comparisons, the definition of cost depends on what is included in it. To avoid ambiguity, different concepts must be distinguished from one another. The relationship between some of these concepts is illustrated in Figure 1.

Lifetime Cost

Lifetime cost is all the money which is ever spent on constructing and operating the building. It includes initial project cost plus operating costs and the cost of alterations and additions over the life of the school. This measure is useful in that a school which is inexpensive to build may be expensive to operate or to adapt to changing needs. Over the long run, the lifetime cost is more significant than the initial cost. This fact is often ignored because it is difficult to calculate the lifetime cost (especially before the school is built) and also because it is difficult to know what value should be attached to money to be spent in the future.

Total Project Cost

The project cost is the total amount that the municipality will have to pay for their school at the outset. It includes the construction contract cost plus land cost, site development, movable equipment, architect's fees, legal fees, and other initial costs. It does not, however, include an allowance

for interim finance, which is discussed
issue is floated, it usually but not alw
The cost per pupil is the total project
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Construction Contract Cost (General Cont

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is usually 70-85% of the project cost,
of the land and site development.

Total Debt Service

The debt service is the sum of all paym
the money borrowed to pay for the new b
equal to the project cost. As shown el
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for interim finance, which is discussed later in this chapter. When a bond issue is floated, it usually but not always covers the total project cost. The cost per pupil is the total project cost divided by the number of pupils, and the cost per classroom is the project cost divided by the number of classrooms.

Construction Contract Cost (General Contract Cost)

Construction contract (or general contract) cost includes only the work in the general contract, i.e., the construction of the building and the site work. Land, architect's fees, movable equipment and other non-contract costs are excluded. Square foot costs are ordinarily quoted on the basis of the general contract cost divided by the gross square footage. In some cases there is more than one general contract, but for most purposes we can refer to all construction contracts as the prime contract. The construction cost is usually 70-85% of the project cost, depending to a large extent on the cost of the land and site development.

Total Debt Service

The debt service is the sum of all payments of the principal and interest on the money borrowed to pay for the new building. The principal is usually equal to the project cost. As shown elsewhere, the interest payments over twenty years may add as much as 50-60% to the project cost. The exact amount depends on the rate and the term of the bonds (see Section II, Chapter 3).

Because the debt service is paid over a long period of time, it is misleading to try to compare the total ("cash flow") cost of debt service with money which is to be spent in the immediate future. The interest is the cost of not paying the full project cost immediately, and may be a very sound use of money. This recognizes that cash spent in the future is not as valuable as cash spent in the present, and the farther off the payment, the less valuable the payment.* In practice, this means that paying for something later is the equivalent of saving money. If anyone has the use of his money longer than he otherwise would have, then this is in itself a financial benefit.

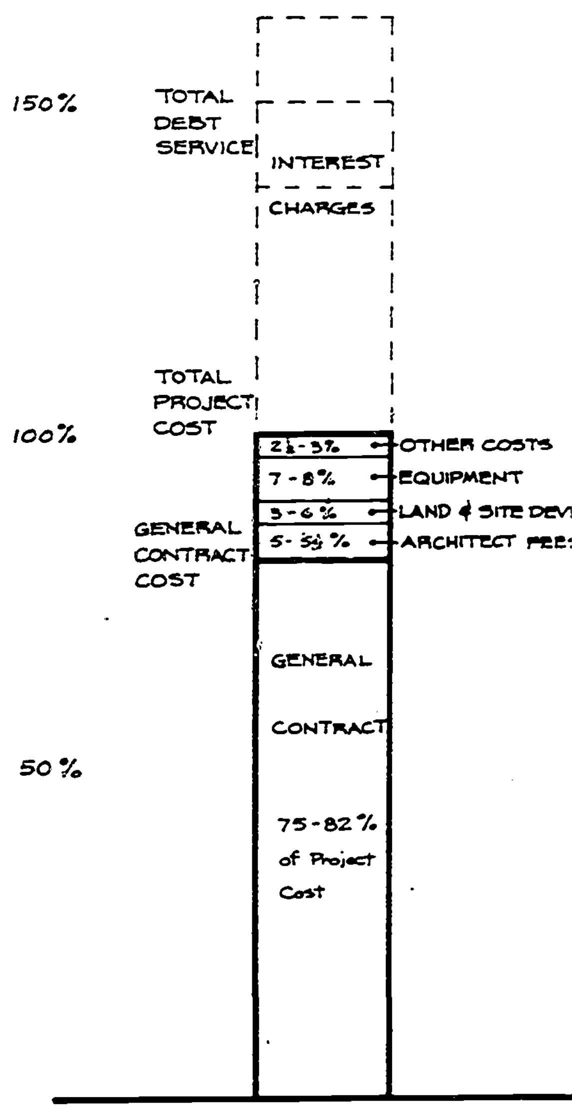
Interim Finance Cost

Interim finance or "nonproductive interest" is the interest on debt which is paid before the school becomes available for use. It is additional to the total project cost.

Strictly speaking, there is no interim finance charge if all construction payments are paid directly from the sale of the bonds. However, during construction, interest is being paid on the debt, and the town is not receiving any use from the building, so this is equivalent to the interim finance paid by any developer. As such, it increases with the length of time of construction even though the contract cost is fixed. This extra cost is very rarely recognized by building committees and may not show up on the town's books, but it is nevertheless a real cost. If a private developer were to provide a school for a town on a turnkey basis, his price would include an allowance for this. This principle is discussed and illustrated further in the Appendix. As soon as the building can be occupied, the interest may be considered productive.

It is worth noting that while in a public contract the interim finance is paid by the municipality, in private development it is paid by the developer. It is therefore very much in the interest of a private developer to minimize his construction period. The public contractor, by contrast, is always nearly fully paid for his work and consequently has no equivalent financial incentive for doing the work more rapidly.

FIGURE 1



HOW THE MONEY IS SPENT

THE COST OF SCHOOLS IN MA

* Farrell, "Planning of Capital Investments", AIA Journal, April, 1969, p.65.

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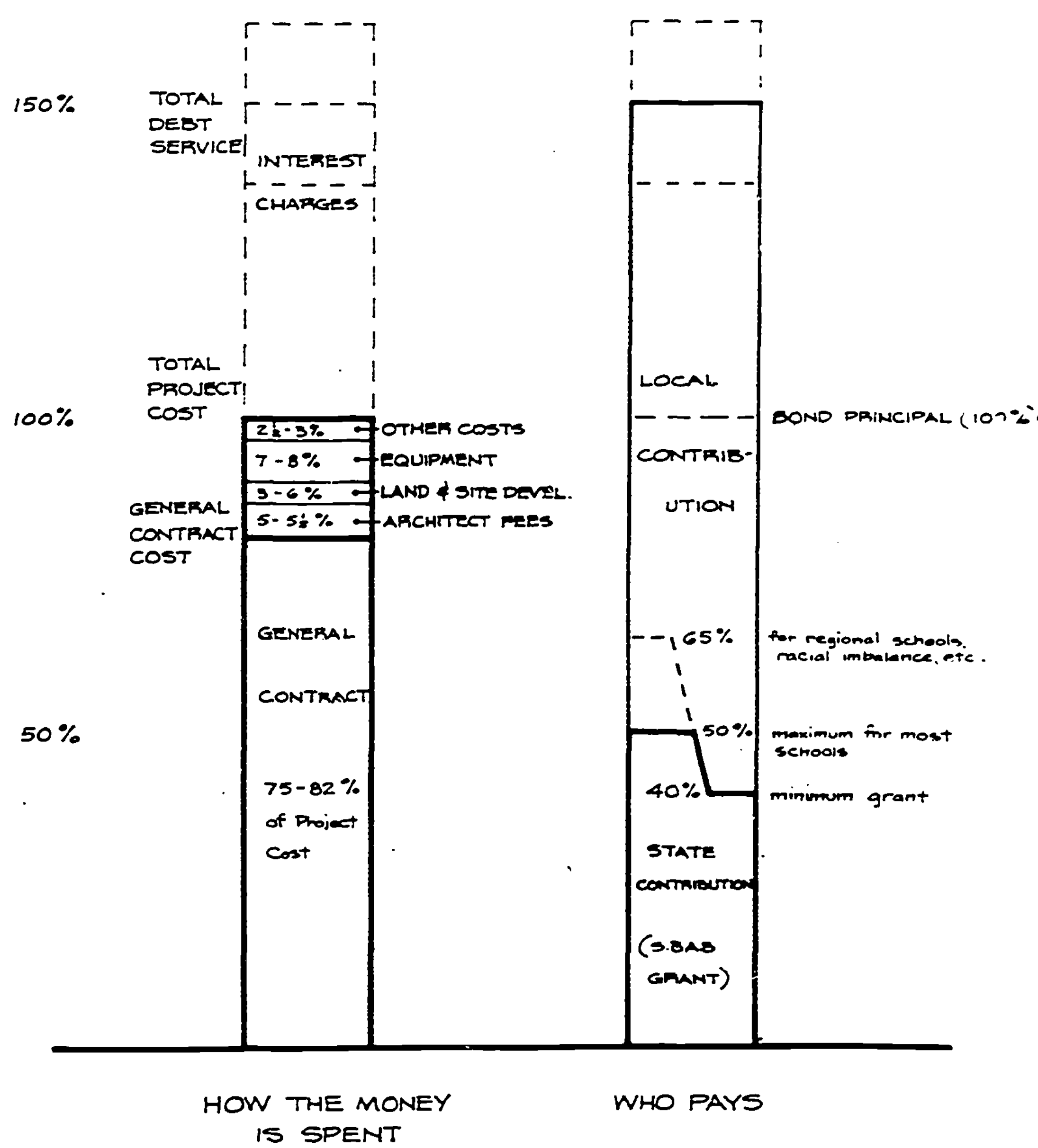
FIGURE I



THE COST OF SCHOOLS IN MASSACHUSETTS

The Cost of Escalation of Construction Costs

The cost of escalation is the amount of money by which the total project cost increases over a period of time due to inflationary changes in the prices of materials, labor, equipment. land and other construction costs.

The major effect of escalation is that it puts a premium on time. Delaying the start of a project insures that it will cost more, and any time spent on the planning, design, approval and construction of the project adds more. The later a project is built. the higher its price will be. Because of general inflation of incomes, the taxpayer's ability to pay at the later date will also be increased. Therefore, the net cost of construction escalation is the difference between the gross increase in construction costs and the increase in the general level of income.

Because the current rate of construction cost escalation is 12% per annum and the general level of inflation is about 5%, the net rate of escalation is about 7% per annum. Because contract costs will be calculated on the basis of prices which obtain at the time different parts of the job are carried out, the difference in cost for two jobs identical in every respect except that one will take a year less to build is estimated by averaging the difference in cost levels at the start of the job (which is zero) and the difference at the completion of the job (in this case. 7%). The net difference would be 3.5% for a difference of one year in construction times.

The case of simple delay is different. If two projects took equally long to construct and one started a year earlier (all phases of the job thus being a completed full year earlier), the saving would be a full 7%.

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This principle will obtain as long as construction inflation continues to outpace general inflation. If, as projected, the rate of construction inflation gradually approaches the rate for general incomes, the difference will approach zero, so that earlier construction will no longer effect a real saving.

One other point should be made. Although real savings on inflation may be made if schools are built earlier, this is only a factor if the schools are actually needed at the time they are completed. The concept of "stockpiling" schools simply in order to beat inflation would be an Alice-in-Wonderland concept of savings. A school which is being used is returning an economic benefit to the town; an empty school is not.

In other words, although it is true that significant savings on inflation are made by building one year earlier, and greater savings are made by building two years earlier, it does not follow that we should therefore build immediately in anticipation of all conceivable future needs simply in order to save on inflation! The reason is that there are other factors which more than counteract savings on inflation from earlier construction. One is the limited supply of money available at any one time to meet a vast array of needs. Furthermore, spending money earlier costs more money in interest.

Delay on construction only costs money, therefore, when completion is delayed beyond the date when the town needs the new space. Since this is currently happening, the saving applies to many schools. If, however, there were a well-planned school building program based on a statewide survey of needs and priorities, the importance of rapid planning and construction would become meaningless in terms of savings on inflation. (It could still, however, be important in terms of savings on interim finance.)

Assume, for example, that on the basis of an analysis of the state's limited resources, it is determined that the state can afford to complete a certain number of schools in 1976. If this is known well in advance, then it makes little difference in terms of inflation whether the planning and construction operation takes three years or four, since one can just as easily start in 1972 as 1973. Therefore, if the starting date can be controlled, the length of the construction period makes much less difference in terms of inflation. Naturally, this does not negate the importance of speed of construction for other considerations such as interim finance and economical use of labor.

Relative Cost to State and to School District

Of immediate interest to many taxpayers is not the total cost, but the total amount of their town's contribution, since this is directly reflected in their property tax. The proportion paid by the school district depends on the amount of the state contribution.

1. Cost to the State

Through the SBAB, the state pays a construction grant of 40-50% of the project cost to municipalities, and 40-65% to regional districts (or an average of about 50%). Since the state does not pay any of the interest, and since the total of interest and principal payments may equal about 150% of the project cost, the state's nominal 40-65% contribution really equals about 25-40% (or an average of about a third) of this total.

2. Cost to the School District

The school district pays everything which the state does not pay. This includes 35-60% (average - about 50%) of the principal plus all of the interest. The school district therefore pays about two-thirds of the total cost.

SCHOOL CONSTRUCTION COST SURVEY

CHAPTER III - 5

Introduction

Massachusetts cities and towns spend approximately 60% of all municipal funds allocated for construction on public schools. This chapter examines the results of contract bidding on conventional public school construction throughout Massachusetts with the following objectives in mind:

1. To determine the cost of public schools being constructed today by conventional methods;
2. To determine the current trends in Massachusetts construction costs;
3. To compare Massachusetts costs and trends with those of other geographical regions;
4. To determine the elemental cost characteristics of schools currently being built in Massachusetts;
5. To provide a basis for comparison of current construction costs with the costs of schools which might be constructed in Massachusetts in the near future utilizing systems building technology as such technology is currently being utilized in other states.

The results of the research for this chapter provide some long-sought answers to questions on the status of school construction costs in Massachusetts today.

Method of Analysis

Basic Approach: In considering the method of cost analysis of schools in Massachusetts, it was thought reasonable to divide the total sample of schools surveyed into subgroups with similar characteristics. It was decided that, for

analytical purposes, the most logic

1. Urban high schools (& vocation
2. Urban elementary and middle sc
3. Suburban and rural high school
4. Suburban and rural elementary

This breakdown was ultimately chose analysis within this chapter.

Data Base: The basic data on const sources:

1. Directly from the existing con
2. From the cost data files maint
3. Through data made available by Bureau.
4. From data obtained from cooper conducted by MBM cost engineer

Through these sources, cost informa struction projects bid since 1965. could not be used because they were to be non-representative.

After careful screening for applica reduced to 118 Massachusetts school follows:

1. Urban high schools:
2. Urban elementary and middle sc
3. Suburban and rural high school

:TION COST SURVEY

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e to divide the total sample of schools
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1. Urban high schools (& vocational-technical schools).
2. Urban elementary and middle schools.
3. Suburban and rural high schools (& vocational-technical schools).
4. Suburban and rural elementary and middle schools.

This breakdown was ultimately chosen and used as the format for statistical analysis within this chapter.

Data Base: The basic data on construction cost was obtained from the following sources:

1. Directly from the existing construction cost files of MBM where applicable.
2. From the cost data files maintained by F.W. Dodge Company.
3. Through data made available by the Massachusetts School Building Assistance Bureau.
4. From data obtained from cooperating school architects through surveys conducted by MBM cost engineers specially for this project.

Through these sources, cost information was derived on 180 separate school construction projects bid since 1965. However, the data on many of these projects could not be used because they were either questionable, incomplete or determined to be non-representative.

After careful screening for applicability the bank of useable cost data was reduced to 118 Massachusetts schools and distributed among the subgroupings as follows:

1.	Urban high schools:	15 samples
2.	Urban elementary and middle schools:	17 samples
3.	Suburban ard rural high schools:	36 samples

4. Suburban and rural elementary and middle schools: 50 samples

These raw data samples were generally lists of the filed sub-bid and general bid results obtained from the "lowest responsible bidders" on each school construction project within the sample. These bid results were then tabulated in matrix form indicating all data pertinent for cost analysis.

These matrices are as follows:

1. Construction cost breakdown for selected urban high schools (including vocational-technical schools)(Appendix Exhibit 1).
2. Construction cost breakdown for selected urban elementary and middle schools (Appendix Exhibit 2).
3. Construction cost breakdown for selected suburban high schools (including vocational-technical schools) (Appendix Exhibit 3).
4. Construction cost breakdown for selected suburban elementary and middle schools (Appendix Exhibit 4).

The location of each of the schools included in these exhibits is plotted on the location map of all schools included in samples (Exhibit 5).

The results of these analyses are summarized in a composite of construction cost data on all 118 schools in the sample (Appendix Exhibit 6).

Cost Breakdown by Building Element: After development of the cost data based on general and sub-bid results, these data were redistributed by statistical means to 16 identifiable building sub-systems or "elements" which, together, comprise the entire school buildings. The purposes for conversion of the data into the elemental breakdown are for better analysis of the composition of the school buildings examined and for comparison in later chapters of this study with the costs of schools contemplated utilizing systems building techniques.

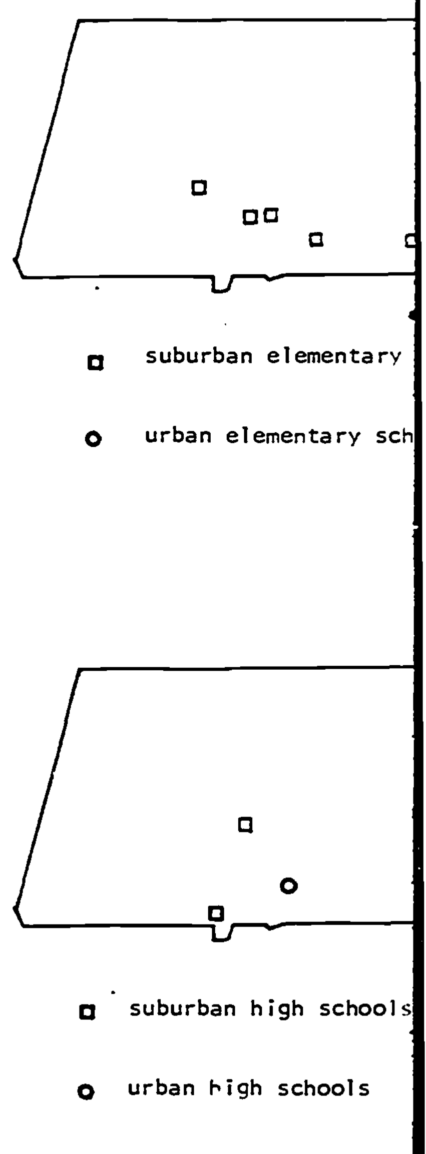

Exhibit 5 Location map of al

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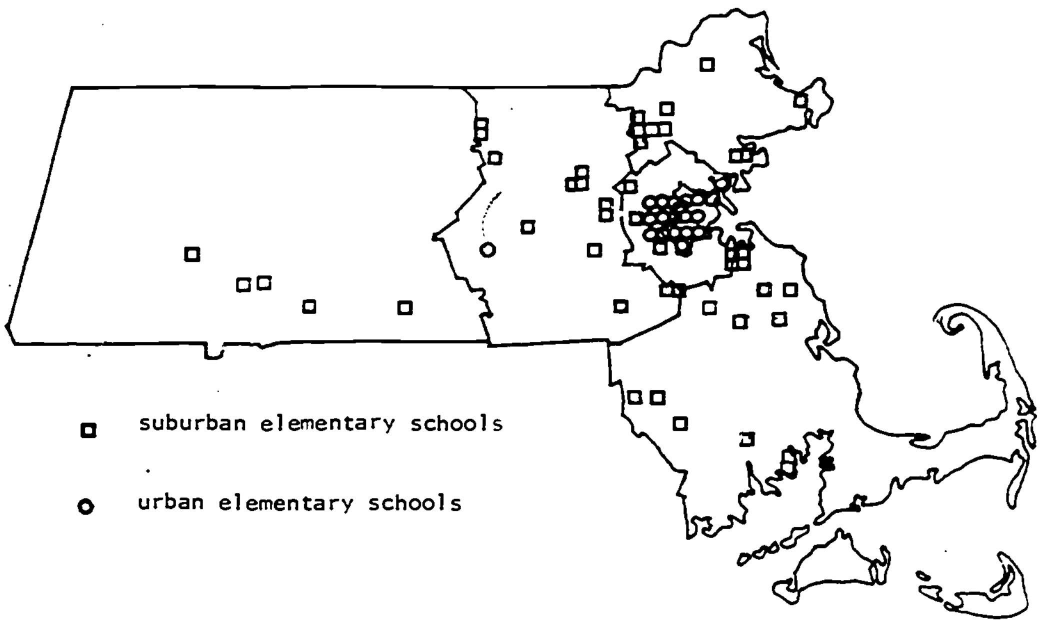

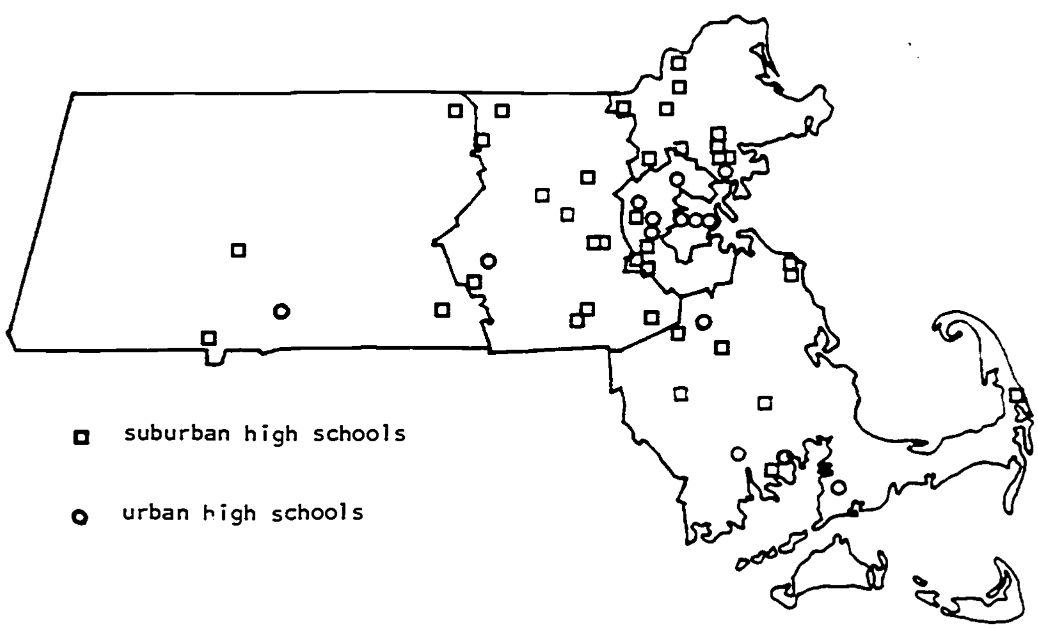

Exhibit 5 Location map of all schools included in sample

Comparison with Costs in Other States: In order to correlate Massachusetts school construction costs and trends with costs and trends in neighboring states and the nation as a whole, reference was made to the national cost of building index published annually by SCHOOL MANAGEMENT Magazine. This index is developed primarily through questionnaires sent to school administrators throughout the country and is based upon their responses. The SCHOOL MANAGEMENT findings are considered to be the most authoritative source of data on national school construction volume and cost trends. The use of the SCHOOL MANAGEMENT Magazine data is gratefully acknowledged.

Constraints: In conducting this study the research staff often encountered confusion and lack of standardization in the reporting of factors used in reaching cost conclusions. For example, although the American Institute of Architects has developed specific procedures for determining and reporting net and gross square footage, there appears to be wide deviation from these standard procedures by many architects. Also there appear to be broadly varying interpretations between educators and designers as to the term "classroom." The increasing emphasis on "open plan" design tends to exacerbate this problem. The criteria for determination of school population also appear to vary from designer to designer with similar effects on cost reporting. Because of these apparent inconsistencies in reporting data, this chapter does not attempt to provide cost information on the basis of classrooms.

Findings

Current Costs of Construction Based upon Survey of 118 Representative Massachusetts Schools (June 1971 Dollars):

1. The size in dollars of the average composite model school construction project is $4,783,920

2. The average school cost per pup

3. The current average cost of sch for all types of schools

4. The current average cost of sch

a. Urban high schools:

b. Suburban high schools:

c. Urban elementary and middle

d. Suburban elementary and mid (All above data from Appen

Significant General Characteristics as Noted by Survey:

In examining the cost per classroom ranges and averages have been ascert suburban schools are smaller in the project size and cost per square foo same relationship exists between ele both in the suburbs and the cities.

1. The average of all schools surv stated academic classroom count stations in addition to classro tion is 26 pupils per classroom (Appendix Exhibit 6).

2. On the average, slightly over 5 chargeable to the subcontractor (Appendix Exhibit 6).

3. The average urban school tends pupils per school than suburban

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2. The average school cost per pupil is $4,911

3. The current average cost of school construction is $35.25 per square foot for all types of schools

4. The current average cost of schools by major subgroup is as follows:

a.	Urban high schools:	$38.76/sq.ft.
b.	Suburban high schools:	$33.01/sq.ft.
c.	Urban elementary and middle schools:	$39.94/sq.ft.
d.	Suburban elementary and middle schools: (All above data from Appendix Exhibit 6)	$32.75/sq.ft.

<u>Significant General Characteristics of 118 Representative Massachusetts Schools as Noted by Survey</u>:

In examining the cost per classroom and cost per pupil of Massachusetts schools, ranges and averages have been ascertained. These statistics indicate that suburban schools are smaller in the number of classrooms, total population, project size and cost per square foot than are their urban counterparts. The same relationship exists between elementary and high school sizes and costs, both in the suburbs and the cities.

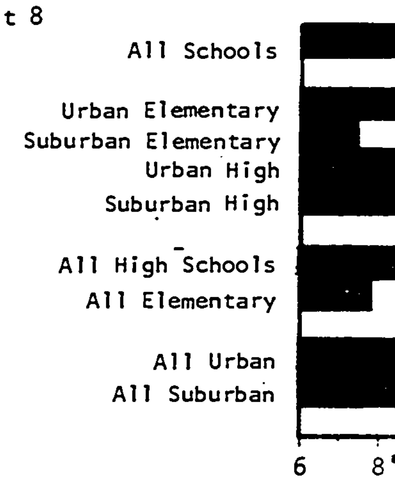
1. The average of all schools surveyed accommodates 966 pupils and has a stated academic classroom count of 31 (but presumably has other teaching stations in addition to classrooms stated). The nominal average population is 26 pupils per classroom with a ratio of 136 sq. ft. per pupil (Appendix Exhibit 6).

2. On the average, slightly over 50% of the school construction cost is chargeable to the subcontractors representing the respective sub trades (Appendix Exhibit 6).

3. The average urban school tends to be considerably larger in average number of pupils per school than suburban schools(Exhibit 8, Appendix Exhibit 6).

4. The average urban high school surveyed is 180,342 square feet in size, has 58 academic classrooms, and accommodates 1,736 pupils (Appendix Exhibit 6).
5. The average suburban high school surveyed is 180,230 square feet in size, has 31 academic classrooms, accommodates 1,014 pupils (Appendix Exhibit 6).
6. The average urban elementary and middle school surveyed is 114,117 square feet in size, has 35 academic classrooms, accommodates 860 pupils (Appendix Exhibit 6).
7. The average suburban elementary and middle school is 70,650 square feet in size, has 26 academic classrooms and accommodates 728 pupils (Appendix Ex. 6).
8. In the years 1969, 1970 and 1971, the size mode for projects studied has tended to be between $1 million and $6 million (Exhibit 7). The tendency, however, is toward larger average projects each year.
9. Urban high schools surveyed tended to be far larger in pupil capacity and number of academic classrooms than all other schools (Exhibit 8, Appendix Ex.6).
10. The square foot area per pupil in all high schools and urban elementary schools surveyed is considerably greater than the area per pupil in suburban elementary schools (Exhibit 9, Appendix Exhibit 6).
11. The cost per pupil of all categories of schools surveyed (average $4,911) is comparable except for suburban elementary schools, which tend to cost considerably less (average $3,086) than all other types of schools surveyed (Exhibit 10, Appendix Exhibit 6).
12. At present rates of escalation and under present methods, the cost per square foot for all schools will double over current costs by 1980 (Appendix Exhibit 11).

Exhibit 8



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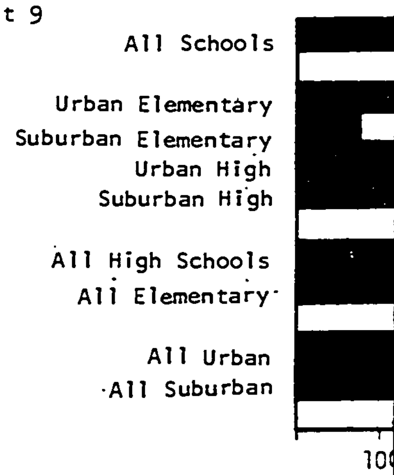

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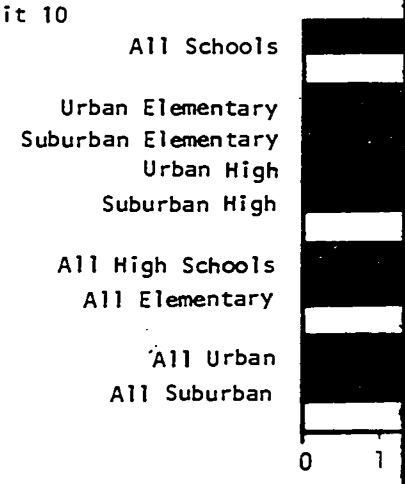

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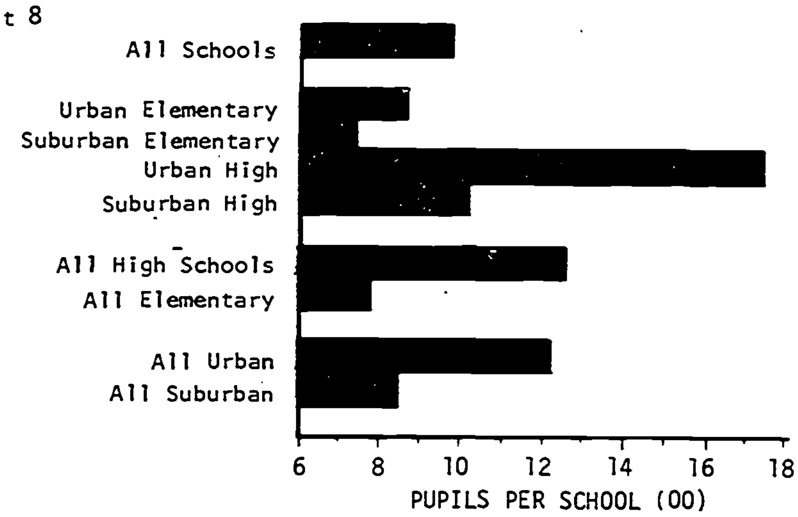

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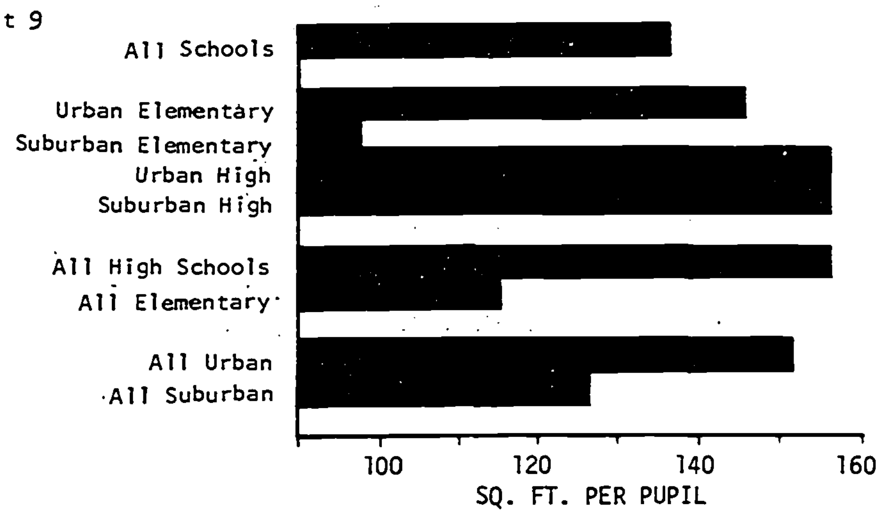
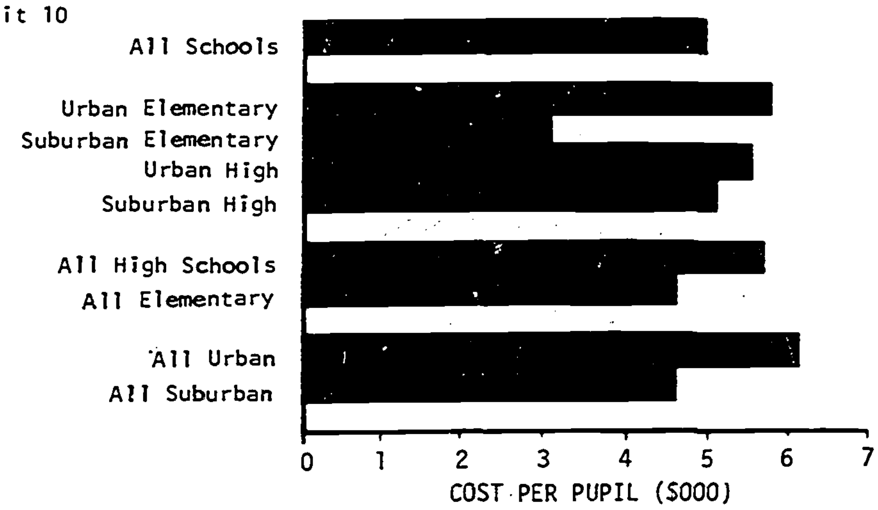


Exhibit 10



Correlation of Massachusetts School Construction Costs with National School Construction Costs and Costs in Other States According to SCHOOL MANAGEMENT Magazine Building Cost Statistics Projected for 1971:*

1. National Correlation:

a. Average Cost per Project (Project Size):

Massachusetts:	$3,455,000
National Average:	$2,020,000
Massachusetts as a % of the National Average:	171%

b. Average Cost per Pupil:

Massachusetts:	$3,800
National Average:	$2,400
Massachusetts as a % of the National Average:	159%

c. Total New School Construction:

Massachusetts:	$175,932,000
National:	$2,742,472,000
Massachusetts as a % of the National:	6.4%

d. Number of Pupils Accommodated in New Schools:

Massachusetts:	45,300
National:	1,048,800
Massachusetts as a % of the National:	4.3%

* Includes only new elementary and secondary schools projected for completion in 1971 and excludes all starts projected and all additions to existing buildings, rounded to nearest $100.

d. Number of Pupils Accommodated ir

Massachusetts:

National:

Massachusetts as a % of the National:

2. Regional Correlation:

a. Average Cost per Project (Projec

Massachusetts:

Regional Average

Massachusetts as a % of the Regional Average:

b. Cost Per Pupil:

Massachusetts:

Regional Average:

Massachusetts as a % of the Regional Average:

c. Total New Construction:

Massachusetts:

Region:

Massachusetts as a % of the Region:

d. Number of Pupils Accommodated i

Massachusetts:

Region:

Massachusetts as a % of the Region:

d. Number of Pupils Accommodated in New Schools:

Massachusetts:	45,300
National:	1,048,800
Massachusetts as a % of the National:	4.3%

2. Regional Correlation:

a. Average Cost per Project (Project Size):

Massachusetts:	$3,455,000
Regional Average	$3,176,000
Massachusetts as a % of the Regional Average:	109%

b. Cost Per Pupil:

Massachusetts:	$3,800
Regional Average:	$3,500
Massachusetts as a % of the Regional Average:	109%

c. Total New Construction:

Massachusetts:	$175,932,000
Region:	$380,666,000
Massachusetts as a % of the Region:	46%

d. Number of Pupils Accommodated in New Schools:

Massachusetts:	45,300
Region:	107,700
Massachusetts as a % of the Region:	43%

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to SCHOOL MANAGEMENT

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$2,400
159%
$175,932,000
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6.4%
:
45,300
1,048,800
4.3%

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dditions to existing

School Construction Cost Trends Observed in Massachusetts, 1967-1971
Based Upon SCHOOL MANAGEMENT Magazine Building Cost Statistics:*

	1967	1968	1969	1970	1971
Total New School Construction Reported: (S000):	87,800	98,033	141,331	83,597	175,932
Total Number of New Projects Undertaken:	60	59	64	29	48
Average Cost Per Pupil (S):	2,311 (100%)	2,290 (99%)	2,276 (121%)	3,418 (148%)	3,883 (168%)
Total Number of Pupils Accommodated:	38,031	42,809	50,555	24,461	45,310
Average Cost per Project (S000):	1,465 (100%)	1,662 (113%)	2,208 (151%)	2,883 (197%)	3,665 (250%)

Conclusions and Recommendations

It is readily apparent from the findings set forth above that Massachusetts is paying more than other states for its schools and that the trends toward higher costs in this state must be reversed. These findings suggest the following conclusions and recommendations for action to control school construction costs:

1. Project Size: The findings indicate a growing gendency toward fewer but larger projects and suggest that project size may be a causal factor in creating higher costs per square foot and per pupil. The economies of scale which would normally be expected on large projects are apparently offset consistently by the effects of absence of sufficient competition

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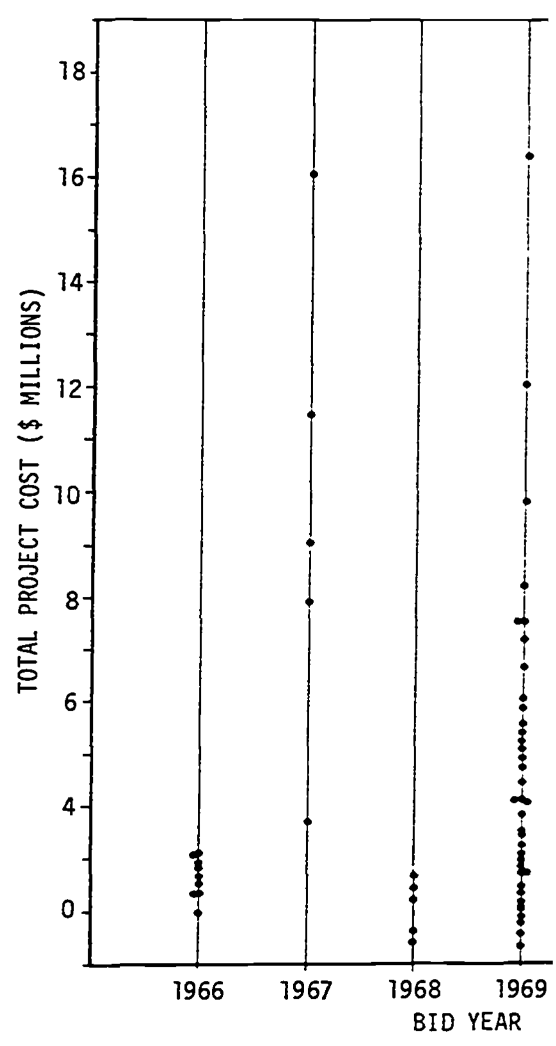
* Includes only new elementary and secondary schools and excludes all additions to existing schools. 1971 figures include only projects scheduled for completion during the calendar year and excludes all new projects started in 1971.

Exhibit 7 DISTRIBUTION OF PROJECT SIZE FOR



Source: M.B.M. Surv

setts, 1967-1971
Statistics:*

	1970	1971
	83,597	175,932
	29	48
	3,418 (148%)	3,883 (168%)
	24,461	45,310
	2,883 (197%)	3,665 (250%)

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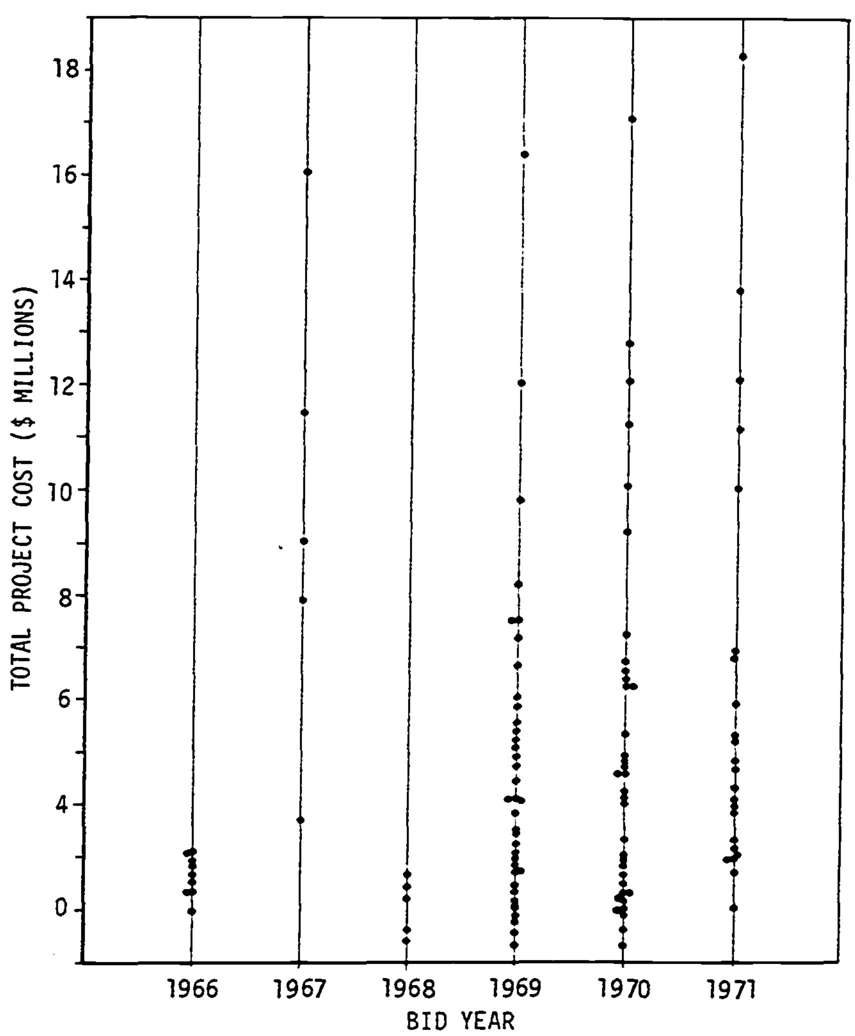
Exhibit 7 DISTRIBUTION OF PROJECT SIZE FOR ALL SCHOOLS IN SAMPLE



Source: M.B.M. Survey of 118 Massachusetts Schools among building contractors. It is readily conceded within the construction industry that as projects exceed $5 million in size the number of contractors with the capability to compete (and most particularly bonding capability) decreases drastically. Therefore, it must be concluded that, in order to control costs, projects will either have to be sized within the limits of reasonable competition or special efforts must be made during the bidding process to ensure strong competition.

2. Project Timing: As described in detail in the following chapter, the timing of projects is extremely critical. The time of the year in which projects are bid and construction is scheduled can have significant impact on costs because of seasonal competitive factors in the market, the availability of labor, and price escalation. Careful scheduling can take advantage of more competitive market conditions and optimize the seasonal factors in construction. Above all, any delay for any reason tends to increase cost in the particularly inflationary economy of the construction industry.

3. Filed Sub-bid Statutes: As noted elsewhere in this report, the Massachusetts procedure causing the general contractor to utilize the services of the lowest filed sub-bidder often increases rather than decreases project cost. Ideally, there should be maximum teamwork and cooperation between the general contractor and all subcontractors to maximize efficiency and minimize cost. In many cases subcontractors with poor reputations for ability and efficiency are imposed upon the general contractors bidding a job, and because of these poor reputations all of the general contractors feel compelled to increase their contingency factors resulting in higher contract bids.

4. Architectural Fees: The prevalent method of determining design fees affects cost adversely. In most cases the architect's fees equal a fixed

percentage of the bid price. Under this s
incentive for the architect to help in rec
fixed fee with bonuses for cost reduction
to the designer to reduce project costs.

5. Contract Documents: The quality, format,
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increase their contingency factors rather
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within the various sub-bids. To correct t
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6. Project Management: The professional capa
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Effective coordination of these discipline

In conclusion it may be stated that anything wh
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percentage of the bid price. Under this structure, there is no positive incentive for the architect to help in reducing construction costs. A fixed fee with bonuses for cost reduction would be a positive incentive to the designer to reduce project costs.

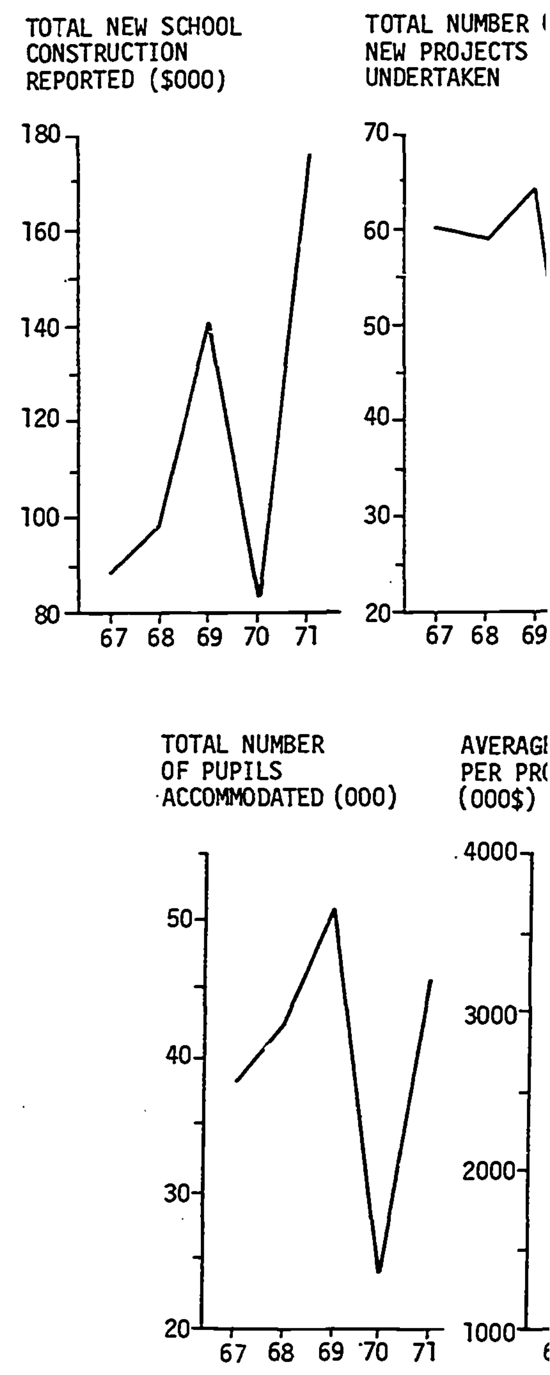
5. Contract Documents: The quality, format, and readability of the plans and specifications significantly affect bid prices. Contractors who do not completely understand specifications often, in their haste, tend to increase their contingency factors rather than taking the time to clarify the meaning of the specifications. Also under the current practices of many school designers there is no consistency as to what is to be included within the various sub-bids. To correct these conditions contract documents must be clarified and instructions to bidders must be standardized.

6. Project Management: The professional capability, dedication, commitment, and level of personal involvement of the architect, engineers, contractors, and school building committee are critical to the success of the project. Effective coordination of these disciplines is also vital to the project.

In conclusion it may be stated that anything which can be done to control and reduce the impact of these factors, individually or collectively, will reduce the cost of school construction.

INDEX OF SUPPORTING EXHIBITS

Exhibit 14 MASSACHUSETTS CONSTRUCTION TRE



Source: School Management Magazine - July

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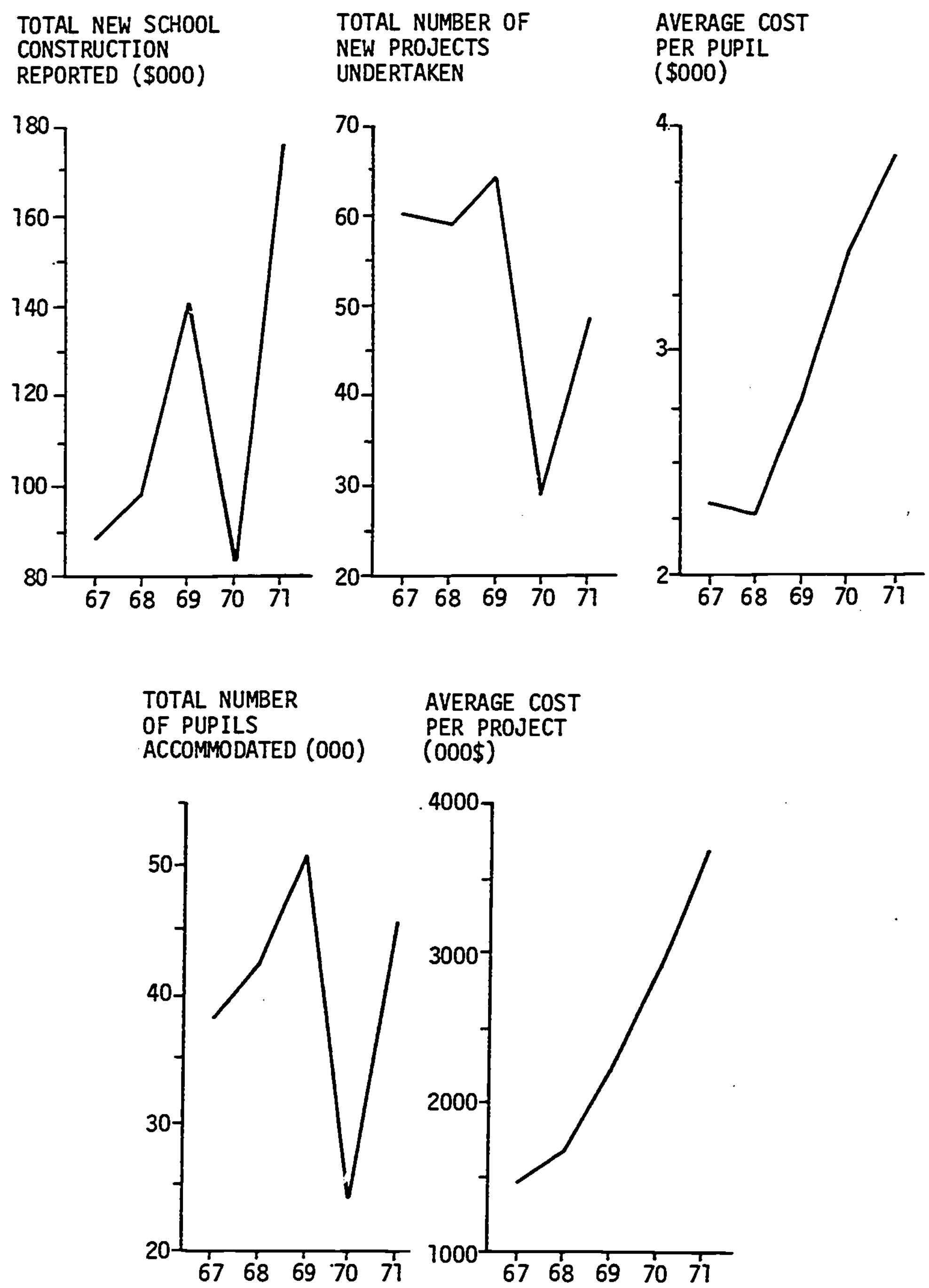
Exhibit 14 MASSACHUSETTS CONSTRUCTION TRENDS



Source: <u>School Management Magazine</u> - July '69, July '70 & June '71.

SCHOOL CONSTRUCTION TIME SURVEY

CHAPTER III - 6

Introduction

Two general observations are most frequently made about the schools built in the Commonwealth in the past five years:

1. Schools cost too much; and
2. Schools take too long to design and build.

The continuation of present economic trends will not reduce school costs. The perpetuation of current practices in their design and construction will not lessen the time required to build them. The cost factors are discussed in detail elsewhere in this study; the time aspects are the subject of this chapter. However, since time and cost are closely related, the longer it takes to design and build a school, the less can be bought for the budget dollar.

To determine just how severe the problem is, a 50-project sample was selected from the projects completed in the Commonwealth over the past five years. Of the projects surveyed, 67 percent finished later than the time initially allotted. Therefore, either the times allocated for the projects were insufficient or a variety of other circumstances prohibited timely completion. Further, of the projects not completed on time, the average time overrun was 35 to 40 percent.

The survey indicated that, to a greater or lesser degree, construction time varied with:

1. Size (and hence total cost);
2. Complexity (and thus unit cost
3. Effectiveness of management pr

These factors are examined in detail in this length of the overall design and construction sions are drawn concerning the implications o are made which, if adopted, could decrease pr project cost, and significantly enhance actua

Design and Construction Time as a Function of

It i- the general practice in Massachusetts, architect to allocate design and construction In other words, the larger the project, the m design and construction processes. Figures I depict the actual times taken for designing a projects examined for this study. From these several schools of the same size can vary sig to design and build them.

Further, schools of different sizes can requi time to build. Time increases as a function general way. Consequently, it is most diffic project should take if one considers only its

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1. Size (and hence total cost);
2. Complexity (and thus unit cost); and
3. Effectiveness of management practices.

These factors are examined in detail in this chapter and their impact on the length of the overall design and construction process is evaluated. Conclusions are drawn concerning the implications of this survey and recommendations are made which, if adopted, could decrease project time, reduce the overall project cost, and significantly enhance actual performance.

Design and Construction Time as a Function of Project Size

It is the general practice in Massachusetts, as in most other states, for the architect to allocate design and construction time in accordance with size. In other words, the larger the project, the more time is allocated for the design and construction processes. Figures I, II, and III graphically depict the actual times taken for designing and constructing the school projects examined for this study. From these graphs it is obvious that several schools of the same size can vary significantly in the time taken to design and build them.

Further, schools of different sizes can require virtually the same amount of time to build. Time increases as a function of project size only in a very general way. Consequently, it is most difficult to estimate how long a project should take if one considers only its size.

Design and Construction Time as a Function of Project Complexity

Referring again to Figures I, II, and III, it is clear that it is equally difficult to draw hard conclusions on the time-versus-complexity relationship. Two schools of comparable size and complexity varied by as much as 60 percent in the time required to design and build them. Further, two schools of similar complexity but varying size took approximately the same amount of time to design and build. To make the study even more confusing, the larger of two schools, in some instances, took less time to complete than the smaller school. Consequently, project complexity is not, in all cases, a valid measure of the design and construction time required.

Design and Construction Time as a Function of Management Practices

The most glaring fault discerned in this survey is the almost total lack of effective management. Improvement of management techniques could significantly affect the design and construction time of schools and reduce costs. The fault, however, lies more in the system than in any of the parties involved. In the following paragraphs, the problems are identified and their impact on project time is assessed.

The local school board's actions in the management process have several areas of impact. The determination of the need to build a school appears to be as much a political process as it is an educational one. Referendum timing is certainly more the result of a political decision than an economic one. Indeed, in most instances, the local school board is not even aware of the economic aspects of a referendum, despite the fact that quite often the economic factors could be invaluable in supporting the timing of a referendum to evoke positive voter response. There is no emphasis given to an order of priorities, the importance of timely decision-making, or the need for positive action.

SIZE AND TIME COMPARISONS

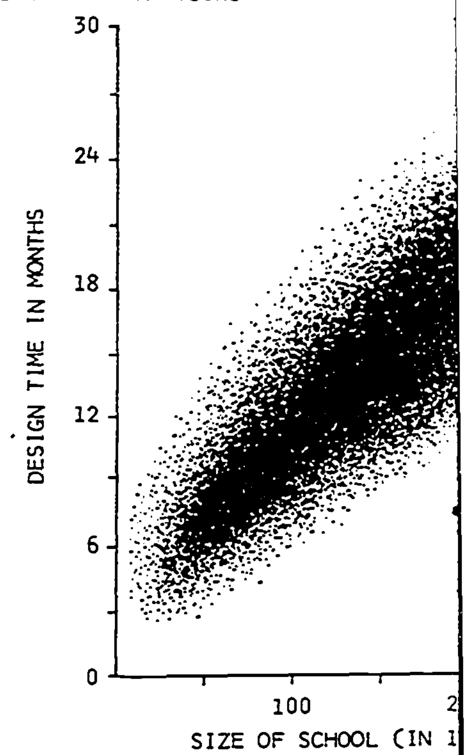

Figure 1

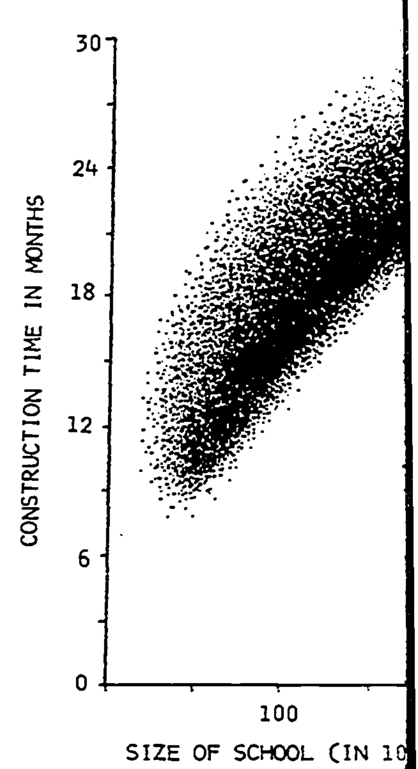

Figure 2

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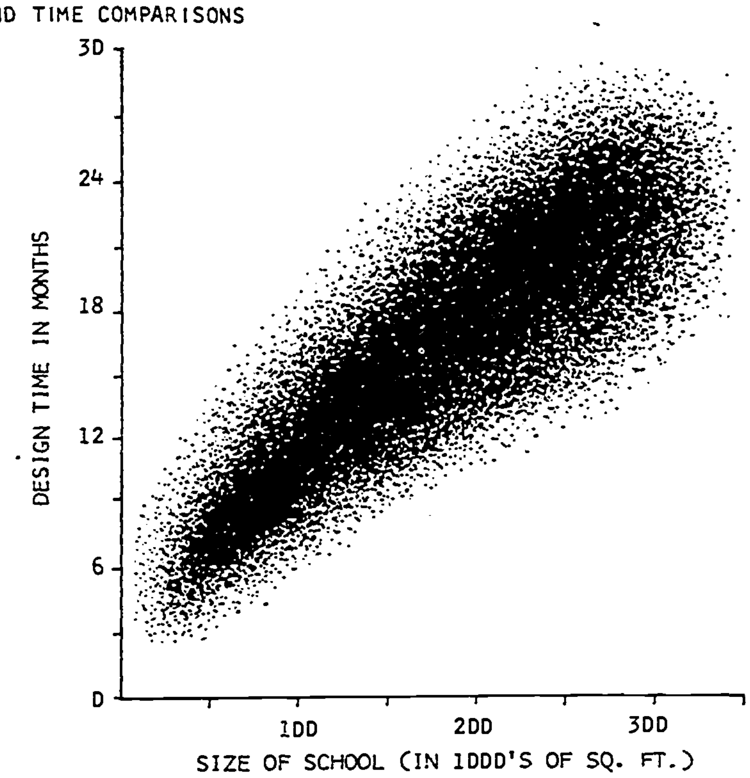

Figure 1

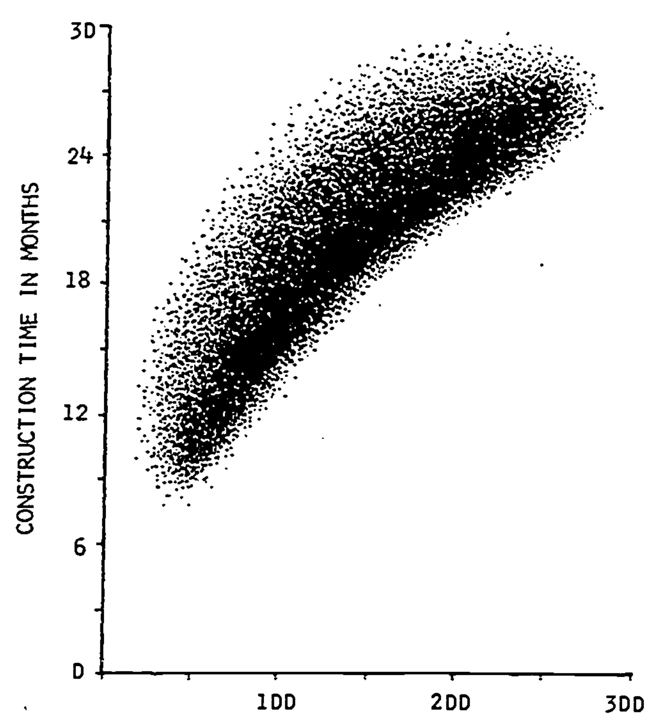

Figure 2

SIZE AND TIME COMPARISONS

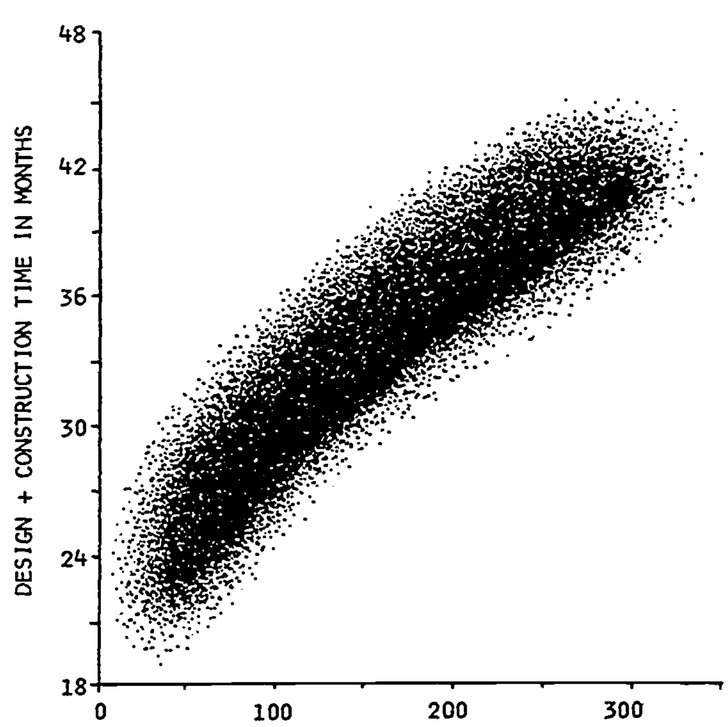

Figure 3

From the above it must be obvious that the school board can serve to delay design and The reasons for these delays range through commitment. From the development of educat definition, from scope development to desi the building process, the local school boa point can serve to lengthen the overall ti increase the cost.

The architect's design process is basicall the design process normally represents no r required to prepare the contract documents. the time is used to prepare the working dr into terms of brick and mortar. In genera the manpower required to execute the worki preparation. Since the average local scho the ability to analyze the architect's pro reluctant to suggest that the designer mig

When entering into an agreement with an ar none of the local school boards surveyed r selves to prepare a schedule which set a d the architects were reluctant to make a co the significant milestones within the desi no method available for the architects to staffs nor to report on their progress to periodic basis.

ND TIME COMPARISONS

From the above it must be obvious that the decisions and actions of the local school board can serve to delay design and construction time significantly. The reasons for these delays range through the entire spectrum of owner commitment. From the development of educational specifications to budget definition, from scope development to design review and ultimately through the building process, the local school board's dilatory actions at any point can serve to lengthen the overall time required and ultimately to increase the cost.

The architect's design process is basically an evolutionary one. However, the design process normally represents no more than one-third of the time required to prepare the contract documents. The remaining two-thirds of the time is used to prepare the working drawings, which translate the design into terms of brick and mortar. In general, more effective management of the manpower required to execute the working drawings could speed up their preparation. Since the average local school board does not normally possess the ability to analyze the architect's progress, its members are consequently reluctant to suggest that the designer might accelerate his progress.

When entering into an agreement with an architect for the design of a school, none of the local school boards surveyed required the architect or themselves to prepare a schedule which set a design completion date. Further, the architects were reluctant to make a commitment concerning the timing of the significant milestones within the design phase. Consequently, there was no method available for the architects to assess the progress of their own staffs nor to report on their progress to the local school boards on a periodic basis.

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SQ. FT.)

The general contractor's management practices are apparently as ineffective as those of the local school boards and architects. This survey indicated that liquidated damages are not a sufficiently coercive force to assure timely project completion. In the rare instances in which the owner has sought to assess liquidated damages, the contractor has successfully resisted any ultimate liability by invoking various defenses available to him. Within the contractor's own organization, ineffective management is readily apparent. The average general contractor has a line organization rather than a staff organization. This means that each project is assigned a project manager who is responsible for project completion. Each project, therefore, rests on its own merits and there is little overall control of the flow of equipment, manpower, or material among projects.

Conclusions

The durations of school construction projects in Massachusetts could be much shorter. When allocating time, primary consideration appears to be directed toward size and complexity as the significant determining factors in spite of the fact that they appear not to be significantly correlated to the time ultimately required.

It would appear that school projects, unlike most other projects, are poorly planned and ineffectively managed; they drift through the design stage and are then impeded by every conceivable obstacle during construction. Provisions for dynamic management are apparently only vaguely considered and, if adopted, only grossly applied.

An owner building with a firm pr
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Recommendations

It is easy to survey the school
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1. At the beginning of each co
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An owner building with a firm profit motive in mind would never tolerate the delays and obstacles which, unfortunately, are standard occurrences in the school construction experience. If an office building or an apartment house or a shopping center can be translated from thought to deed in minimum time at minimum cost through proper management, there is no reason why the same cannot be done for schools. Indeed, in the face of today's rising costs and critical needs, it is imperative that proper management practices be initiated.

Recommendations

It is easy to survey the school construction scene in the Commonwealth and draw conclusions which would indict the major parties affecting design and construction. What is difficult, however, is to present viable, achievable and profitable recommendations for curing the ills identified.

1. At the beginning of each construction project, a comprehensive construction strategy must be developed. It should set forth a schedule that is efficient, practical and achievable. It should incorporate all design and construction activities. School building committees should recognize their responsibilities in providing timely decisions and adequate funding.
2. A monthly status report on the progress of the project should be prepared. It should identify activities completed, activities started but not completed, critical activities and their status, potential problems and suggested resolutions thereof, and a plan of continuing operations.

3. The construction plan should be developed with a view toward reducing time and minimizing cost using techniques such as:

   a. Earlier funding;

   b. Prepurchasing of materials;

   c. Concurrent design and construction methods;

   d. Continuous cost control; and

   e. Systems components.

4. The construction contractor(s) should be required to prepare a time plan of the entire construction process. The schedule should be monitored on a monthly basis and contractor progress payments should be dependent upon such review. The contractor should not be compensated for completed work until he demonstrates either that the project will be completed on time or that a time extension is justified.

QUALITY OF CONSTRUCTION SURVEY

CHAPTER III - 7

Due to the time which intervenes between the architect's preliminary design and the occupancy of the completed school building, a survey of schools actually in operation can most successfully demonstrate how schoolhouses recently have been designed and built, and provide a base from which to draw inferences about current trends. In many respects, the typical recently-occupied Massachusetts school building does not differ significantly in its construction from those built during the past decade or two. There are, however, visible signs of a trend toward types of construction which facilitate the periodic rearrangement of the spaces inside the building envelope, brought on in part by the rapidly developing educational programs which place great importance on this sort of adaptability.

Most schools are built using relatively lightweight and inexpensive structural components. Steel is most commonly used: open-web joists supported on columns carry corrugated steel decking. Concrete block bearing walls, however, have not entirely gone out of use. Precast concrete construction is also used in some schools, primarily for multi-story structures, where its integrally fire-resistant characteristics give it an advantage over steel and other metals, which must be fire-proofed by the application of additional substances following erection. Cast-in-place concrete construction requires the use of complex forms and shoring to contain and support the fluid material before it solidifies and develops sufficient strength to be considered safely self-supporting. Because of the time and additional

expense which this process requires,
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expense which this process requires, cast-in-place concrete is not normally used for major structural members. It is used, however, for floor slabs and occasionally for roofs. It is placed either directly on the ground or over decking which serves as a self-supporting formwork and is left in place after the concrete sets. Almost without exception, the roofs over gymnasiums and other large column-free spaces are carried on longspan steel joists.

Walls, both around the building perimeter and between the various interior spaces, are almost always screen partitions which carry no superimposed loads other than their own weight. Exterior walls commonly are constructed from brick, concrete block or metal-and-glass curtain wall components. Cast-in-place concrete is used for below-grade applications. Minimum window sizes and locations are specified by law, with some occasional resulting additional expenses. The four small interior courtyards in a new elementary school in Amherst, for instance, are at least partially due to this requirement, which appears to predate the existence of effective and inexpensive mechanical ventilation systems.

Interior partitions typically are either stud walls faced with gypsum board, or concrete block. Lath and wet-applied plaster partitions are rarely used due to the significantly greater cost and longer construction time which this technique entails. Some partitions incorporate retractable sections which make it possible quickly to subdivide one space into two or more smaller ones. In a few cases use is also made of demountable walls, which can easily be removed and re-erected elsewhere when it becomes desirable to change the plan configuration of the school in response to changing educational needs. The importance of this sort of internal flexibility appears to be growing, in response to an accelerating rate of change in educational methods.

Interior wall finishes for areas subject to normal wear, such as classrooms, instructional materials centers, offices and cafeterias, are generally paint, with occasional use of vinyl wall coverings and other special finishes. Walls in areas receiving harder wear, such as corridors, service areas and locker rooms, frequently are finished with ceramic tile or epoxy paints. Decorative paneling and masonry of brick, stone or textured concrete block are used in lobbies, auditoriums and other areas to provide visual accents.

There is a long-standing preference for resilient tile (primarily asphalt, vinyl-asbestos and vinyl, but also rubber and cork) as durable, fairly easy-to-maintain floor finishing materials. Evidence is available, however, indicating an increasing trend toward carpeted floors in classrooms, offices, libraries and similar spaces, although it is still considered somewhat unusual for a school to be carpeted. This growing use of carpet is primarily due to its excellent acoustical properties. Carpet is an excellent sound-absorptive material, which noticeably reduces the reverberation of sound within a room. In addition, it cushions and mutes the impacts due to footsteps, moving furniture and other common classroom activities which would otherwise be audible, and so reduces the amount of sound generated within the space. An added, less measurable but apparently significant effect is the more home-like atmosphere of carpeted schools, which is claimed frequently to elicit a "halo effect" in the form of improved student behavior. As these characteristics of carpet become more widely respected, it is likely that carpeting will lose its old reputation as being out of place in a "functional" school environment, and will come into even wider

use. Further incorporation of open plann
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Floors in locker rooms, kitchens and fre
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Polished hardwood floors, traditionally
commonly employed, although competition
purpose resilient materials.

Sound absorptive ceiling treatment is al
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acoustical tile ceiling suspended below
include both small square tiles, usually
and larger (two by four feet or more) ti
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use. Further incorporation of open planning and other educational innovations into new schools will further increase its use; it is, for instance, questionable whether the open-plan school would really be feasible at all without the acoustical treatment which carpeting is instrumental in providing. It should be obvious that the cleaning and maintenance of carpet requires different materials and techniques from those used on other flooring materials, but whether keeping carpet clean is any more time-consuming or expensive than keeping, say, resilient tile in a similar state of appearance is a hotly debated issue whose likely ultimate resolution has so far been unclear.

Floors in locker rooms, kitchens and frequently in entrance lobbies are finished with quarry tile or other hard, durable and easily cleanable material. Service area floors commonly are of hardened concrete, as are the floors of some shop areas. Other shops have wood or composition floors. Polished hardwood floors, traditionally used in gymnasiums, continue to be commonly employed, although competition is appearing in the form of special-purpose resilient materials.

Sound absorptive ceiling treatment is almost universal in corridors and teaching spaces, either in the form of exposed fiber decking or as an acoustical tile ceiling suspended below the structure above. Common varieties include both small square tiles, usually installed on concealed supports, and larger (two by four feet or more) tiles laid in exposed carriers. Exposed supports make access to equipment and service lines mounted above the ceiling a relatively simple matter; since all tiles are easily lifted out and removed without requiring the use of special tools, these ceilings are particularly desirable for use in school situations where maintenance or relocation work must be performed quickly in order not to interfere with the use of teaching spaces.

Fluorescent lighting is ordinarily used for general illumination throughout the building. Incandescent fixtures are used for accents and in other special situations. Gymnasium lighting is typically accomplished with high-output (mercury) vapor lamps. A particular problem with these very bright sources, noticed in some of the installations visited by members of the study team, is that when the fixture design and installation does not adequately shield the lamps from view, the result is an unpleasantly bright and "glary" ceiling.

Central gas or oil fired hot-water boilers are the normal source of heat, supplying unit heater-ventilators located in the teaching spaces. Local control is by automatic electric or pneumatic thermostats, with manual control for blower speed and amount of outdoor air. Air conditioning is not yet in widespread use, but has been incorporated into at least portions of a number of schools, primarily larger high school buildings containing substantial numbers of windowless interior classrooms. Air conditioning, or at the absolute minimum mechanical supply and exhaust ventilation, is needed for schools with interior rooms or with large open teaching spaces remote from exterior walls. Should many communities give serious consideration to keeping their schools open throughout the year as one means of reducing their needs for new classroom space, this factor will combine with the present trend toward flexible and open-space plans to increase significantly the incidence of school air-conditioning systems.

Almost without exception, pipes, conduits, ductwork and
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Almost without exception, pipes, conduits, ductwork and wiring in "finished" spaces are carefully located out of sight within the wall and ceiling construction. All piping, wiring and ductwork connections are made by hand and are essentially permanent. Prefabricated disconnectable joining devices such as plug-in cordsets are not used, even in cases where the labor saved should result in a net first-cost saving, despite their higher purchase prices. Lighting fixtures and air grilles rarely are exactly coordinated with ceiling tile sizes and locations, requiring that the ceiling tile be cut and fitted to accommodate them. As a consequence of these constraints, relocation of lighting fixtures and air outlets to accompany other modifications to the building is not readily possible without substantial amounts of cutting, fitting and patching. Similarly, because wiring and piping are ordinarily run inside partitions even when the walls in question are nominally demountable, the future relocation of these walls often will be a matter for the attentions of an outside contractor, accompanied by disruptions and dirt which can make continued occupancy throughout the process a difficult procedure at best.

It is in the form into which these parts are assembled where the most noticeable changes have occurred over the past ten to fifteen years. Until recently, the dominant form of plan organization has been a series of discrete cellular classrooms lining both sides of a central corridor, with all, or nearly all, of the rooms having an exterior wall exposure. This organization has resulted in fairly long building elements which are approximately sixty feet wide--two classrooms and a corridor. These elements are joined together into various "finger" and "donut" configurations ranging from one to three stories high. Recently, however, there has been increasing evidence of a trend toward more compact and less linear "loft" forms. The reasons behind this trend are complex. They appear to relate at least in part to a growing awareness of the desirability of a building whose internal configuration can be rearranged to accommodate changing educational programs. The economic advantages which loft planning offers come in the form of less exterior surface for a given area and a more advantageous heat gain-loss situation which can lower the operating costs of the heating and cooling systems. Further, increasing interest is being shown in open space planning, where the teaching space is laid out in large areas, equivalent in size to several classrooms each, within which activities are separated only by distance and movable elements which serve as bulletin boards, writing surfaces, storage units and the like, rather than by conventional fixed walls.

Two very dissimilar approaches to a desirable classroom environment were evident in the schools visited by members of the study team. Both have definite advantages and weaknesses. The first approach is the one which has been traditionally used: isolate each teaching space from the others as much as possible. It requires acoustically dense construction and is difficult to accomplish completely, since something as simple as a door left ajar can effectively destroy the room's isolation. The environment which results, however, can be quite free of distracting sounds and movements, but the effect of the distractions which do occur is enhanced by contrast. The second approach, characteristic of open-planned schools, is to integrate each class into the whole group of people using a teaching area. It depends for its success on constant peripheral activity which

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onstant peripheral activity which absorbs most distractions into the general background noise and movement. Except for special-purpose spaces designed to accommodate noisy activities such as music, physical education and shops, the construction need not be as acoustically dense. This approach has been criticized as a poor environment for concentration when compared to the theoretically more tranquil atmosphere of the isolated classroom, but it seems to work, particularly in elementary and middle school situations. Whether this represents another example of the "Hawthorne effect" (improvement in output due to irrelevant factors) or not, only time will tell. In the meantime it is likely that both philosophies of environment will continue to be well represented in new schools built in the Commonwealth for the foreseeable future.

In summary, the recently-constructed Massachusetts schools which members of the study team were able to visit are generally very good quality structures, despite the fact that some members of the team were troubled by the social and psychological implications of the sheer size of certain ones of them. There are several ways in which they could, however. be made more cost-effective:

1. By modifying the building codes to eliminate certain excessively stringent requirements, such as those relating to window area and fresh air supply rates (see Sections III-8 and V-2 for discussions of building codes and their implications);
2. By giving more consideration to developing built-in long-term adaptability as a means of facilitating and reducing the cost of the renovations which inevitably occur during a building's lifetime (Sections III-10 and IV-2);

3. By developing and taking advantage of means to reduce the effects of cost escalation and fixed carrying charges on the cost of a school building, both through shorter construction time and shorter overall project delivery time, measured from the first awareness of need through occupancy of the completed school (Sections III-5 and IV-2);
4. By the implementation of other concepts and tools discussed throughout this report.

SCHOOL BUILDING CODES

CHAPTER III - 8

> If a builder has built a house for a man, and his work is not strong, and if the house he has built falls in and kills the householder, that builder shall be slain.
>
> Article 229, The Code of King Hammurabi. 1700 B.C.*

Introduction

The need for some kind of building code for the protection of the public is universally accepted. The problem is how to accomplish this in a way which is fair to everyone and does not inhibit sound and economical construction more than is necessary.

The present orgainzation, administration, and substance of codes for Massachusetts schools do not meet this problem as well as they might, but much improvement has been made in recent years, and other improvements are being made. The current outlook therefore is encouraging. The main problems remaining are in four areas:

1. Division of responsibility among a large number of government bureaus slows processing and increases the likelihood of misunderstandings.
2. Overly specific regulations inhibit change.
3. Ambiguous regulations invite differences in interpretation.
4. The lack of any effective appeal procedure puts too much power in the hands of individual inspectors.

* Quoted in Sanderson, R.L., Codes and Code Administration, Building Officials Conference of America, Inc., Chicago, 1969, p.5.

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use of building codes.

Purpose and Scope of Codes

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Before we examine these problems, we should be clear about the purpose and use of building codes.

Purpose and Scope of Codes

Building codes have two purposes:

1. Public Safety

The public, especially small children in schools, need to be protected from building hazards. This primarily means insuring that the building is structurally stable and that occupants can exit from the building safely in case of fire.

2. Protection of Property

The majority of code requirements are for the protection of the building itself, especially from destruction in fire. Related to this are regulations to assist and protect firemen combating fires. For example, in a single-story school, public safety would require only adequate means of escape plus measures to restrict the spread of fire for the few minutes that would be needed for this escape. The code, however, also provides that the building be divided into zones separated by one-hour fire walls so that the spread of fire will be restricted and that firemen will therefore be safer within the building. Other regulations are similarly directed toward prevention of destruction or deterioration of the building. This is reasonable for public buildings, since the taxpayers wish to have their investment protected; accordingly, it is specifically required by the terms of the enabling legislation, Chapter 143 of the General Laws.

It is somewhat more difficult to see the justification for extending the scope of the safety codes into the realm of environmental standards which have nothing to do with the health or safety of children. An example is the section which regulates the amount of daylight which must enter school rooms. The question here is not whether the amount of daylight required is reasonable, but rather what is the authority or the qualitications of the Board of Schoolhouse Structural Standards to control it.

Division of Responsibility

There are in Massachusetts thirteen different state departments, agencies, boards, or divisions issuing building regulations.* The thirteen are:

1. Department of Public Safety
2. Board of Boiler Rules (in, but not under the DPS)
3. Board to Facilitate the Use of Public Buildings by the Physically Handicapped (in, but not under, the DPS)
4. Board of Fire Prevention Regulations (in, but not under, the DPS)
5. Board of Standards (in, but not under, the DPS)
6. Board of Schoolhouse Structural Standards (in, but not under, the DPS)
7. Gas Regulatory Board
8. Department of Labor & Industries (Division of Industrial Safety)
9. Department of Public Health
10. Bureau of Air Use Management (under the DPH)
11. Division of Nursing Homes and Related Facilities (DPH)
12. Department of Public Works (Outdoor Advertising Division)
13. Board of State Examiners of Plumbers

*Compiled by Herbert Eisenberg, A.I.A., and Francis Harvey, Engineer, for the Massachusetts State Association of Architects, September, 1970.

Together, these bureaus produce a total
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Together, these bureaus produce a total of 85 different sets of regulations. In building a school, at least four and usually six or more of these organizations are involved.

The main one of these is the Board of Schoolhouse Structural Standards, which publishes the Building Regulations for Schoolhouses (BRS). The code is essentially a copy of the BOCA* Basic Building Code, 1970 edition, which has been modified where desired to fit particular Massachusetts requirements.

The Board has eight appointed members from a variety of disciplines relating to education and construction and three _ex officio_ members representing The Department of Education, the Department of Public Works, and the Department of Public Safety. Present membership includes two architects, a mechanical engineer, two structural engineers, a DPW official, a school superintendent, a municipal official and the three _ex officio_ members. As constituted under Chapter 362 of the Acts of 1958, the Board is "in the Department of Public Safety but not under the control of the Commissioner." It is therefore an independent board which has its money, offices and clerical services provided by the Department of Public Safety. Its only function is to establish and amend codes -- it has no powers of enforcement or appeal. The Board is established for three-year terms and must be re-established at the end of each term or it will be dissolved. The current term expires in 1973.

The code is enforced by the Department of Public Safety inspectors, who are responsible both for plan approval and for field inspection. As we shall see later, this division of authority between the Board of Schoolhouse Structural Standards and the Department of Public Safety is a prime source of

* Building Officials Conference of America, Inc.

difficulty. Nevertheless, it is a great improvement over the situation which existed before 1968. Unitl that time hundreds of local codes were used, so that any standardization was impossible. Architects and builders had to relearn the codes each time they came to a new town, and practices which were totally acceptable in some communities were officially "unsafe" in others.

The problem of fragmentation of responsibility occurs in the other state bureaus which also have authority to write and enforce regulations governing construction. For instance, in addition to the Board of Schoolhouse Structural Standards, a school will have to meet Department of Public Health regulations on its kitchens, swimming pools and sewage facilities. The Board to Facilitate the Use of Buildings by the Handicapped controls a large number of features relating to circulation into and within the building. Depending on the kind of HVAC and cooking facilities provided, the Board of Boiler Rules and the Gas Regulatory Board may be involved. The Board of State Examiners of Plumbers writes and enforces its own uniform code in the field of plumbing.

The Electrical Code and the Elevator Code are separate statewide regulations established by the Department of Public Safety and incorporated into the Board of Schoolhouse Structural Standards by means of cross-referencing only. The result of this is that processing of any job takes much longer than it should, and the potential for mistakes and conflict is increased.

Not all of the bureaus have the staff or other capacity to carry out all their own functions. This applies in particular to the Handicapped Code, which the Department of Public Safety inspectors enforce for the Handicapped Board as a "courtesy." However, these inspectors cannot waive any of the handicapped

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Keeping Pace with Change: Performance

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rules (although in reasonable circumstances they may waive their own rules), so they have no power to exercise discretion. If a part of a building does not comply to the Handicapped Code, it is necessary to appeal directly to the Handicapped Board for any relaxation of rules.

As a practical matter, the Building Regulations for Schoolhouses and the codes of the other regulatory bureaus deal directly with only a fraction of the possible construction questions within their jurisdiction. The great bulk of rules to be followed are covered simply by short statements referring to any one of a large body of other standards or references produced by national boards, insurance underwriters, test laboratories and others. This is standard practice for codes, and avoids making the code an impossibly bulky volume. The Building Regulations for Schoolhouses, for instance, refers to 88 other standards. Since most of these 88 standards, in turn, refer at certain places to yet other references, there is actually a huge pyramid of hundreds of documents which people would have to keep and catalog if they wanted to be prepared to answer all possible questions concerning building regulations. Even the Department of Public Safety itself does not possess all the relevant documents.

<u>Keeping Pace with Change: Performance vs. Specification Codes</u>

Any code must be updated frequently to keep pace with changing building requirements and technology. However, the way a code is written can go a long way to retard the rate of obsolescence of the code and to help it cope with unforeseen changes.

There are two essentially different approaches to establishing rules governing construction and safety: specification rules and performance rules.

Sanderson makes the following distinction:

> Building codes are commonly classified as being specification codes or performance codes. The specification code describes in detail exactly what materials are to be used, the size and spacing of units, and the methods of assembly.
>
> The performance code, on the other hand, prescribes the objective to be accomplished and allows broad leeway to the designers in selecting the materials and methods that will achieve the required results.*

In other words, the specification code is rigid, and the performance code is flexible. The problem with specification codes is that new and better ways of building are often prohibited, because the code is necessarily written on the basis of what has already been done, and cannot anticipate what might be done later.

In responding to innovation, the specification code can be changed only by making new rules to allow new types of construction after they have already been developed, if the old rules seem to prohibit them. In practice, this is the pattern which has been followed in most building codes. Since it always takes time to establish new rules, there is a tendency for codes to lag several, often many, years behind technical development. In many cases, innovations were allowed only because the inspectors made a liberal interpretation of the codes. However, one cannot always depend on finding a sympathetic or enlightened building inspector.

The theoretical alternative to a rigid specification is a performance code. This has the virtue of being flexible enough to incorporate any new way of building, provided that it fulfills the necessary function. However, there are practical difficulties with a purely performance code. For one thing, in many cases it is much more cumbersome and difficult to establish desired

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* Sanderson, R.L., op. cit., p. 15.

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performance levels than to describe materials or products which perform at that level. It would also result in a very cumbersome procedure if every detail of construction were to be approved only on the basis of meeting test standards, especially if this meant setting up new tests for every building. It would also make impossible demands on the knowledge of the men who were obliged to enforce the standards.

Obviously this is not practical. The reasonable alternative is a combination of performance and specification standards. In practice, those codes which claim to be of the performance type actually contain elements of both types. An interesting and sensible variation is the British code, which establishes performance standards for most aspects of design and construction but then follows each of these with "Deemed to Satisfy" provisions, i.e., a list of ways which are known to be acceptable. If the designer chooses to use other methods, he can do so if he proves that they meet the performance requirements.

The Board of Schoolhouse Structural Standards code (Building Regulations for Schoolhouses) has been described as being a performance code because it does not spell out exactly how a school is built. For example, an innovation such as the use of the space above a fire-rated ceiling as a return air plenum was recently accepted when the architect was able to produce test results which showed that his particular assembly had maintained the necessary rating.

Nevertheless, many code requirements are narrowly defined, which means there is always the likelihood of innovation being hampered even though a new material or technique is superior or at least equal to the old. This is true in particular of the Plumbing Code, which is separate from the Building Regulations for Schoolhouses and is promulgated by a separate agency. One regulation which necessitates the use of both expensive materials and unnecessary labor is the prohibition of the concealed use of plastic piping, which has performed satisfactorily in many other states and countries for years and would be accepted by any reasonable performance standards. Another "make work" regulation is the prohibition of single-stack plumbing, which could save thousands of dollars on many jobs. Yet single-stack plumbing is also a standard procedure used for years in other locations and which would also be permitted by any performance standards for adequate ventilation of fixtures that might be written.

While some disputes may be inevitable simply because of human differences and folly, it is nevertheless clearly desirable to try to frame any code to eliminate as much ambiguity as possible and to balance reasonable standards of safety with the variety of circumstances which may apply.

Although a continuous effort is being made by architects and by most code-writing authorities to rewrite code provisions as serious questions arise, there is still room for improvement. A significant example with far-reaching cost implications in the Building Regulations for Schoolhouses is the lack of clear differentiation between the various ways of determining the pupil capacity (occupancy load) of school buildings and classrooms. Different figures are used in different circumstances on the same building. It may be based on the student load submitted to SBAB, or on the day-to-day student population (which will fluctuate), or on calculations based on a predetermined area per student. One method of measurement is used for toilet requirements, a different measure for ventilation, and yet another for means of escape. The figures used may be determined through negotiation with the Plans Supervisor, but can differ by a factor of 4:1 depending on which method of measurement is used. Surely this confusion could at least be clarified

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Procedural Problems: Appeals

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The codes are in any case ambiguous enough to be misinterpreted by the DPS inspectors. On one recent job, regulations were initially interpreted to mean that in a semi-open-plan school, where partitions visually separate but do not enclose two parts of the same space, carpeting could not pass under the partition because it would allow air and therefore smoke to pass under the partition and thus reduce the wall's fire rating. Yet air was completely free to pass around the ends of the free standing walls. The interpretation of course was eventually corrected, but the delay it caused was unnecessary.

Procedural Problems: Appeals

A major procedural problem which presently exists, particularly with the Building Regulations for Schoolhouses, is the lack of any satisfactory appeal procedure. There is hope that this may soon be remedied.

The desirability of avoiding appeals wherever possible is generally agreed. The need for appeals generally arises in two circumstances:

1. Disputes over interpretation of ambiguous regulations. (The fact that there is a difference of interpretation may be taken ipso facto as evidence that the regulation was ambiguous.) Although every effort should be made to make codes as clear, concise and complete as possible, any code is subject to varying interpretations. This is particularly true in the present case where an independent body, the Board of Schoolhouse Structural Standards, establishes the codes, and another body, the Department of Public Safety, has final authority to enforce and interpret those codes. The problem of

varying interpretations is aggravated by the separation of authority between the Supervisor of Plans and the Field Inspector (as opposed, for example, to the British "District Surveyor," who first deals with the plans in his office and then follows through with the job in the field).

2. Requests for waivers in situations where there may be no ambiguity, but where the regulation is felt to impose an unreasonable hardship. The Handicapped Code in particular is frequently singled out as being unnecessarily strict. One ruling which caused particular bitterness in a certain case was a requirement for provision of an elevator to the balcony of a field house, in order to make sure that handicapped students could use the facilities there, even though all the balcony facilities were simply duplicating some which existed on the main floor (See Appendix).

The standard approval procedure is for the Supervisor of Plans to approve construction drawings before construction is begun. This approval is provisional since it is never possible for every aspect of construction to be determined from the plans; some problems will only show up in the field. If the decision of the Supervisor is challenged, there is no legal recourse other than to go to court, a difficult, expensive and time-consuming procedure into which a town rarely wants to enter. The question may be taken up with the Board of Schoolhouse Structural Standards, which meets once a month, and they can informally advise on questions of interpretation. However, the Board of Schoolhouse Structural Standards is unique among the independent boards which are in but not under the Department of Public Safety in that it has no power to grant waivers from the regulations. The Board has attempted to have itself established as an appeal body but so far has not succeeded in having the necessary legislation passed. Effectively, therefore, there is no appeal procedure from rulings of the Supervisor of Plans.

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After the plans have been approved, they are interpreted on the job by the Field Inspector, and it is he who ultimately must issue the Certificate of Occupancy. The Field Inspector is an employee of the Department of Public Safety and reports directly to the Supervisor of Plans. (At one time local building inspectors carried out field inspection.)

Although many architects are unaware of it, an appeal procedure has been set up to deal with questions which arise in the field. On receiving a complaint the Supervisor of Plans sets up a three-man tribunal consisting of the Field Inspector involved in the job plus two others. One may question, however, the concept of a court in which one of the advocates is also a judge, and where his workmates are the other judges.

Appeals are arduous in any circimstances, and people will usually go out of their way to avoid them. In practice, it is often easier to comply with an inspector's ruling than to appeal even if this requires extra construction. This is particularly true in the later stages of the job, when a delay in the issuance of the Certificate of Occupancy may cost the client as much as $1,000 a day. There is no expedient way of appealing which is not more damaging than compliance. This was the problem most frequently cited by architects interviewed for this study.

Fortunately, as is described below, moves are now underway to remedy this situation.

Code Reform

Each of the problems identified above has to be dealt with if schools are to be built as quickly and economically as they should be.

Occasional arbitrary or ambiguous code provisions must be accepted as part of any code. In any case, they will not be swept away by code reform. More performance requirements could simplify the introduction of new materials and techniques.

The lack of an adequate appeal procedure could be overcome by relatively modest changes within the existing structure, and moves are now underway to do this. Speaking for the Borad of Schoolhouse Structural Standards a member recently reported, "The Board well realizes this deficiency and in the Board's last public hearing it held hearings for the inclusion of four new sections having to do with the interpretations of rules and has the opening statement:

> 'For the purpose of providing uniform interpretation and application of the provisions of these regulations, the Board in an official meeting may review upon written application any claim that the true intent of the regulations have been incorrectly interpreted, are in need of interpretation, (or which) as expressed do not fully apply...'

This material was voted to be put in regulation form by the Board and presently is at the Attorney General's office for approval and then it will be submitted to the Secretary of State to become effective."*

This change, if enacted, would therefore greatly strengthen the Board and provide the appeal procedure which so many people have demanded.

The problem of fragmentation of responsibility could only be changed by a more sweeping reform. The Department of Community Affairs is currently sponsoring such a move. The attempt is to produce a uniform state code for all building types, administered by a single new board and enforced by the Department of Public Safety. Adoption of the code by towns would be optional for some building types, but schools, of course, would remain under mandatory state control.

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* Letter from Board of Schoolhouse Structural Standards to Nelson W. Aldrich, September 16, 1971.

RENOVATING AND REMODELING COSTS SURVEY

CHAPTER III - 9

Introduction

The amount of money expended each year to renovate and remodel Massachusetts schools is high. Within the limits of what is possible in traditionally built schools, this is probably money well spent, but the design of new buildings could significantly reduce future remodeling costs.

It is not known how much remodeling is carried out each year. It is possible that the backlog of need for remodeling is over $300 million. If even a tenth of this is undertaken each year, the annual cost of remodeling would be $30 million, or one fifth the current annual statewide expenditure for new schools.

Remodeling receives much less attention and publicity than does new construction -- less, in fact, than the difference in the figures would account for. There are several possible reasons for this:

1. The total annual cost of remodeling is unknown, so that very few people have any idea how much taxpayers are paying.
2. Remodeling rarely requires a bond issue, so it is out of the view of the voting public. It is often included in the operating budget, where it has low visibility. New construction, by contrast, requires a vote and therefore is a public issue.
3. Remodeling costs are spent in small amounts over most of the life of a building, whereas new construction money is spent in one big chunk.
4. Remodeling costs are accepted as being inevitable to a degree, whereas a new school is not always so seen.
5. Some remodeling work may be carried out by maintenance personnel, in which case it will not show up as a separate item even in the operating

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budget, or it may be paid out of the public works budget instead of the school budget. Other remodeling work may be carried out on the basis of no-bid contracts, which are not ordinarily publicized.

Despite its lack of public notice, or the small size of the individual jobs carried out, $30 million is obviously not to be spent carelessly.

This chapter will discuss the following findings:

1. Remodeling existing facilities is often a very sound investment. In fact, to replace schools as soon as they become out of date or in need of repair would be absurd.
2. The cost of remodeling could be reduced if schools were initially designed for flexibility (see also Chapter III-10).
3. Remodeling may include not only renovation of existing school buildings but also conversion of other types of buildings into schools.
4. A quantitative formula for evaluating the feasibility of remodeling can be developed. A simple version of this formula is outlined.
5. If a systematic procedure for dealing with all renovations were developed, the whole state would benefit.
6. More research should be carried out in order to learn how to save money on remodeling and to put the subject into its proper perspective.

<u>The Cost of Remodeling</u>

A recent sutdy for Cambridge evaluated the feasibility of remodeling all of the city's thirteen elementary schools to bring them up to the same space, equipment and environmental standards as three new Cambridge schools currently under construction. Since the schools had been built over a period of 70 years from 1892 to 1961, this sample provides a useful insight into the relative costs or remodeling both older and more recent schools. The 1892 school was eliminated from consideration because it was a multi-story wood frame building and the cost of rendering it fire resistive was not considered. The remaining twelve were all built in this century, the oldest dating from 1903. Of these, seven were built between 1903 and 1930, and the other five were built between 1956 and 1962. None were built from 1930 to 1956, and only two of the old schools had been remodeled previously.

The cost of remodeling the seven older schools was calculated in detail, and the cost of the other five wa.. projected. The study found that in every case remodeling was considerably cheaper than new construction. Even the oldest of these buildings could be remodeled to current standards for no more than half the cost of new schools. Two of the smaller schools would cost $20 and $21 per square foot to renovate; all the others would cost less. These costs are plotted in Exhibit I.

The remodeling of schools may, however, create a need for new space as well. Because many old schools are built to low space standards and remodeling ordinarily involves an improvement or increase in space standards, the student capacity of a remodeled school will usually be reduced. In other words, if the school was already at the limit of its capacity, some students will be squeezed out by remodeling, and at least some new space will be required. This factor obviously affects any calculation of the space and cost implications of remodeling.

The Need for Remodeling

A 1965 survey of need for renovation and remodeling reported that at least 20% of all class space in Massachusetts was in need of major renovation.* A further 21% of all space was reported to be in need of minor repairs as well. However, replacement of all of it would be questionable use of money, especially in the case of the schools which are less than 50 years old. It would cost over

* Dept. of Education Memorandum, Dr. Geo. Collins to Bd. of Education, January 23, 1969.

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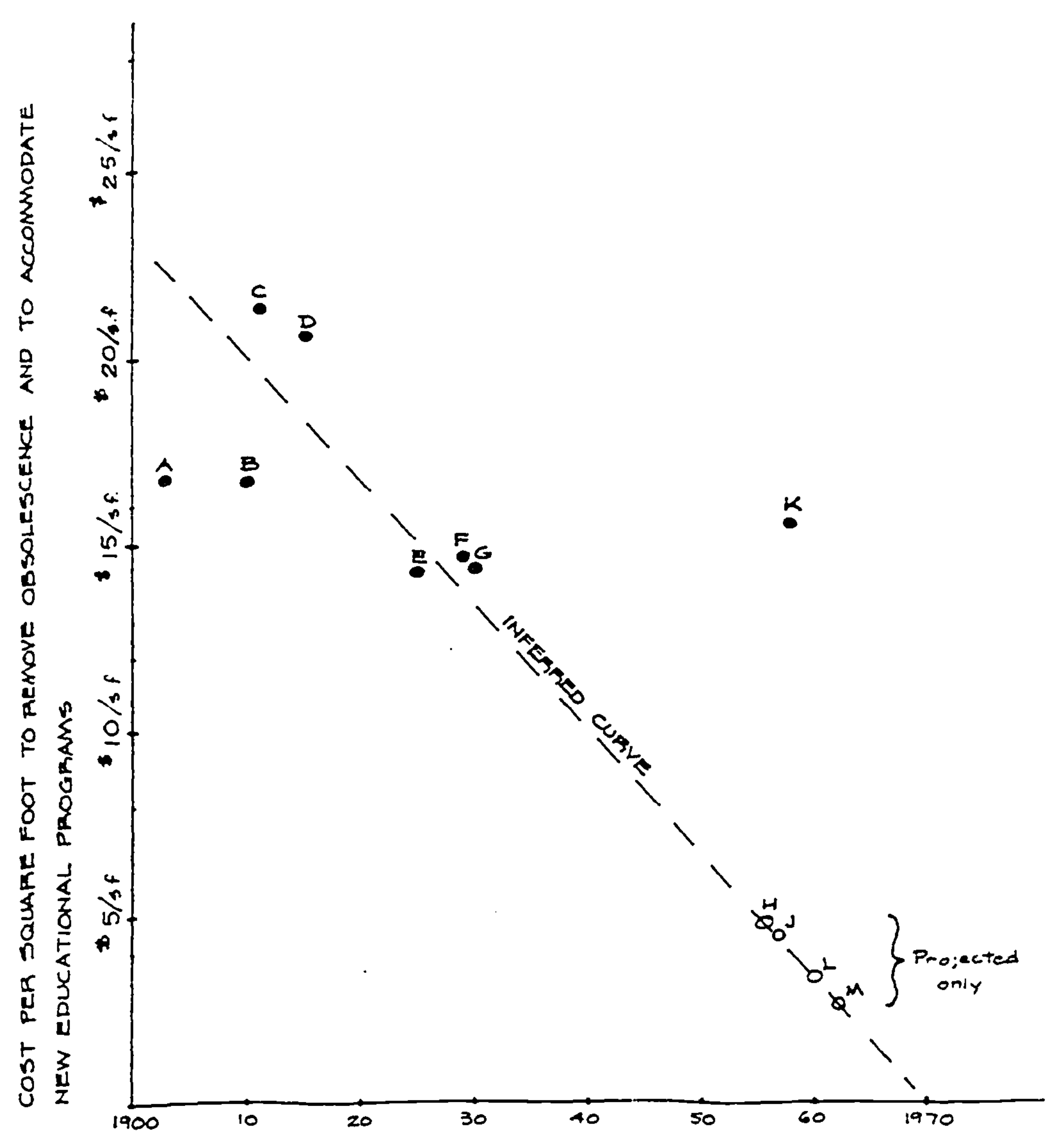
Since renovation costs may vary from almost nothing up to half the replacement cost, we may estimate that an average renovation may cost one fourth as much as replacement. This would suggest that the potential renovation need is over $500 million. This figure may be reduced in proportion to the number of schools which will be replaced, but it seems reasonable to assume that at least half, or $250 million of remodeling, would still be needed.

These rough figures are generally consistent with those derived from extending Cambridge's pattern of need to the rest of the state. The total cost of Cambridge's remodeling need is about $6.5 million. If the rest of the state (population 5.6 million) has a remodeling need comparable to that of Cambridge (population 100,000), then the total need would be about $360 million.

It is unknown how much of this need is being met each year. However, since wear on the building and technological change are continuous, a certain amount of renovation is necessary each year just to maintain old schools in their existing condition (i.e., to keep them from deteriorating further). Even if a program to overcome existing need were spread out over ten years, this would still cost $25 to $50 million per year. In the course of those years other needs would undoubtedly develop so that this rate of expenditure would be continued. If this amount is not currently being spent on remodeling, it

*. Collins to Bd. of Education,



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Abstracted from Elementary School Building Study, Vol. 6 (Rehabilitation Feasibility Study), Cambridge Planning Dept. 1970

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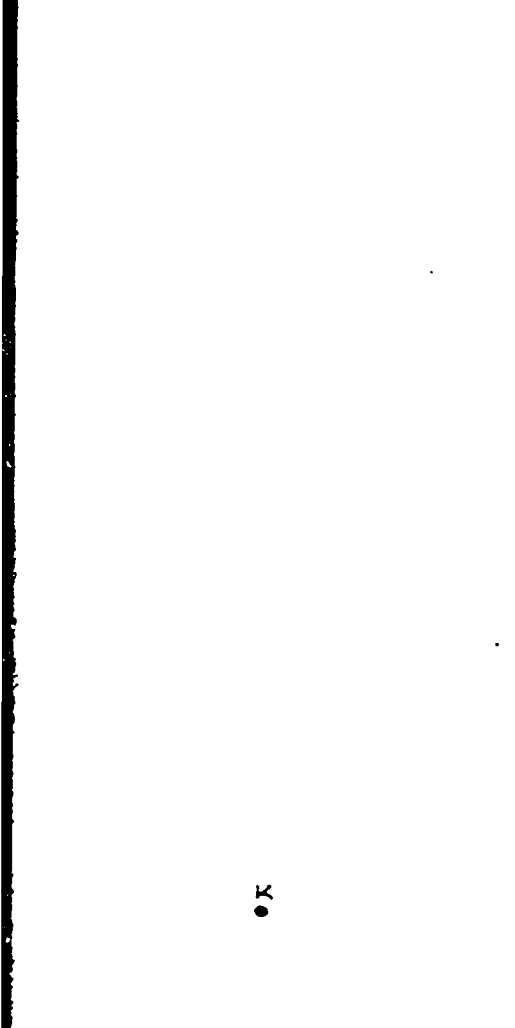

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, Cambridge Planning Dept. 1970

probably should be.

Under the provisions of Chapter 754 of the Acts of 1968, the costs of major renovations may be reimbursed by SBAB on a par with new construction. Until 1968, the state school construction subsidy in effect discouraged remodeling by contributing 40 percent or more to the cost of new construction and nothing to remodeling: this weighted economic analyses of the relative costs of the two alternatives in favor of the new construction. The town's investment in new construction would be reduced by the state subsidy, so the state would end up paying for schools which would not otherwise be needed. Equalization of these subsidies means that comparisons now can be carried out purely on the relative merits of the two choices.

Quality of Remodeled Schools

From architectural and educational viewpoints, the virtues of remodeling may be argued both ways. On the debit side, redesigning an existing building places obvious constraints on a designer's ability to arrange spaces. However, an existing building often has a charm and warmth of its own, and many people (including architects) express preference for a well-designed renovation over new buildings. In addition, the constraints of an exisitng building sometimes suggest unique solutions which the architect never would have conceived otherwise. In one recent instance, an A.I.A. National Honor Award for design went to a 43 year old printing plant which had been converted to educational space (see Appendix). Recent Progressive Architecture Design Awards have also been won by buildings converted to schools. From a civic design standpoint, preservation of an older building often gives continuity to an otherwise changing neighborhood. Many local citizens attach a great deal of sentiment to their neighborhood school and do not like to see it torn down.

Regardless of how it comes about, Massachusetts school children deserve schools with a good quality environment. This can be provided either by new construction or by remodeling. Since it is not reasonable to tear down a building every time one aspect of it becomes run down or out of date, some remodeling will always make sense. A continuing program of renovation should be carried out at least to the extent of maintaining a reasonable environment. No child should be asked to attend school in depressing and demeaning conditions. As Robert Hamilton points out in his study of Cambridge schools:

> School buildings are a major omni-present factor in (our children's) formal educational environment. Inadequate lighting; grimy walls and ceilings; falling plaster, water stains, peeling paint and buckled floors resulting from leaking roofs and walls; the odor of urine from broken plumbing pipes; worn flooring and stair treads broken;missing coat room and toilet cubicle doors; drafty rooms and inoperative temperature control systems are all part of the educational environment of our children. A so-called rehabilitation can remove an accumulation of deteriorated and obsolete conditions -- a building can be salvaged, but it cannot salvage the educational experience of students who spent eight or nine years exposed to run down conditions in the schools. *

Problems with Remodeling

Although remodeling of old buildings may save money in comparison to the cost of new buildings, much more money could be saved if schools were

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* J. Robert Hamilton, Architect for the Cambridge School Committee, Elementary School Building Study, "Choice for the '70's, Vol. 6, Nov., 1970.

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* Boice, John(editor), Building S
Vol. 1, No. 1(Spring 1969), p. 2

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initially designed with the recognition that they might change. The limited analyses which have so far been carried out on the cost of renovating traditional and systems schools (see Section V) indicate that systems schools can be renovated for half or less than half the cost of traditional schools in less time and with less noise and inconvenience. *

The advantages of flexibility and the extent to which it is being built into new schools in Massachusetts are the subjects of the next chapter. Unfortunately, flexibility cannot suddenly be injected into already existing facilities. Solving the problems of existing schools entails identifying the best way of dealing with the situation at hand.

One of the difficulties with remodeling is that often improvement of one aspect or part of a building has a "domino effect" in requiring a series of other improvements. The installation of more lighting and electrical equipment may increase the heat load, which in turn requires cooling, which in turn requires larger ducts, which in turn requires more space in the ceilings, which in turn affects the walls, and so on. A building is a more delicate balance than is sometimes thought, and the full implications of any change should be recognized before work is undertaken.

Designers can never anticipate all the problems in remodeling because there are too many unknowns. At the time they are drawing up their plans, architects must make certain assumptions about the construction of the old building, because so much if it is covered up by flooring, plaster, dirt and dust. There is always the inevitable, unanticipated defective

* Boice, John (editor), Building Systems Information Clearinghouse Newsletter Vol. 1, No. 1 (Spring 1969), p. 20.

pipe which must be replaced, or the unexpected beam or electric line. More design and supervision time is required because of these complications, and this is reflected in substantially higher architect's fees.

Construction is also more complicated. Material handling is less efficient than for new work, and work is generally dirtier, making mistakes more likely. Limitations of work space and lack of access to key services add to the problem. Contractors often include a healthy figure for "contingencies" to cover the many unknown problems which always crop up in renovation work.

Planning and cost estimating is greatly facilitated if a building can be gutted before major plumbing and electrical services are replaced, rather than trying to carry out these tasks in an otherwise finished and occupied building. However, this is not usually possible. In any case, since gutting is a major operation, it is desirable to carry out all major changes at once, rather than bit by bit as needs are observed.

Types of School Building Improvements

1. Face-lifting Operations

Much renovation of school buildings consists of little more than maintenance or rehabilitation, e.g., changing incandescent lighting to fluorescent, painting, installing plastic tile flooring, carpeting. As long as none of the inner workings of the building (the structure and the service distribution networks) are touched, this is a simple operation. When renovations have been completed, however, the classrooms are still the same size and shape; no fundamental limitations have been overcome and the rigidity of the old plan remains.

2. Remodeling of Existing Schools

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2. Remodeling of Existing Schools

Renovation becomes remodeling when the arrangement of spaces is altered or when significant new services are added which allow tbe building to be used in a different way. This is the usual sense of the term "remodeling."

A recent example of this kind of work is the remodeling of the Grafton Street Middle Schoolin Worcester. The school was originally constructed in 1924 as a four-story junior high school for 1,100 students. Two years ago a 1,500 student junior high school was constructed two and a half miles away, and the Grafton Street School was closed. A new middle school was also needed, however, and estimates for new construction ran from about S4.5 million. Instead of building a new school, the city decided to remodel Grafton Street. The most current cost estimate, including fees, is S1.5 million or one third of the estimates for a new school.

The new capacity of the school is 1,000 students, hence the cost of renovation--S1,150 per student--was very low. The site area remains the same at 1.9 acres. A public park directly across the street is used by the school for physical education and playing fields. The cafeteria, library, industrial arts and home arts spaces were all relocated. A new elevator was installed for the handicapped, as required in all new shcools. The remaining space was divided into three areas two and a half times the normal classroom size with divisible partitions for large and small group instruction. New lighting and electrical outlets were installed. Plumbing generally remained unchanged. Other work included repainting, new roofing, acoustic ceilings and wall-to-wall carpeting. The remodeled school, therefore, is comparable in quality to new construction.

3. Conversion of Nonschool Buildings into Schools

As school population increases and new construction becomes increasingly more expensive, the conversion of non-educational buildings into schools becomes more appealing. Structurally sound old buildings such as warehouses, armories and offices often can be used advantageously for a variety of educational functions. Fulfillment of the educational program is of utmost importance. If the building cannot accommodate the program, it should not be considered. If it does, however, considerable savings may be realized.

Many cities are taking advantage of non-educational buildings. In Philadelphia, several garages are being used for vocational training. Former churches in Washington are being used for kindergartens. Chicago has made extensive use of commercial buildings as vocational schools.

In 1965, for example, Chicago purchased a 420,000 square foot building on a 7.5 acre site at a total cost of $750,000 (or less than $2 per square foot). The basement, first and second floors of the building were converted into a 1,500 student vocational high school at a cost of approximately $1,400,000 or about $5 per square foot. The new space, therefore, cost about $7 per square foot, a bargain by any standard. Eventually, the third and fourth floors will also be rehabilitated.

In another case, a New Jersey college is acquiring a nearby armory for an athletic facility as the result of an analysis which revealed that converting the armory would cost $3 million, while construction of a new gymnasium on campus would cost $4.1 million. Not only does the armory cost less, but it will have twice the athletic space and will seat 50 percent more people.

When to Remodel

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When to Remodel

Towns frequently face the question of whether to build a new school or to remodel an old one. It is a major decision involving millions of dollars, and the only sound way to reach that decision is to conduct a study of all the relevant factors.

To help towns with this decision, the State Board of Education has prepared a "Suggested Guideline for Implementing Chapter 754 of the Acts of 1968" (See Appendix). The three main considerations according to the state Guideline are safety, economics, and educational adequacy. These considerations are divided into the following categories:

- Long range planning
- Educational adequacy
- Structural soundness
- Fire safety
- Site adequacy
- Healthful school environment
- Reasonableness of expenditure

The significance of each of these considerations is explained in the Guideline.

The Department of Education has now also prepared a four page standard form (SBAB-137a) for summarizing data relevant to this decision (see Appendix). One frequently quoted rule of thumb is that if remodeling costs exceed 50 percent of replacement cost, remodeling should not be considered.

Another general rule is that buildings built prior to 1900 should not be considered for remodeling. These rules may be used as indicators of what is likely to be a final recommendation but should never be used as the basis for a decision

Any thorough and conscientious economic analysis will consider the following factors:

1. expected operation and maintenance costs
2. student capacity of the building before and after improvements
3. adaptability of the structure for conversion
4. comparative cost of renovation vs. new construction
5. time required for improvements
6. expected life of the building

A generalized formula for relating all economic factors has been developed and is included in the Appendix.

The Possibility of a System for Remodeling

The recognition of standard elements in any procedure suggests the viability of developing a system for improving the process. Unlike building systems for new schools, a system for remodeling might aim toward standardizing procedures rather than standardizing building components. The lack of any standard dimensions within older buildings limits the usefulness of existing systems components. These components, in any case, were never intended for use inside non-systems buildings. Remodeling work is totally different from new construction work, so there is no rational reason to expect a system for this work to have much in common with a system for new buildings.

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A study of the problems and requirements of remodeling, however, might begin to pinpoint areas in which solutions which have worked well before may be capable of being incorporated into a standard procedure. For instance, a typical problem in remodeling is how factory-made building elements can fit into the non-standard dimensions and surface profiles found in older buildings. Perhaps this problem could be sidestepped by never trying to fit standard elements or fixtures to the old construction but simply leaving a space and then filling the space with another material. Likewise, it is always expensive and messy to fit new stairs into old construction. Perhaps it would be possible to locate new stair towers outside the enclosure of the old building, avoiding the necessity for cutting through floors. Such procedures and principles could be developed for all aspects of remodeling work. A major task of the study would be identification of the most expensive and time-consuming aspects of the work, so that the development work would be directed at those aspects of remodeling which can benefit most.

Among other things, such a system might make remodeling more attractive to architects. Although remodeling problems are intriguing, architects generally shy away from them because they often lose money on them in spite of the larger percentages which are allowed.

A system could also make remodeling more attractive to builders, who are likewise cautious about this kind of work. Part of their caution results from the fact that every remodeling job is so different. If a standardized process were established, an experienced builder could bid on jobs with the confidence that he was dealing with a known process.

The Need for Further Research

The lack of data on remodeling and the lack of appreciation of the scale of the problem make this a field which should receive more attention. So far we can only speculate on the overall scale of the problem.

The limited sampling of this study has shown vividly that there are great potential savings in this field and that if a great deal of money is not already being spent on remodeling perhaps more should be. However, it is impossible to generalize meaningfully from limited data. The only way to overcome this problem is further research.

It should be pointed out again, however, that remodeling can at best provide improved accommodations for the same number of students. In a situation involving increasing enrollments, additional space must be created, something which renovating existing schools can not do.

DEGREE OF FLEXIBILITY

CHAPTER III - 10

General

The approach to design which is customarily taken results in a building which is "tailor made" to fit a particular set of needs. Conventional construction techniques convert this close fit into a concrete overcoat, so that as needs change it is difficult, disruptive and expensive to modify the building. If the building is not adapted to suit evolving needs, its effectiveness as a container for the educational program of a community will go down, and the costs of operating the program will usually rise, either directly or indirectly, through decreased efficiency.

Buildings change over their period of existence more than is generally acknowledged. Educational philosophies evolve, new teaching methods are developed, school populations change and standards for the physical school environment are modified, frequently in response to new technological developments. A school building either adapts to these changes or gradually becomes obsolete.

The ways in which buildings may inhibit change are boundless and richly varied. Close spacing of columns may make it difficult to rearrange partitions, or pipes and other service chases may be in the way of a desired plan arrangement. In other situations, mechanical services may be inaccessible when access to them is needed. Likewise, services may be near enough at hand but may lack adequate capacity to meet new requirements placed upon them. When larger service conduits are needed, the available space above

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the ceiling may be inadequate to contain them. A particular building may work excellently for one program, but it may be impossible to adapt to factors which require change. Floor load capacities may be inadequate to support relocated partitions or equipment. Differing ceiling heights and support grids for different rooms may be impossible to reconcile when the separation between the rooms is removed. Dimensionally uncoordinated parts may require extra work for cutting and fitting together. Special products may be impossible to replace because they are out of production. Equipment may be difficult to replace because it is not readily demountable from the building, or extensive demolition may be required to gain access to parts which might just as easily have been left accessible in the first place. In general, changes to existing buildings cause more noise, mess and disruption of operation than should reasonably be necessary, and many desirable changes can not be made at all. The result is that the direct and indirect costs of change are greater than they need to be.

The usual building is tailored to meet specific needs, and it therefore becomes a special building. The more closely a building is shaped for one particular set of uses, however, the less suitable it becomes for any others. In other words, the more specialized and efficient at fulfilling a particular set of needs a building becomes, the less flexible and adaptable it is to any others.

A factor which is extremely difficult to measure is the cost of <u>not</u> making changes. When the inflexibility of a building prevents change, the resultant cost of losses of operating effectiveness are impossible to measure and remain among the hidden costs of running a school system which are passed on to the taxpayers.

As the need for flexibility in buildings has been increasingly recognized in recent years, various techniques have been developed for achieving it. In order to clarify what these techniques are trying to accomplish, it is useful to understand the underlying principles of flexibility:

1. Separation of permanent and impermanent elements
2. Indeterminacy
3. Interchangeability of components
4. Accessibility

1. Separation of permanent and impermanent elements

All building elements may be classified in terms of their expected lifespan as either permanent, lasting the full life of the building from its erection to demolition, or impermanent, requiring renewal or replacement before the building is finally demolished. The impermanent elements can be further classified into recoverable elements which can be salvaged and reused, and unsalvageable elements which cannot be reused and must be thrown away. Ordinarily, permanent elements are those parts of the building which cannot be moved, such as structure and primary utilities, or those which do not need to be moved, such as floors. Recoverable elements are typically prefabricated items such as doors, demountable partitions and mechanical equipment which can be taken down and reused. Unsalvageable elements are those which either are built in (plumbing, conventional partitions) or are for other reasons not capable of reuse after being dismantled.

In conventional buildings, elements of different lifespans are often so interlocked that elements which have no intrinsic need to change are removed

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simply because they are connected to or are in the way of something which does have to be replaced. To facilitate change, permanent elements should be separated as much as possible from recoverable and unsalvageable elements, and the connections between them made as simple as possible. Although it is desirable to minimize the cost of unsalvageable items, some extra cost on permanent elements can occasionally be justified if it is necessary to improve their separation from the impermanent elements.

Separation of permanent and impermanent elements implies that the permanent elements should be reduced to a minimum in order to lessen their interference with future changes. This suggests that columns and structural walls should be as widely spaced as possible. Fixed walls in particular are a limitation, since they cannot be "bypassed" as easily as columns. In theory it is possible to manipulate the plan so that the various rooms can be fitted between the obstructions of a short-span structure. In view of the unpredictable nature of change, of which the current trend toward open planning is a clear example, the only certainty is that longer spans, with their greater distances between obstacles, are preferable. Any plan which can fit a building with short-span structure can probably also fit into a building with long structural spans; the reverse is not as likely to be true. Since buildings often expand in size, walls on the perimeter of the building should also be made relocatable.

Service mains are expensive and disruptive to move. Therefore, they should be considered as permanent. They should be located to cause minimum obstructions. Horizontal service runs can be located out of the way within the ceiling, and the vertical risers may be concentrated in a few strategic locations.

2. Indeterminacy

Indeterminacy is the principle of leaving the spatial organization of a building sufficiently loose that a change in one area does not necessarily produce a chain reaction of adjustments throughout the building. The idea is to let expansion occur at any one place without greatly upsetting the rest of the school.

The tendency to plan buildings in a very compact way, with adjacencies as close to each other as possible, is basically rational. The difficulty is that the requirements which have generated these intricate relationships do not remain fixed, but the forms containing them do. Alteration can then become very difficult. The more specialized the plan, the more it can relate only to the particular set of requirements which obtained at the time of design. The more carefully a building is tailored to a particular program, the more certain it is to require additions and alterations within a few years. Such plans assume a static world. Yet, as Buckminster Fuller frequently has pointed out, not only are the world and its technology changing, the rate of change itself is accelerating.

Indeterminacy can be reflected in open-ended plan concepts which by virtue of structure and layout will permit growth at a maximum number of points, ordinarily to the outside of the building, but possibly into internal open spaces or courtyards. In terms of form, an informal massing is implied, which will appear natural at any stage of growth. The more compact and centralized the building, the more difficult it becomes to alter and add to it without destroying its basic cohesiveness. By contrast with this, open-ended growth can be compared to the natural extension of a healthy organism.

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3. Interchangeability

Interchangeability of parts is a basic element of any concept of flexibility. It is part of all building systems and is employed to varying degrees in conventional construction. By means of standardized dimensions and details, the same building element may be used in a variety of places, or a variety of different elements may be used in the same situation. For instance, the same wall panel may be used anywhere throughout a building as long as the ceiling height and connection details are standardized. Alternatively, a wall panel may be removed or exchanged for a doorway or even for a different kind of wall panel. This principle affects the relationships among all the different subsystems and relates particularly to modular coordination. When change is desired, elements may be removed and reused elsewhere without the occurrence of any problems of special cutting to fit, or other waste. Likewise, worn out or obsolete components may be replaced by newer ones, provided only that the same dimensions and connections are used.

4. Accessibility

Accessibility is an obvious principle of flexibility, and curiously enough, one which is universally ignored. It is necessary to provide sufficient space to work in and a reasonably convenient way of getting there if the effort spent in providing interchangeability and separation of permanent elements from impermanent is not to be wasted. Accessibility relates primarily to the lower end of the scale of change--the replacement of services and other elements without making significant plan changes. This is the most frequent kind of change, occurring almost continually throughout the life of the building. Because it is frequently done by maintenance personnel, this sort of change may never show up on cost records, making it likely that the importance of accessibility as a means of simplifying and facilitating this sort of change will be overlooked.

Provision of access may involve simply providing strategically located removable service panels, or special ceilings, or in extremely complex cases it may mean a special service floor. In making small changes a disproportionate amount of the effort tends to be expended in gaining access to the work, and this is avoidable. The important principle is to provide for the accessibility of any component in direct proportion to its anticipated frequency of repair or change and the scale of the work involved.

Survey of Massachusetts Schools

A great deal has been said and written about flexibility and flexible space for schools. School buildings in Massachusetts and elsewhere are frequently altered and expanded from their original configurations. Additions and alterations figured in approximately one fourth of all state-aided school building contracts let between July 1, 1967, and June 30, 1970. The actual total amount of alteration work is greater than these figures would suggest, since state aid was not available for alteration work until last year; the figures referred to above include only situations in which new construction was added to existing buildings.

The reasoning behind many educators' expressed desires for flexible space derives from their concept of the school building as essentially a physical envelope for an educational program. As is only too obvious, educational programs and philosophies change as time goes by. School populations grow,

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Given that change is a basic fact of life, the initially known program which a school is designed to house ultimately has little more validity than any subsequent modifications of it. Accordingly, the building should be constructed with the inherent possibility of changing to accommodate a radically different program, say, from cellular to open classroom or vice versa. Failure to provide this capability can unduly penalize desirable changes and the introduction of innovative teaching methods.

On the other hand, the need for flexibility in a school building is not total. Every school has special-use spaces, such as gymnasiums, auditoriums, washrooms and the like, which are far less likely than the remainder of the building to change their basic mode of use over the life of the building. Because of the special nature of these spaces and the equipment which they contain, it is not generally considered economically worthwhile to provide them with the capacity for rapid future change to another use.

With these facts in mind, members of the study team visited several completed schools and inspected the architectural drawings of others not yet built. In general, the picture which emerged suggests that while increasing provision is being made for day-to-day flexibility, Massachusetts public school buildings as a whole do not at the present time incorporate more than limited provisions for long-term flexibility.

On the positive side, almost all new schools built in the Commonwealth have columnar structure, rather than bearing walls, thereby minimizing the permanent obstacles to future plan changes. Accordion and panel retractable walls are widely used to allow rapid changes in room size to accommodate various sized class groupings. Demountable partitions are in use in a few schools and are planned for inclusion in several more.

Beyond these rather simple manifestations of day-to-day flexibility, there is much less attention paid to means of facilitating long-term change. Systematically separating the permanent elements of the building from the impermanent ones is still a relatively rare part of the design process. Its absence leads to buildings in which little or no distinction is made between the elements which can be expected to require removal or replacement during the life of the building and those which will not. Consequently, many elements which would logically be classified as impermanent and recoverable, such as interior partitions and air diffusers, are rendered permanent through the use of inappropriate materials and construction methods. Concrete block partitions, for instance, cannot be removed without major disruption of on-going activities, dirt, mess and the need for extensive patching, all of which are characteristics of permanent, unsalvageable elements. Similarly, conventionally installed air diffusers, consisting of rigid ductwork brought through a hole cut in the ceiling, are not wholly salvageable and require substantial cutting, fitting and patching, all taking time and disruption to accomplish, to relocate.

In addition to poor choice of products for permanent and impermanent elements, the principle of separation of these two categories of component is rarely observed. An example of the problems which can result when the need arises to take advantage of some aspect of a building's

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flexibility is demountable interior partitions and some of the conditions which can reduce or destroy the desired flexibility. Poorly considered interfacing can and frequently does mean that when a partition is to be relocated, floor, ceiling and wall finishes must be patched or even installed for the first time where the partition had abutted them. Piping, electrical wiring and outlets running inside of demountable partitions must be removed and capped, and their penetrations of finish elements must be patched and refinished. It is not unheard of that ceilings on opposite sides of a partition be made of different materials, hung at different heights on different grid alignments, thus memorializing the late partition with a cut-and-fit "fudged" joint. Building enclosure walls with attached HVAC units, baseboard radiation or other elements which give its inner face a complex profile again force major cutting and fitting when partitions are removed or installed. All of these problems are avoidable by application of the principle of separation of permanent and impermanent elements early in the design process. While historically there has been almost no hardware available at prices suitable for school construction to provide for quick and easy changes of utility distribution systems and terminals, such hardware is now available as a result of the SEF project in Toronto. Much of it is being incorporated into the two systems schools currently under construction in Boston under the BOSTCO program.

Interchangeability of elements is not common. Most lighting fixtures, for instance, must be "permanently" mounted and wired into place. With the exception of lay-in fixtures designed to take the place of one or more tiles in an acoustical ceiling, patching and touch-up work is required following the removal of a fixture, and the installation of a new one requires damaging the existing finish. The problem does not lie entirely with overly conservative local boards or their architects, however. An attempt to specify plug-in wiring for the lighting in a recent school project resulted in bids significantly higher than for conventional "permanent" wiring, despite the fact that this development would cut the time required to install a fixture to less than one twentieth of the time required to complete one conventionally, a saving on labor costs more than adequate to pay the additional cost of the prefabricated cordsets and show a net saving to the owner.

The accessibility of mechanical services is generally less than ideal. "Out of sight, out of mind" is an acceptable working method only until an element needs replacement or maintenance. The degree of access to mechanical services provided in the schools visited ranged from adequate to poor. In general, the better access came in the form of generous openings into the vertical riser shafts and suspended acoustical ceilings in which relatively large tiles were laid in an exposed grid, allowing each to be removed for easy access to the elements above.

The most flexible schools recently constructed or designed in Massachusetts are the two demonstration buildings of the BOSTCO program, currently under construction in Boston. They incorporate the full set of elements which comprises the successful system in the Toronto SEF development project. These components are highly interchangeable and provide both a good degree of separation between permanent and impermanent elements, including wiring and lighting, and very high accessibility to components for service and replacement, all in a reasonably-priced package. This system is currently the leading example of the state of the art, and incorporates a number of sophisticated approaches to the problem of providing maximum flexibility

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Without question, provisions for long-term flexibility in the design and construction of Massachusetts schools are inadequate. It may be useful to propose some tentative reasons why this should be so.

The first undoubtedly would be the low priority placed on long-range planning by local school boards. While it is an extremely important activity, long-range planning is not particularly urgent or critical in the sense that if it is not done there will be no immediate consequences. As a result, few committees are aware of the rapidity with which changing needs and conditions can compromise the effectiveness of operations within existing buildings. Because of the absence of meaningful criteria for school operation, few local boards have any idea of the extent of such a loss of efficiency and its significance in terms of dollars.

A lack of technical knowledge leaves most school boards in a poor position to deal with new and sophisticated concepts. The typical school or building committee is composed of amateurs, citizens serving without pay, with limited time and technical expertise available to devote to the job. That the system of local boards has operated successfully for years is in itself a tribute to the dedication and enthusiasm of thousands of present and past board members. A consequence of the limited time available to school board members, however, is that non-critical activities, such as research, are frequently crowded out by more urgent and critical concerns which must be dealt with immediately. The problem is made more difficult by the absence of any systematic information service available through the State Department of Education which might help keep local boards current with recent developments in the field.

Conservatism is a factor tending further to restrict the amount of flexibility required of and designed into Massachusetts schools. It is both informal and institutionalized. Building codes and state agency procedures represent a formal, institutionalized conservatism. They have been developed to respond to the status quo and generally are not at all favorable to innovation.

Informal conservatism is shared by school committees and their architects alike. They perceive the risk of unreliability to be greater with new hardware than with older, tried-and-true materials, making its use less attractive to them, regardless of cost or the benefits which it may offer. Many architects, including some of those who have designed a great many school buildings, have developed their own ways of working and favored materials and details which they are reluctant to abandon for the uncertainty of something new at which they may not be so adept.

Beyond this, however, is the pervasive lack of any general understanding on the part of school committees, the voting public, or even the architectural profession of the implications of providing or not providing flexibility and adaptability over time to their new schools. The benefits conveyed by flexibility always lie in the future and are therefore elusive and very difficult to prove conclusively. The costs of providing flexibility, however, sit firmly in the present, so that the situation is frequently perceived as one of risking incurring an additional cost right now against the unprovable need for a benefit at some time in the future. The perceived additional costs incurred by the inclusion of adequate provisions for flexibility are strong deterrents. Despite the examples of highly flexible schools built at or below prevailing costs through the California SCSD, the Florida SSP and the Toronto SEF programs, there is widespread

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feeling among committees and architects that additional flexibility is a luxury which automatically and of itself means additional cost. Contractors do, indeed, tend to bid higher on products or processes with which they are not familiar in order to cover the risks to them due to that unfamiliarity. All other things being equal, however, prices drop and stabilize quite quickly as the innovation comes into use.

Notwithstanding the need for greater long-term flexibility observed in recently completed schools, the situation within the Commonwealth appears to be on the verge of significant improvement. Widespread use of systems building in Massachusetts can be expected to result in schools which are greatly superior to recently completed buildings in both day-to-day and long-term flexibility. Schools embodying these advantages are already under construction, and their number is increasing, making the likelihood very good that new schools in the Commonwealth will be increasingly able to adapt rapidly and economically to future changes.

GEOGRAPHIC/DEMOGRAPHIC FACTORS

CHAPTER III - 11

Massachusetts is a relatively small state. Its land area of 7,833 square miles ranks it 45th in size of the fifty United States. Nevertheless the Commonwealth is endowed with a rich spectrum of climatic and geographic characteristics which combine to require a high standard of thoroughly enclosed, weatherproof construction in order to build habitable and comfortable schoolhouses.

Climate

Meteorologists refer to Massachusetts' climate as temperate, the result, no doubt, of an arithmetical averaging process which does not bother to take into account either winters with sub-zero temperatures in many parts of the state or summers with temperatures approaching one hundred degrees in others. Historically, winter conditions have exerted the greater climatic influence on school building design than those of summer, for the obvious reason that most school systems are in recess from late June until early September.

In order to conserve heat and help hold down the amount of money which must be spent on keeping them warm, most school buildings tend to be compactly planned, with a minimum of exposed surface consistent with other planning determinants, such as natural light and ventilation for classrooms. Construction is thermally dense and well insulated in order to retain heat inside the building. The combined effects of low temperatures and significant annual snowfall (an average of 42 inches at Boston) make the campus

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type school, which is viewed very favorably in warmer climates, less desirable here than a plant in which all teaching spaces are accessible without requiring persons to leave heated and sheltered indoor areas. Snow and ice accumulations incur removal costs which act to reduce paved exterior areas to a minimum.

Winter weather conditions have exerted the major influence on the design of Massachusetts schools constructed to date. The greater use which can be gained from school buildings by operating them throughout the year is becoming increasingly attractive to communities as a means of reducing their need for new classroom space. Such a major change in operating policy will make designing to meet summer weather conditions no less important than winter. Successful accommodation of summer weather presents an equally demanding design problem. In contrast to January low temperatures averaging in the low twenties, July highs average well over eighty (U.S. Weather Bureau figures for Boston), making air conditioning necessary for the comfortable and effective use of buildings. The generally compact building forms and thermally dense construction required in response to winter weather happen to work also to advantage in air conditioned buildings. While sunlight entering the building in winter is both a psychological asset and a reduction of the heating load, it is a liability during the warm months, since it adds to the heat which the air conditioning system must then remove.

Topography

The topography of Massachusetts was formed by glaciation and erosion and is almost as varied as the state's weather. The land varies from marshes, outwash plains, drumlins and moraines along the seacoast through rolling hills to the high ridges of the Berkshires in the western part of the state. Its elevation varies from sea level to 3,491 feet at the summit of Mount Greylock in Williamstown. Topographical variations are sudden and dramatic, a fact which must be familiar to everyone who has experienced the sudden change which occurs passing over the ring of hills forming the rim of the "Boston Basin." Along with these visible features go other changes, also frequently abrupt, in what lies beneath the surface of the ground. Bedrock, for instance, lies several hundred feet below the Cape Cod peninsula, but in other parts of the state it thrusts above ground as exposed ledge. The materials overlying the bedrock vary from organic mud through silt, clay, sand and gravel. The amount and complexity of the foundations required to support buildings erected in these different places vary widely. Accordingly, sitework and foundation costs vary greatly from one site to another, depending on the need for piles, blasting, rock removal, dewatering and many other factors.

Demographic Variations

Far more important than geological and topographical considerations in their effect on Massachusetts school building design, however, are the large and significant differences between the environments for building in rural, suburban and urban areas of the Commonwealth. Population densities vary greatly from place to place. A conservative idea of the magnitude of these variations can be gained by comparing Dukes County, with a density of 58 inhabitants to the square mile (0.09 per acre), to Suffolk County, whose mean density is 12,750 (almost 20 per acre).* The difference is on the order of 220 times. Such a wide spread of population densities between the

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most and least inhabited (and therefore built-up) areas results in a wide variation in the amount of land available for a proposed school, the costs of acquiring and developing it, the overall form of the school building itself, the degree of resistance to fire which the building must have, and of course the cost of construction.

In rural areas there is usually sufficient land available at a reasonable price that the configuration of a school building can be totally determined by factors other than the size or shape of the site. There is sufficient land to accommodate future expansions with ease. Since it is not necessary to conserve scarce and expensive land by stacking the building more than one story high, construction costs are reduced by the absence of need for a heavy-duty structure capable of supporting several floors of construction. In addition, emergency means of escape from the building are usually simple and direct. This, taken together with the normal absence of nearby or abutting structures, means that the requirements for fireproofing of the structure need not be as stringent as for sites in more densely populated and built-up areas, a factor which can result in further savings in construction cost. Set against these cost advantages of a rural school are site development costs which frequently are pushed upward by the absence of municipal sewer and water service, and the need to develop new means of access to the site.

Urban school sites present very nearly the opposite situation. Land values are high, and available land is scarce, forcing the construction of multistory buildings whose configurations are primarily determined by the need to squeeze a large amount of building onto a small amount of land. Multistory buildings require heavier structural systems and a greater degree of fire resistiveness than low construction. The amount of vertical circulation required both for easy circulation and to assure the safe evacuation of occupants in the event of fire cuts into the total usable space available, necessitating larger buildings and further increasing per-pupil costs. Closely abutting structures make a greater degree of fireproofing necessary to minimize the risk to adjacent properties from fire. If the site is vacant when it is acquired for a new school, site development costs may be lower than in a rural area simply because the site area is much smaller and utilities are usually available beneath an adjacent street. More commonly, existing buildings must be removed, adding another significant extra item to the cost of construction.

The very accessibility of most urban sites, located on busy streets, creates additional problems. Off-street service and loading areas must be carved out of what is ordinarily a minimum-sized parcel of land. The general level of air pollution in urban environments is made worse by the noise and dirt of vehicular traffic. Air conditioning becomes highly desirable under these circumstances as a means of cleaning and deodorizing the air supplied to the building and has the further benefit of allowing the building to be sealed against distracting outdoor noise.

Suburban sites partake of aspects of both rural and urban conditions. Superficially, suburban and rural schools resemble each other to a great degree. Although site area usually has more influence on the configuration of the suburban school than on its rural counterpart, both types of building are relatively low and spread out. Municipal water and sewer service is more frequently available, particularly in the more established and heavily

built-up suburbs. Althou
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built-up suburbs. Although the protection of neighboring property is not ordinarily a major consideration, plan forms which tend to require more stories than in rural situations require a higher degree of fire protection, although obviously not as much as in densely built-up urban situations.

The preceding discussion has touched upon some of the natural and demographic constraints on the design and construction of school buildings within the Commonwealth. Many of these constraints have been institutionalized and given force of law by means of building codes, such as the Building Regulations for Schoolhouses of the Massachusetts Department of Public Safety. A more complete discussion of the operation and effect of building codes is contained above in Chapter III-8 of this report.

SPACE UTILIZATION AND PLANNING STANDA

CHAPTER III - 12

Schools in Massachusetts are among the highest quality schools in the nation. They are also among the largest in terms of area per pupil. Currently, there are no standards or guidelines to determine educational space requirements in Massachusetts.

A recent survey of 83 schools provided some basic information on how space is being utilized in Massachusetts schools. The survey is an analysis of instructional areas (size of area and ratio of gross to net square feet) and an analysis of instructional spaces. The survey establishes a median and reveals that individual spaces in schools are rarely too small but are often too large. Therefore, many schools are built with more space than is needed to provide a good educational environment.

A second survey was made of minimal area standards for instructional spaces in 23 states. From the median derived for schools in Massachusetts and the median derived from the survey of 23 other states, a comparison is made between space standards in Massachusetts and standards in other states.

This study also identifies two areas of potential major savings in space planning in Massachusetts schools.

<u>An Analysis of Instructional Areas</u>

A survey of architects who designed schools and who had contract bids approved by the voters between 1965 and 1970 in Massachusetts provided some basic information on 83 school projects. Included in the group were 25 elementary schools, 9 additions to elementary schools, 14 middle or junior high schools, 5 additions to middle schools, 19 senior high schools and 11

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additions to senior high schools. Exhibit I presents the basic information as reported by the architects on the name of the schools, location, student capacity, grades, areas in square feet, and ratios of gross to net square feet. These projects ranged in size from 4,470 square feet for the Macomber School in Westport to 563,000 square feet for the New Bedford High School. Exhibit II presents the smallest, median (50th percentile) and largest area in gross square feet per student. The smallest project (37 square feet) is an addition to an existing elementary school, and the largest project is a vocational school (233 square feet).

Additions to schools vary considerably depending upon the existing educational spaces, student capacity and the accommodations needed for new educational programs.

The median figures in Exhibit II represent basic planning areas of the past (1971-1975). For the school projects reported in the survey, the median areas from the architectural survey were 81 square feet for elementary schools, 136 square feet for middle schools and 153 square feet for senior high school. Most recent developments in education, and particularly the new standards from the American Library Association in 1970, have added from 10 to 20 square feet per pupil to new buildings.

Ratio of Gross Area to Net Area

Faculty and administrators in education want optimal instructional areas in schools. Taxpayers want the most instructional area for the least cost. Recent developments in open-space teaching have reduced the gross area of school facilities by as much as 20 or 30 percent. The variation is sometimes evident in analyzing the gross area of a school (which includes all

Exhibit 1

Basic Information on 83 School Projects with Approved Contract Bids between 1965 and 1970
Elementary Schools
(25)

School, Location	Capacity Grades	Total Gross Square Feet	Gross SF Per Pupil	Total Net Square Feet	Net SF Per Pupil	Ratio - Net to Gross SF
Wilowood Elementary Amherst	775 K-6	79,330	102.4	61,59?	79.4	.78
Fox Hill Elementary Burlington	840 K-6	61,206	72.8	44,750	53.3	.73
Martin Luther King Jr. Cambridge	905 K-8	136,000	150.9			
Lt. Peter Hanson Elem. Canton	720 1-6	57,562	79.9			
The Robbins School Carlisle	200 K-6	21,000	105.0	18,780	93.9	.89
Maple Road (Byam) Elem. Chelmsford	750 K-6	61,000	81.3	40,000+	53.3	.66
Harrington Elementary Chelmsford	750 K-6	61,000	81.3			
Peabody School Concord (5-7 now)	540 K-6	56,500	104.6	45,600	84.4	.81
Meadowbrook Elementary East Longmeadow	600 K-6	52,000	86.7	41,320	68.9	.79
Plum Cove Elementary Gloucester	240 K-6	17,500	72.9	14,000	58.3	.80
Elementary School Grafton	840 K-6	65,130	77.5	49,649	59.1	.76
East Meadow Elementary Granby	540 4-6	37,000	68.5	28,000	51.9	.76
Plymouth River Elementary Hingham	675	72,250	107.0	47,400	70.2	.66
Elementary School Millbury	720 K-6	55,000	76.4	44,000	61.6	.80
Ryan Road School Northampton	420 K-6	29,400	70.0	22,855	54.4	.78
Bates Elementary North Salem	615 K-6	75,500	122.8	70,150	114.1	.93
Mosier Elementary South Hadley	750 K-6	59,151	78.9	46,521	62.0	.79
Hastings Elementary Westborough	693 K-4	75,214	108.5	55,273	79.7	.73
Belmont St.. School Worcester	900 K-6	94,582	105.1			
John M. Tobin Elementary Cambridge	1000 K-8			120,000	120.0	
Frank Smith Road Elem. Longmeadow	550	53,480	97.4			
Greenwood Park School Longmeadow	402 K-6	31,000	77.1			
New Burr Elementary Newton	500	53,000	107.0			
Witchcraft Heights Salem	750 K-6	92,000	122.7	70,000	93.3	.76
Wessacusset Elementary Weymouth	595 K-6	46,231	77.7	33,360	56.1	.72

School, Location	
Chelmsford Elementary Westlands Addition Chelmsford	
Elem. Sch. Addition Freetown	
Hillside Elem. Add. Needham	6
Bryantville Elementary Pembrooke Alt. & Add.	
Chace Street School Somerset Alt. & Add.	6
Plains School Addit. South Hadley	
Emerson School Add. & Alt. Bolton	
Campbell Elem. Add. New Bedford	
Macomber School Westport	

School, Location	
Junior High School Amherst-Pelham	
Edward B llamy Middle School - Chicopee	
T. Burgess Intermed. Hampden	
Glenbrook Middle Longmeadow	
Rupert A. Nock Middle School Newburyport	
Middle School Northborough	
Pentucket Reg. Jr. H.S. Pentucket	
Sharon Junior H.S. Sharon	
Junior High School Wilbraham	
Transitional School Wilbraham	
Weston Jr. High & P.E. Facility - Weston	9 12
Lexington Jr. High Lexington	
Longmeadow Middle School Longmeadow	
Westport Middle School Westport	
Peter Thacker Middle A & A - Attleboro	
Peter W. Reilly School Addition - Lowell	
Middle School Addition Somerset	
South Attleboro Middle A & A - South Attleboro	
Wellesley Jr. H.S. Add Wellesley	

…ct Bids between 1965 and 1970

Total Net …quare Feet	Net SF Per Pupil	Ratio - Net to Gross SF
61,594	79.4	.78
44,750	53.3	.73
18,780	93.9	.89
40,000+	53.3	.66
45,600	84.4	.81
41,320	68.9	.79
14,000	58.3	.80
49,649	59.1	.76
28,000	51.9	.76
47,400	70.2	.66
44,000	61.6	.80
22,855	54.4	.78
70,150	114.1	.93
46,521	62.0	.79
55,273	79.7	.73
120,000	120.0	
70,000	93.3	.76
33,360	56.1	.72

Elementary Schools
Additions and Alterations
(9)

School, Location	Capacity Grades	Total Gross Square Feet	Gross SF Per Pupil	Total Net Square Feet	Net SF Per Pupil	Ratio - Net to Gross SF
Chelmsford Elementary Westlands Addition Chelmsford	580 K-6	47,500	81.9			
Elem. Sch. Addition Freetown	180 1-8	8,755	48.6	8,123	45.2	.93
Hillside Elem. Add. Needham	600(180)	New & alt. 12,500	69.4	New & Alt. 10,430	57.9	.83
Bryantville Elementary Pembrooke Alt. & Add.	442 K-6	44,420	100.5	38,916	88.1	.88
Chace Street School Somerset Alt. & Add.	630(305)	21,430	70.3	17,010	55.8	.79
Plains School Addit. South Hadley	180 K-6	15,732	87.4	11,677	64.9	.74
Emerson School Add. & Alt. Bolton	325 add, 1-5	33,000	101.5			
Campbell Elem. Add. New Bedford	180	12,542	69.7			
Macomber School Westport	120 1-8	4,470	37.3	4,236	35.3	.95

Middle Grades
(14)

School, Location	Capacity Grades	Total Gross Square Feet	Gross SF Per Pupil	Total Net Square Feet	Net SF Per Pupil	Ratio - Net to Gross SF
Junior High School Amherst-Pelham	1100 7-8	196,000	178.2	148,481	134.9	.76
Edward B llamy Middle School - Chicopee	1200 5-8	175,000	145.8			
T. Burgess Intermed. Hampden	600 5-8	71,900	119.8	56,775	94.6	.79
Glenbrook Middle Longmeadow	690 6-8	95,000	137.7	71,350	103.4	.75
Rupert A. Nock Middle School Newburyport	1400 4-9	164,500	117.5	113,800	81.3	.69
Middle School Northborough	900 608	132,310	147.0	98,313	109.2	.74
Pentucket Reg. Jr. H.S. Pentucket	1100 7-9			66,170	60.2	
Sharon Junior H.S. Sharon	735 7-8			78,136	106.3	
Junior High School Wilbraham	731 7-8	99,750	136.5	81,757	111.8	.82
Transitional School Wilbraham	600 4-6	53,551	89.3	43,693	72.8	.82
Weston Jr. High & P.E. Facility - Weston	900Ac 7-8 1200Pe 7-10	132,655	147.4	98,210	109.1	.74
Lexington Jr. High Lexington	900 7-9	120,000	133.3	79,100	87.9	.66
Longmeadow Middle School Longmeadow	700 6-8	95,000	135.7			
Westport Middle School Westport	830	116,000	139.8			

Additions and Alterations (5)

School, Location	Capacity Grades	Total Gross Square Feet	Gross SF Per Pupil	Total Net Square Feet	Net SF Per Pupil	Ratio - Net to Gross SF
Peter Thacker Middle A & A - Attleboro	800(449) 6-8	55,968 add	133.6	39,979 add	89.0	.67
Peter W. Reilly School Addition - Lowell	250 4-6	19,126	76.5	13,369	53.5	.70
Middle School Addition Somerset	480 5-8	31,280	65.2	22,368	46.6	.72
South Attleboro Middle A & A - South Attleboro	750(480) 6-8	59,943	124.9	39,963	83.3	.67
Wellesley Jr. H.S. Add Wellesley	1800(750) 7-9	80,900 24,500 add	107.9	64,370 19,100	85.8	.80 .78

High Schools
(19)

School, Location	Capacity Grades	Total Gross Square Feet	Gross SF Per Pupil	Total Net Square Feet	Net SF Per Pupil	Ratio - Net to Gross SF
Hoosac Valley Regional Adams	1000 9-12	161,000	161.0	134,000+	134.0	.83
Braintree High School Braintree	2800 9-12	385,000	137.5			
Physical Education Building - Brookline	1200	70,100	58.4			
Mohawk Trail Regional Buckland	950 7-12	119,000	125.3	89,838	94.6	.75
Dover-Sherborn Regional Dover	800 9-12	184,868	231.1	100,450	125.6	.54
Nauset Regional H.S. Eastham (core 1000)	800 9-12	157,000	196.3	100,000	125.0	.64
Easton Sr. High School Easton (core 1200)	900 10-12	141,854	157.6			
Oliver Ames Sr. H.S. Easton	900 10-12			117,750	130.8	
Holliston High School Holliston	1200	221,670,	184.7	159,150	132.6	.72
Hudson High School Hudson (exp. 1200)	900 9-12	144,617	160.7	124,903	138.8	.86
Mansfield High School Mansfield	1000 7-12	149,000	149.0	109,775	109.8	.74
Medford High School Medford (500 voc)	3500 9-12	536,000	153.1			
High School Southwick	700 9-12	107,214	153.2	84,467	120.7	.79
Old Rochester Regional H.S. Marion	600 7-8	70,000	116.7	45,500	75.8	.65
Middleboro High School Middleboro	1000- 1200	154,000	154.0 128.3			
New Bedford High School New Bedford	3000 10-12	563,000 464,000 fin.	154.7	378,000	126.6	.81
Senior High School Waltham	2600 10-12	363,00	139.6			
Westborough Senior H.S. Westborough	1100 8-12	150,000	136.4			
Whittier Reg-Voc H.S. Whittier Region	1500 9-12	350,000	233.3	240,000	160.0	.69

Additions and Alterations
(11)

School, Location	Capacity Grades	Total Gross Square Feet	Gross SF Per Pupil	Total Net Square Feet	Net SF Per Pupil	Ratio - Net to Gross SF
Masconomet Jr-Sr H.S. Boxford (addition	2100(570) 7-12	62,770	110.1	59,642	104.6	.95
Agricultural H.S. Add. Bristol County	360+ existing 9-12	23,900		22,680 new	85.2	.95
Natick Sr. High Alt. & Add. - Natick	750 9-12	102,562	136.8	72,300	96.4	.70
Needham High Addition Needham	1810 10-12			153,980	95.1	
Northampton High School Addition - Northampton	1093(500) 9-12	53,900	107.8	39,530	79.1	.73
Algonguin Regional H.S. Add. Northboro-Sboro	1500(700) 9-12	92,626	132.3	66,088	94.4	.71
Scituate High School Addition - Scituate	1600 9-12			118,650	74.2	
Somerset Sr. High Add & Alt. - Somerset	1200(300) 9-12	88,820	74.0	72,466	60.4	.82
Cohasset Jr-Sr. High Cohasset - Add. & Alt.	900	55,130 add to 90,000 existing = 145,130 gross 161.3 per pupil				
Mt. Greylock Regional H.S. Add. - Williamstown	450 9-12	65,822	146.3	50,413	112.0	.77
Wayland High School Add. Wayland	400 9-12	19,230	48.1			

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Gross SF Per Pupil	Total Net Square Feet	Net SF Per Pupil	Ratio - Net to Gross SF
161.0	134,000+	134.0	.83
137.5			
58.4			
125.3	89,838	94.6	.75
231.1	100,450	125.6	.54
136.3	100,000	125.0	.64
157.6			
	117,750	130.8	
184.7	159,150	132.6	.72
160.7	124,903	138.8	.86
149.0	109,775	109.8	.74
153.1			
153.2	84,467	120.7	.79
116.7 154.0 128.3	45,500	75.8	.65
154.7	378,000	126.6	.81
139.6			
136.4			
233.3	240,000	160.0	.69

Alterations

Gross SF Per Pupil	Total Net Square Feet	Net SF Per Pupil	Ratio - Net to Gross SF
110.1	59,642	104.6	.95
	22,680 new	85.2	.95
136.8	72,300	96.4	.70
	153,980	95.1	
107.8	39,530	79.1	.73
132.3	66,088	94.4	.71
	118,650	74.2	
74.0	72,466	60.4	.82
= 145,130 gross 161.3 per pupil			
146.3	50,413	112.0	.77
48.1			

Exhibit II

Gross Square Feet Per Student

	Smallest	Median	Largest
Elementary	68	81	151
Addition	37	70	101
Middle or Junior High	89	136	178
Addition	65	108	134
Senior High	117	153	231
Addition	48	110	146
Vocational		233	

of the area including the walls) with the net area or the basic instructional requirements for space listed in educational specifications (which excludes walls, corridor, toilets, boiler rooms, etc.).

Exhibit I shows the ratio between gross and net areas. To simplify the analysis, the smallest, median and largest ratios are presented below for the three basic types of school projects.

Type of School	Ratio of Gross to Net Area Smallest	Median	Largest
Elementary	.66	.78	.93
Middle or Junior High	.66	.75	.82
Senior High	.54	.74	.86

Most educational programs for self-contained instructional rooms usually have a ratio of about .67; some efficiencies in designs reach a ratio of .70 to .75. The most efficient buildings would have larger ratios of .80 or .90, but these ratios were not possible until educational programs accepted open-space instructional methods. Withoug a research unit to measure the gross and net square feet in a project with consistent methods, some caution must be noted before comparing one school with another school project in Exhibit I.

Most elementary schools in the nation have a cluster of classrooms which permit open-space, small group or more individualized instruction. Many middle schools are also providing clusters of classrooms, but very few senior high schools have accepted this new method of teaching. Among the schools analyzed between 1965 and 1970 in Massachusetts, senior high schools show the lowest ratios--.54 and .74. More elementary schools are beginning to reach the high eighties and lower nineties with clusters of classrooms.

Although newer educational programs provide a basic economy in gross square feet, the resulting compact space may cost more per square foot. An overall economy, however, is possible with open-space or clusters of classrooms and more efficiency in design to achieve lower gross to net rations.

Two cautions should be emphasized before requiring all schools to provide more open space or clusters of classrooms:

(1) Teachers must be prepared to teach effectively in open or clustered spaces.
(2) Students must learn to work without distraction in open or clustered spaces.

Recommendation to Reduce Gross Areas Through More Efficient Planning

The variation in net to gross ratios ranged from .54 to .93 percent. It is possible to increase the ratio of elementary schools to the median, 78 percent, or senior high schools to 74 percent. This would provide a 12 percent increase in elementary schools and 20 percent increase in secondary

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More Efficient Planning

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schools. This increase in efficiency could provide a reduction in cost of 10 to 15 percent. When more open or clustered spaces are used or individualized and programmed instruction is accepted by the educational profession, an additional 10 percent of the gross area could be reduced. The latter is a goal that the Department of Education could pursue without legislation. The ratio of gross to net area required additional research to improve efficiency of space requirements. Each has potential economies for future taxpayers.

<u>Analysis of Instructional Spaces</u>

Another important analysis of the school projects reported by architects shows the square feet required by educational specifications for 63 of the 83 school projects reported in Exhibit I. Each of the basic areas in the 63 school projects are presented in Exhibit I, but Exhibit III summarizes the smallest(s), median(m) (the 50th percentile), and largest (l) areas required. For example, art spaces vary in elementary schools from 900 to 1150 square feet with a median of 1000 square feet. In middle schools the median is 1174 square feet, and in senior high schools the median is 1250 square feet.

Sometimes more than one class may use a facility in what could be called open-space, cluster or individualized instruction. This seems to be the reason for the largest areas provided in the middle and senior high school projects. There is some economy in having several spaces grouped together when walls and sometimes corridors are eliminated.

Exhibit III provides the square feet in area for twelve types of instructional spaces. It is important to note that neither the Massachusetts Board of

Education nor the School Building Assistance Commission used standards for instructional spaces. The Board of Schoolhouse Structural Standards and the Department of Public Safety use a standard for minimum requirements for safety and egress. Exhibit IV presents the areas for ning different instructional rooms. The instructional work area is much larger than the safety area, but the Department of Public Safety requires the width of exits to correspond to their dimensions. For example, 22 square feet per student is required for primary and intermediate students in a classroom. For instructional purposes, materials and teachers' desks, 30 to 35 square feet may be required. Consequently, a room of 900 square feet designed for 25 students and a teacher would need exit protection for 39 students (900÷23 = 39 students).

Supporting Instructional Spaces

An analysis of the 63 projects reported by architects is presented in Exhibit V. It shows the smallest, median and largest area for eleven supporting instructional areas. These include the auditorium, cafeteria, library resource center; also areas for remedial and special education, student activities, offices, guidance, health, faculty and custodial.

Although the medians provide an excellent central measure of areas, a smaller school enrollment ordinarily requires less area, while a larger school enrollment requires more area. The library resource center has one additional factor which makes the data less reliable for the smallest and median areas in Exhibit III. The American Library Association (ALA) published new standards to keep pace with the expanding number of books and the multiple media (television, film strips, films, slides, copying

Art

Business (Typing)

Homemaking

Indust. Art

Music

Science Lab

Math. Lab

Soc. Sci. L

Reading Lab

Language Lab

Kindergarten

Non-specialized general classrooms

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Exhibit III

Size of Instructional Spaces in Square Feet
in School Facilities Constructed in
Massachusetts Reported by Architects (1965-1970)

	Elementary			Middle			Secondary		
	s	m	l	s	m	l	s	m	l
Art	900	1000	1150	790	1174	1870	896	1250	1520
Business (Typing)	-	-	-	900	1068	1342	620	865	1280
Homemaking	-	1800	-	785	1368	2500	900	1080	1444
Indust. Arts	-	1800	-	970	1635	4352	553	1580	3400
Music	120	175	1300	800	1000	2000	480	1200	2500
Science Lab	200	900	1650	860	1150	1575	577	1025	2300
Math. Lab	-	-	-	300	-	412	703	900	1200
Soc. Sci. Lab	-	-	-	300	453	1525	860	-	1000
Reading Lab	-	-	-	988	-	1474	-	-	-
Language Lab	-	1100	-	600	1161	1499	768	840	1500
Kindergarten	1100	1327	1440						
Non-specialized general classrooms	700	900	1236	700	860	1120	450	768	1500

Exhibit IV

Present Regulations for Safety and Egress

Subject Area	Square Feet
Kindergarten	25
Primary and Intermediate	22
Secondary	23
Science	30 to 40 gross
Homemaking	30 net; at least 50 gross
Art	30 to 35 net
Shops	50 to 75 net
Vocational	75 to 100
Lecture halls with table arm chairs	10

Total Occupancy--equally divided:

Girls' WC		Boys' WC	
Elementary	1 for 30	Elementary	1 for 60
Secondary	1 for 45	Secondary	1 for 90
		Urinals	1 for 30

Kindergarten & Primary "1 WC for 30" actual 1 WC for each sex.

Lavatories -- 1 for 50

National Council on Schoolhouse Construction:

	Girls	Boys
Grades 1 - 8	1 - 35	1 - 60
Grades 7 - 12	1 - 45	1 - 100

Code for Structural Standards for Schoolhouse Construction

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Survey of Minimal Standar

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machines, etc.) brought upon by an expanding technology. The State Board of Education is recommending the ALA standards as minimal regulations under authority of Chapter 15, Section 1G. This will improve the library supporting area and increase the net square feet of a school project.

Survey of Minimal Standards

Massachusetts does not publish minimum area (square feet) standards for educational spaces in secondary schools. The Board of School house Structural Standards requires minimum safety standards, but those are not adequate for teaching. The primary objective of safety standards is for egress in an emergency. Instructional spaces must accommodate students, teacher(s), instructional materials, unfinished projects, special equipment, displays and must permit some movement for functional learning activities. A survey of state departments of education revealed that twenty-three (23) states provided recommended minimum standards. The range of area for general classrooms is from 550 square feet in Louisiana to 1200 square feet in Ohio. In Massachusetts, architects reported a range from 450 to 1320 square feet. The Median or middle ranking of twenty-two (22) respondents to this item was 750 square feet. Exhibit VI shows a listing of special spaces with the range in area (square feet) and the median for the survey of State Departments of Education. For 862 general classrooms reported by architects in Massachusetts the median was 768 square feet.

Although the smallest and largest area is presented for each state, the extremes are not a workable guideline for school districts. The smallest area of the minimum standards is usually required for Southern rural and

Exhibit V

Size of Supporting Instructional Spaces in Square Feet in School Facilities Constructed in Massachusetts Reported by Architects (1965-1970)

	Elementary			Middle			Senior		
	s	m	l	s	m	l	s	m	l
Auditorium/ Theatre	850	2500	4800	1000	4804	13,200	1760	6900	10,675
Cafetorium	4500	6620	11000	5946	-	6448	-	11000	-
Cafeteria	1352	3500	7880	1520	5200	12,185	1000	7635	14,500
Library Resource Center	1100	2000	7104	2196	3780	13,371	2040	5700	20,750
Remedial and/ or Spec. Educ.	270	616	3220	100	780	1156	345	730	1,645
Student Activities	660	-	2640	450	798	1250	90	800	1,540
Offices area	220	1000	2700	888	1250	5900	705	1370	6,970
Guidance area	157	480	800	440	935	1489	962	1200	5,690
Health Ser.	120	364	1100	200	589	1084	488	834	1,335
Faculty Area	140	618	3096	195	1000	2915	780	1370	4,870
Custodial Services	80	320	3368	154	1190	10,600	280	1060	2,930

Western mountain s
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Middle		Senior		
m	l	s	m	l
4804	13,200	1760	6900	10,675
-	6448	-	11000	-
5200	12,185	1000	7635	14,500
3780	13,371	2040	5700	20,750
780	1156	345	730	1,645
798	1250	90	800	1,540
1250	5900	705	1370	6,970
935	1489	962	1200	5,690
589	1084	488	834	1,335
1000	2915	780	1370	4,870
1190	10,600	280	1060	2,930

Western mountain states. Every state allows districts to exceed the minimum standards. The largest area of the standards are commendable instructional spaces. The largest area usually provided space for storage of students' projects, instructional materials, books and special equipment.

Pennsylvania provides standards for 19 to 20 instructional areas tabulated in Exhibit VI. At the other extreme Washington has one standard for kindergarten.

The median or middle area in the range of state standards provides a reasonable guide for a minimal school.

From an historical analysis of state standards, two observations are apparent. First, most school buildings have exceeded the minimum standards, and second, many state minimal standards were inadequate for instructional programs in the Seventies and were not changed frequently enough to respond to new educational needs for storage and instructional space. This analysis in Exhibit 6 of state standards seems to indicate that state standards can be reasonable.

Pennsylvania provides an example of reasonable minimum standards that were revised in the 1960's. States with minimum standards should periodically review and revise the information on area for instructional spaces or rooms. With open-space and team teaching, more electronic teaching aids, and individualized programs for students, research is needed on appropriate sizes of instructional spaces to accommodate additional programs.

Comparison of Secondary Instructional Rooms

From the analysis of school projects in Massachusetts reported by architects and the median from the survey of 23 states, a comparison provides some

Exhibit 6

Minimal Standards Used by State Departments of Education

June 1971

Instructional Area	Number of States Reporting Standards	Minimal Standards		
		Range in Sq. Ft.	50th Percentile	Penna.
General Classrms.	22	550 to 1200	750	850
Kindergartens	6	900 to 1250	1050	900
Arts & Crafts	10	575 to 1600	1000	1000
Business Labs	7	575 to 1200	900	1125
Homemaking	10	875 to 1500	1200	1000
Industrial Arts	10	1000 to 2400	2000	1800
Language Labs	5	850 to 1125	900	850
Music	11	575 to 2000	875	1000
Indoor Phys. Ed.	8	3000 to 19347	6200	7500
Swimming Pool	1		6000	6000
Science Labs	13	840 to 1500	1150	1000
Seminar Rooms	1		425	425
Special Education	1		850	850
Large Group Instr.	1		1500	1500
Assembly/Auditorium	3	$6\frac{1}{2}$ to 9/student	7	7-9
Multi-Purpose	1		2499	-
Cafeteria	5	10 to 15/student	12	10
Health Service	3	400 to 737	660	660
Library	13	20 to 40/student	30	30
Kitchen	5	$1\frac{1}{2}$ to 3/student	$2\frac{1}{2}$	3

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Minimal Standards

e in Sq. Ft.	50th Percentile	Penna.
50 to 1200	750	850
00 to 1250	1050	900
75 to 1600	1000	1000
75 to 1200	900	1125
75 to 1500	1200	1000
00 to 2400	2000	1800
50 to 1125	900	850
75 to 2000	875	1000
00 to 19347	6200	7500
	6000	6000
40 to 1500	1150	1000
	425	425
	850	850
	1500	1500
to 9/student	7	7-9
	2499	-
to 15/student	12	10
00 to 737	660	660
to 40/student	30	30
to 3/student	2½	3

insight into the reasonableness of instructional areas. Exhibit VII presents the median areas for ten instructional rooms and also shows the standard of Pennsylvania.

The median area for art spaces in Massachusetts (1250 square feet) exceeds the 23-state median, and Pennsylvania standard, by 250 square feet, which is not a very large area.

In business education the Massachusetts median is the smallest at 865 square feet. For homemaking (1180 square feet) Massachusetts is 120 square feet less than the 23-state median, but exceeds Pennsylvania by 80 square feet.

Massachusetts has the smallest area for industrial arts at 1580 square feet. In music, Massachusetts has the largest area for choral or general music classes at 1200 square feet. This space is not, however, sufficient space for a senior high band or orchestra. The median space for science in this state (1025 square feet) for the past five years was smaller than the median for the 23 states (1150 square feet) or Pennsylvania (1000 square feet).

For math, social science and language laboratories, the medians for Massachusetts are an indication of newer demands for improving educational programs not apparent in standards for any states.

General classrooms for English, math, history, social science, and foreign languages are nearly the same for Massachusetts (768 square feet) and the 23 states (750 square feet). Pennsylvania is requiring 850 square feet. This comparison shows that medians in Massachusetts are relatively close to the minimum standards of many states. Additional research into the functional programming in each instructional space is needed and Massachusetts could provide reasonable and flexible standards of instructional spaces for schools.

Recommendation for Reducing Space in Excess of Other States' Standards

The largest instructional areas are more than acceptable in comparison to the standards of other states, and the median areas are small in only two disciplines: business (865 square feet) and language laboratories (840 square feet). In all other instructional spaces the median would make an acceptable space for one class. Clustered and multiple classes could be submitted in increments or multiples of the basic class size. The recommended saving in individual spaces would probably be small--about 5 percent when the smaller spaces are brought to the medians.

Supporting spaces could also be reduced, particularly the cafeteria which could double as a designed study or instructional spaces for periods before and after lunch.

The greatest economy from space submissions comes from establishing student capacities for a school facility. (Chapter II-4 explains the process and summarizes three ways of establishing student requirements for a secondary school in Exhibit V.) Utilizing the capacities of a divisible assembly or auditorium, the cafeteria-dining areas and library areas for students with study periods or scheduled classes provides a 25 percent increase in capacity. This principle of scheduling applies to middle and junior high schools as well, but to a lesser degree--about 15 to 20 percent. Schedules prepared with the use of a computer can easily achieve a 90 percent utilization without overcrowding facilities or eliminating important smaller classes such as Latin IV or calculus, remedial or advanced work.

In reducing space from a larger to smaller school, the economies are not directly proportional; consequently, the best that could be expected would be about a 10 percent reduction in cost.

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Music
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Math. Lab.
Soc. Sci. Lab
Language Lab.
General Classrooms

States' Standards

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Exhibit 7

A Comparison of Secondary Instructional Rooms (in square feet)

	50th Percentile of Minimums for 23 States	Median for Massachusetts (1965-1971)	Pennsylvania
Art	1000	1250	1000
Business	900	865	1125
Homemaking	1200	1080	1000
Industrial Arts	2000	1580	1800
Music	875	1200	1000
Science Lab.	1150	1025	1000
Math. Lab.	-	900	-
Soc. Sci. Lab	-	860	-
Language Lab.	-	840	-
General Classrooms	750	768	850

In summary, the two recommended savings in space are 10 percent for more efficient planning (net to gross ratio) and 10 percent for a better utilization of space and small reductions in the instructional areas and supporting spaces (cafeteria and library).

PROJECTION OF SCHOOL NEEDS

CHAPTER III - 13

There are several ways to measure the need for school facilities. One reliable method frequently used to obtain a parameter of needs is to ask each superintendent of schools to estimate his present shortage and projected needs for the next five years. The total figures accumulated this way can either be used "as is" or adjusted to correct for the superintendents' tendency to overstate their needs in anticipation of reductions by other hands.

This study of the need for school facilities in Massachusetts will use the estimates of superintendents as the most reliable assessment of the need for school facilities. The distribution of needs will be divided by geographical areas, annual requirements, and types of facilities. In an attempt to validate the school needs this study will use the best information available. This information will begin with an analysis of student increases from 1965 to 1975, including non-public school transfers. It will utilize the reports to Congress on the condition of school facilities in 1965. It will compare the construction of new facilities in Massachusetts between 1965 and 1970 with the needs for school facilities.

For the next five years (1971-1975) superintendents reported a need for 10,697 instructional spaces in cities, towns and regional public school districts of Massachusetts. An additional 1,570 to 2,350 spaces might be needed to accommodate the transfer of non-public school students to public schools. This combined need of 12,000 to 13,000 instructional spaces could make the demands for new school construction for the next five years the largest in the history of education in Massachusetts. Postponement

SCHOOL NEEDS

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education in Massachusetts. Postponement of this large a need for educational facilities could do irreparable harm to students and add a tremendous burden to local property taxpayers.

An Estimate of Needs

The primary source of information comes from a survey of superintendents of public schools which indicates that Massachusetts needs 10,697 instructional spaces by 1975. This is a significant increase from reports in 1965 which required only 5,000 instructional rooms to eliminate overcrowding.[1] The estimate includes the needs for instructional spaces for students who attend public schools and for instructional spaces which will be required when kindergartens are introduced. The superintendents did not anticipate the number of students that might transfer from non-public schools during the school years from 1971 to 1975, but many noted the uncertainty and probability of increasing enrollments from non-public schools.

Estimates for spaces to accommodate students from non-public schools were developed from a history of transfers for the Commonwealth during the last three years and from a study of transfers from October 1, 1968, to October 1, 1969, for the 351 cities and towns in the Commonwealth.[2] Projections were developed based on the trends of the last few years, and half of the new student predictions were assumed to enroll in classrooms that could accommodate them. The other half of the estimated student transfers were presumed to need new classrooms. This is a method of preparing needs for school construction used in preparing reports to the United States Congress in 1962, 1965 and 1970. Consequently, the 1,570 instructional rooms estimated for transfers of non-public school students represent accom-

[1] School Construction, 1965 Hearings before the General Sub-committee on Education of the Committee on Education and Labor. House of Representatives, Eighty-Ninth Congress, First Session, July 27, 1965. p. 24.

[2] These data were prepared by the Department of Education, Division of Research and Development, and are presented in the Working Papers of this report.

modations for only one-half of the estimated student transfers, based upon the assumption that 25 percent of the students might transfer. If the assumption is increased to 37 percent, then one-half of the student transfers would need 2,350 instructional spaces.

Instructional Spaces

Types of instructional teaching spaces needed include (1) special instructional laboratories, rooms or spaces and (2) regular, interchangeable or general classrooms or equivalents of "open spaces" which are a cluster of several classrooms. Special instructional spaces include art, music, shop, homemaking, science, typing and office practice areas.

Not included are general-use teaching stations for physical education, large-group auditorium or assembly, library/instructional resources center, language laboratory, mathematics laboratory, music practice rooms, conference rooms, or other special service areas. Special service areas not included in the superintendents' survey are cafeteria, guidance, administrative offices, faculty work room, custodial work room, health clinic, remedial or student activity work rooms.

1. Geographical Distribution of Needs

The impact of projected needs for instructional spaces is evident in every section of the Commonwealth. Map 1 shows six subdivisions of the Commonwealth -- Metro (Boston), Suburban (Boston), Mid-East (Worcester area), Northeast, Southeast (including Cape Cod), and Western Massachusetts. This grouping of cities and towns divides the population into groups of about 900,000 persons according to the preliminary estimates of the 1970 Census for the United States. The range in population varies from 907,449 in the Northeast to 972,463 in the "Metro" area. Table 1 shows the population for

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each of the geographic subdivisions. The needs for 10,697 instructional spaces are presented in Exhibit I.

Significantly large needs for instructional rooms are evident in the Southeastern part of the Commonwealth, but the Middle Eastern (Worcester) area and the western part of the state also show a need for significantly large numbers of instructional spaces.

2. Annual Distribution of Needs

Another way of looking at the distribution of required instructional spaces is by year. The impact of needs is greatest in the next three years (1971-1973). If facilities are not provided during this period the impact will be shifted to future years -- 1974 and beyond.

The large number of instructional spaces indicated in the superintendents' reports for 1973, in some respects, reflects some of the requirements for kindergartens. Most of the needs for 1973, however, are for middle, secondary and occupational facilities -- about 1,300 spaces.

It may be inferred that part of approximately 800 spaces requested for students in elementary schools are for kindergarten, but no more than about one-third of the requirements. It is also possible that some of the requirements for middle and secondary schools will provide spaces in older schools for kindergartens. Consequently, about 12 percent or one-eighth of the spaces needed for 1973 could be in anticipation of kindergartens. The large decline in 1974 and 1975 might reflect the decrease in births evident in the last few years.[1]

3. Types of Facilities Needed

In addition to dividing the needs for new instructional spaces by geographical location and by year, the reports present the need for spaces

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[1] Presented in greater detail in Table 9 of this section.

Table 1

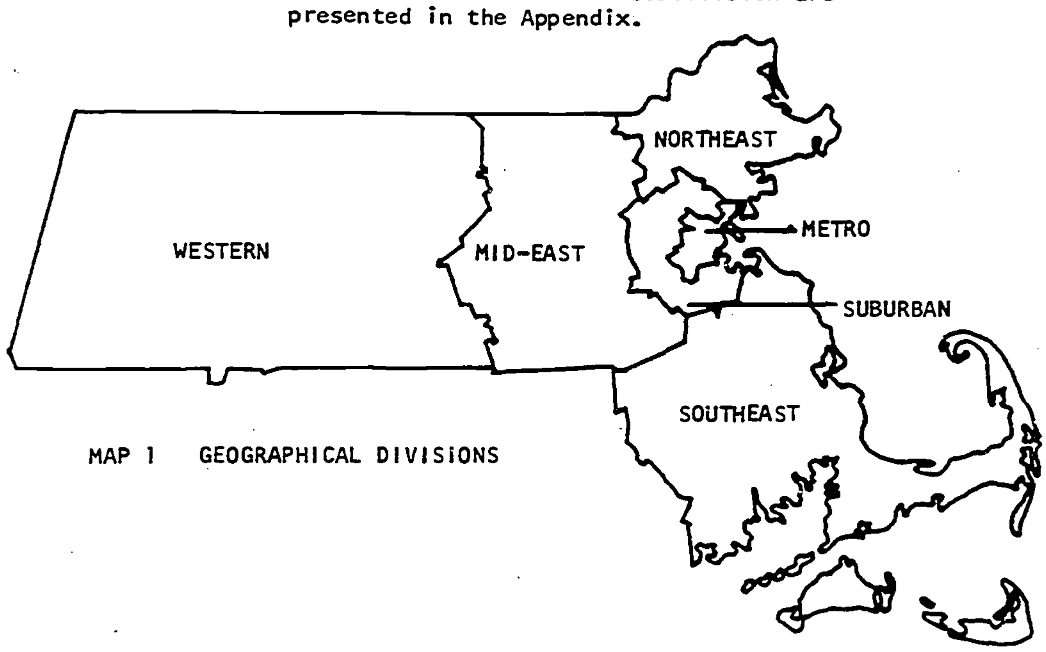
Population by Six Geographical Distributions

Massachusetts, 1970

Region	Population
Metro	972,463
Suburban	927,730
Mid-East	927,165
Northeast	907,449
Southeast	970,843
Western	932,224
TOTAL	5,637,874

Source: Preliminary Estimates United States Census

Note: Cities and towns in each subdivision are presented in the Appendix.



MAP 1 GEOGRAPHICAL DIVISIONS

R

METRO

Elementary
Middle
Secondary
Occupational

SUBURBAN

Elementary
Middle
Secondary
Occupational

MID-EAST

Elementary
Middle
Secondary
Occupational

NORTHEAST

Elementary
Middle
Secondary
Occupational

SOUTHEAST

Elementary
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Secondary
Occupational

WESTERN

Elementary
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Population

972,463

927,730

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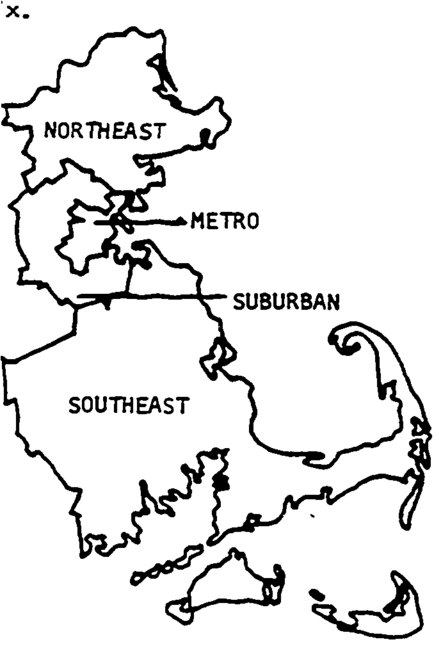

Exhibit I

Estimate of Additional
Instructional Rooms
Reported by Superintendents of Schools
1971 - 1975

	1971	1972	1973	1974	1975	Total
METRO	103	216	930	202	178	1629
Elementary	56	5	254	202	178	695
Middle	24	107	236	-	-	367
Secondary	18	104	230	-	-	352
Occupational	5	-	210	-	-	215
SUBURBAN	245	192	228	132	69	866
Elementary	48	77	86	48	26	285
Middle	13	10	66	27	11	127
Secondary	174	95	66	47	17	399
Occupational	10	10	10	10	15	[illegible]
MID-EAST	316	443	739	320	299	2117
Elementary	125	117	247	96	75	660
Middle	126	89	154	23	94	486
Secondary	39	198	266	189	120	812
Occupational	26	39	72	12	10	159
NORTHEAST	319	349	595	284	75	1622
Elementary	85	96	219	83	22	505
Middle	84	77	129	33	6	329
Secondary	119	155	206	139	34	653
Occupational	31	21	41	29	13	135
SOUTHEAST	575	453	768	303	405	2504
Elementary	129	150	230	110	176	795
Middle	159	178	185	86	137	745
Secondary	272	103	218	42	75	710
Occupational	15	22	135	65	17	254
WESTERN	575	360	442	294	288	1959
Elementary	224	148	129	73	175	749
Middle	179	139	146	125	71	660
Secondary	163	58	125	59	34	439
Occupational	9	15	42	37	8	111
TOTAL	2133	2013	3702	1535	1314	10,697

by type of instructional program. This division by type of educational program indicates that most of the needs are in elementary and secondary high schools.

It is possible that some of the needs for vocational facilities are underestimated for two reasons. One reason is that regional vocational schools that are in the first stages of planning for new facilities are not among the operating school districts included in this survey. A second reason for an understatement of vocational spaces might be a lack of information about shifting emphasis in educational programs and occupational requirements of industry. Business and industry provide employment requests for current needs and do not plan years in advance for new employees or for the replacement of retiring employees in future years.[1]

Most of the needs for new instructional facilities are required for elementary schools (about 35 percent) and senior high schools (about 31 percent).

Superintendents of schools are very knowledgeable about educational programs, receive periodic reports on new students, know the rate of new housing developments in school districts and can determine the need for new instructional spaces. They are also realistic predictors of the need for additional school facilities, being aware that school needs were not the same as the fulfillment by construction. Many superintendents anticipated long periods of delay while school needs are discussed and studied before voters authorize approvals of bonds for new construction.

The most uncertain element in predicting future school needs anticipated by many superintendents of schools, particularly the city superintendents, is the rate of transfers from and closings of non-public schools. This

[1] Records and Interviews of the Massachusetts Division of Employment Security and the United States Department of Labor.

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apprehension and likely probability of transfers, therefore, encouraged a special study to predict some of the requirements.

Non-Public School Transfers

An historical review of enrollments in non-public schools provides some indications of the impact of transfers to public schools. Table 2 shows the number of students attending non-public schools by grade for the last three years. A study of the decreases in attendance in every school district in the Commonwealth indicates that the impact of transfers can be a problem in small districts like Shirley as well as the largest school district in Boston. This compilation, district by district, is presented in the working papers for this report for the school year October 1, 1968, to October 1, 1969.

During the period of 3 school years, enrollments in non-public schools decreased by 24,685 students. The decreases by grades show that 19,698 students, or 13 percent of the students enrolled, were in elementary grades (1-8) and 4,739 students, or about 8 percent of the students enrolled, were in secondary grades (9-12).

Based on the historical ratios of decrease from grade to grade presented in Table 3 (Appendix), projections for 1975 enrollment probabilities for public schools might be about 50,790 students (K-12), or about 25 percent of the non-public students. Table 4 shows these increases by grade for the Commonwealth. About 35,490 students would be in elementary grades (1-8) and 13,850 students would be in secondary grades (9-12). Estimates by some persons on the Massachusetts Special Commission to Study Public Financial Aid to Non-Public Primary and Secondary Schools (1970-1971) indicate that as many as 100,000 students could be anticipated in public schools following a recent Supreme Court Decision (June 28, 1971).[1] An overall estimate of needs

[1] Discussed in greater detail in Chapter II, 1.

Table 2

Non-Public School Enrollment History

State of Massachusetts

	1968-1969	1969-1970	1970-1971
Kindergarten	16,709	16,579	15,346
1	18,946	17,626	15,175
2	18,417	17,405	15,813
3	19,356	17,742	16,028
4	19,348	18,509	16,447
5	19,160	18,602	17,066
6	18,958	18,610	17,484
7	18,595	17,457	16,526
8	18,368	17,723	16,911
1-8	151,148	143,674	131,450
9	15,257	14,393	13,795
10	15,187	14,054	13,817
11	15,191	14,164	13,640
12	14,578	14,380	14,222
9-12	60,213	56,991	55,474
Kindergarten - 12	228,070	217,243	202,270
Ungraded	2,363	3,292	3,478
TOTAL	230,433	220,535	205,748

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1969-1970	1970-1971
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17,626	15,175
17,405	15,813
17,742	16,028
18,509	16,447
18,602	17,066
18,610	17,484
17,457	16,526
17,723	16,911
143,674	131,450
14,393	13,795
14,054	13,817
14,164	13,640
14,380	14,222
56,991	55,474
217,243	202,270
3,292	3,478
220,535	205,748

would indicate that about 3,140 new instructional spaces would be needed. However, it could be presumed that only about one-half of the student transfers would overburden existing facilities and would need new classrooms; therefore, the need could be reduced to about 1,570 instructional spaces. It is also assumed that the other half of the transfers would increase student-room ratios, which would affect the quality of instruction, but would not necessarily require additional rooms. This indicates that already overcrowded public school districts will feel the impact of the smallest increases in enrollments for public schools.

Closings of entire schools provide some opportunities for temporary leasing or rental of non-public school facilities; but the steady transfers of students without a closing of a school create a problem of providing new public school facilities.

A Second Estimate for Transfers

Another way of validating the estimates of transfers from non-public schools is to study the transfers for one year for each city and town.

A computer listing showing the enrollments of non-public schools of each city and town was prepared by the Department of Education, Division of Research and Development, on October 1, 1968, and October 1, 1969. It is available among the working papers for this study. From this listing and an analysis of the decreases for the most recent three years, a second listing by city or town was prepared. The basic information on the non-public schools, however, was obtained from the geographical location of the non-public schools as distinguished from the residences of students. Many students attend non-public schools located in adjacent school districts, and no summary of reports of all students by residence was available. If

Table 4

Projected Enrollments for Non-public School Students based on 2-Year Ratios - State of Massachusetts

	Actual 1970-1971	Ratios	Projected 1971-1972	1972-1973	1973-1974	1974-1975	1975-1976
Births (-6 yrs)	107.970	0.15	100,262	97.513	94.870	91.761	93.535
K (-5 yrs)	15.346	0.15	14,627	14,231	13.764	14,030	13,897
1	15.175	0.91	15.039	14,627	14,231	13,764	14,030
2	15.813	0.94	13.809	13.685	13.311	12,950	12,525
3	16,028	0.94	14,864	12,980	12.864	12,512	12,173
4	16,447	0.94	15,066	13.972	12,201	12,092	11,761
5	17,066	0.96	15,460	14,162	13,134	11,469	11,366
6	17,484	0.90	16,383	14,842	13,596	12,609	11,010
7	16,526	0.96	15,736	14,745	13,358	12,236	11,348
8	16,911	0.78	15,865	15,107	14,155	12,824	11,747
1-8	131,450		122,222	114,120	106,850	100,456	95,960
9	13,795	0.94	13,191	12,375	11,783	11,041	10,003
10	13,817	0.95	12,967	12,400	11,633	11,076	10,379
11	13,640	0.97	13,126	12,319	11,780	11,051	10,522
12	14,222		13,231	14,732	11,949	11,427	10,719
9-12	55,474		52,515	49,826	47,145	44,595	41,623
K-12	202,270		189,364	178,177	167,759	159,081	151,480
Ungr.	3,478						

students transfer from non-pub
the districts where their resi
problem of statistical assignm
be on some public schools, and
important for determining futu
dating in many ways the estima
declines based on the most rec

Transfers of student
about 25 percent. In distric
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facilities. Wherever estimat
report prepared for the Massac
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are presented by year of trans
factor is a reasonable estimat
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showed that the enrollment in
and decreased to 205,748 stude
could be increased for a five-

The impact of this i
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began to make an impact in ope
additional school facilities.
the needs in a number of citie
Commission was appointed to st
sented and released in May of
near future.

2-Year Ratios - State of Massachusetts

1973-1974	1974-1975	1975-1976
94.870	91.761	93.535
13.764	14.030	13.897
14.231	13.764	14.030
13.311	12.950	12.525
12.864	12.512	12.173
12.201	12.092	11.761
13.134	11.469	11.366
13.596	12.609	11.010
13.358	12.236	11.348
14.155	12.824	11.747
106.850	109.456	95.960
11.783	11.041	10.003
11.633	11.076	10.379
11.780	11.051	10.522
11.949	11.427	10.719
47.145	44.595	41.623
167.759	159.081	151.480

students transfer from non-public school, they usually will attend schools in the districts where their residences are located. Notwithstanding this problem of statistical assignment of students by residence, the impact will be on some public schools, and the total impact for the Commonwealth is important for determining future needs for school facilities and for validating in many ways the estimates of need prepared from projections of declines based on the most recent three-year enrollments.

Transfers of students by district were generally assumed to be about 25 percent. In districts where new public schools were under construction, a slight increase was imputed for the attraction of new school facilities. Wherever estimates of student transfers were available from the report prepared for the Massachusetts Special Commission to Study Public Financial Aid to Non-Public Primary and Secondary Schools (1970-1971), they are presented by year of transfer. (See Appendix Table 5.) The 25 percent factor is a reasonable estimate for several reasons. First, the enrollment for all non-public schools was analyzed over a two-year period. Table 2 showed that the enrollment in non-public schools was 230,631 students in 1968, and decreased to 205,748 students by 1970, or about 10.8 percent. This could be increased for a five-year period to about 27 percent.

The impact of this increase on public school facilities was not immediately apparent. After about three years, the accumulation of increases began to make an impact in operating budgets for public schools and for additional school facilities. Then, closings of entire schools magnified the needs in a number of cities and towns. By 1970, a Special Legislative Commission was appointed to study the problem. A summary report was presented and released in May of 1971; the full report is anticipated in the near future.

A 25 percent transfer factor is not unreasonable because the state average was about 25 percent and also because a detailed study of resident enrollments in five selected school districts verifies the findings to some degree. The five communities studied by the geographical location of residence for a student show about a 20.6 percent decrease for the past five years with insignificant transfers for the first two years and a heavier impact the last three years.

School District	Base Year	Five-Years Later	Differences No.	Differences %
Boston	43,499	34,545	8,954	20.6
Chelsea	1,527	1,180	347	22.7
Dartmouth	541	415	126	24.4
Easthampton	931	716	215	23.1
Quincy	3,633	2,028	705	19.6
TOTAL	50,131	39,784	10,347	20.6

On June 28, 1971, the Supreme Court of the United States declared the Pennsylvania plan of contracting for educational services unconstitutional (Lemon v. Kurtzman). The Court also upheld an Appellate Court ruling that the Rhode Island plan for reimbursing some of the expenses for instruction in some subjects was also unconstitutional (Robinson v. DiCenso). At one extreme, this may cause an acceleration of non-public school closings, or, at the other extreme, the current rate of transfers might continue with a planned decrease in services. For the purposes of this study, the effect of this decision is presumed to be planned reduction. However, an acceleration of transfers could also be imputed from the method used.

First, it is assumed that about 25 percent of the student enrollment in non-public schools would transfer to public schools. This would increase public school enrollments by 50,790 students.

If the increase accelerates, for example, to 37 percent, then public school enrollments would increase by about 75,000 students. For every 12 percent increase, about 25,000 students would be added to public school enrollments.

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also because a detailed study of
school districts verifies the findings
studied by the geographical location
20.6 percent decrease for the past
for the first two years and a

Five-Years Later	Differences No.	%
34,545	8,954	20.6
1,180	347	22.7
415	126	24.4
716	215	23.1
2,028	705	19.6
39,784	10,347	20.6

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students would be added to public

With a 25 percent increase in student transfers, 1,570 instructional facilities would be needed; if it were assumed that one-half of the students would crowd existing public school facilities but not require new instructional spaces, and the second half would overcrowd existing public school facilities. Any variation in this assumption would change the requirements for new facilities. This assumption was utilized in reports to the United States Congress and proved to be a reasonable assumption.

This increase to 37 percent would require about 2,350 instructional spaces which would be in addition to the 10,697 instructional spaces reported by superintendents of public schools. Therefore, the total need for the next five years would be about 13,050 instructional spaces.

If transfers accelerate to 50 percent, about 3,140 instructional spaces would be needed making the total need for the next five years about 13,840 instructional spaces.

A list of cities and towns with the estimates of the more significant transfers was presented in Table 5 (Appendix).

Projections of Public School Enrollments

An historical study of public school enrollments and births in the Commonwealth provides important indicators of future enrollments. Table 6 (Appendix) presents the enrollments by grade for the Commonwealth from 1961 to 1970. The overall increase was 281,370 students, or 31.7 percent, from 886,565 to 1,167,935 students. Most of the increases have been in grades 7 - 12, reflecting a larger number of births in the 1950's. The average increase in secondary grades (7-12) was about 15,000 compared to about 11,000 for elementary grades (K-6). The most significant increases in the last few years reflect the number of transfers from non-public schools. Table 7 (Appendix) shows the ratio of grade to grade progressions in the Commonwealth for 3 years, 5 years, and 9 years. The ratios for the last 3 years are the largest for every year except the last two years of high school (grades 10-11 and 11-12).

The "Eclectic" or best inference of future progression ratios is also required for the next five years. For example, kindergarten ratios were between 51 and 61 percent, but beginning in 1973 all public schools may be required to provide kindergartens. Not all students are able to or will want to attend kindergarten. Present regulations of the State Board of Education do not make attendance compulsory; consequently, an adjustment for 1973, 1974 and 1975 will be required for significant increases which might be expected, but not the full potential. Projections for future public school enrollments based on the adjustments are presented in Table 8. This indicates that enrollments will increase from 1,167,935 in 1970 to the largest number in 1973 of 1,179,400 students in public schools. This does not account for accommodating all kindergarten students, but it does assume that when space becomes available more school districts will provide facilities.

Decrease in Elementary Students for 1975

A decrease in students for elementary grades will reflect the decline in births for the past decade. Table 9 shows the decrease in births by year from 1962. By 1968 this reached 23,002 for a six-year period. This indicates that overall student population will go down, but allowances for new enrollments for kindergarten and transfers from non-public schools will continue to keep public schools crowded, but less crowded than the first few years of 1970. For example, the enrollment projections for grades K-6 would show the following decreases as the larger birth years of the late 1950's, which exceeded 100,000 births, move to secondary grades causing serious overcrowding there, and the lower births of the 1960's enter more of the grades.

Year	
1970	Actual
1971	Projected
1972	
1973	
1974	
1975	

Although this ope
and transfers from non-publ
and eliminate the use of ir
school districts may have s
first time since World War

Estimates for inc
Table 8 as follows:

Year	Projected
1971	59,288
1972	57,681
1973	55,791
1974	56,869
1975	56,781

The estimates in
births will be students by
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Increase in Secondary Stud

The great impact
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For example, kindergarten ratios
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but less crowded than the first few
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r birth years of the late 1950's,
condary grades causing serious over-
he 1960's enter more of the grades.

Year		K - 6	Difference Number	Cumulative
1970	Actual	620,765		
1971	Projected	608,068	12,697	
1972		597,058	11,010	23,707
1973		582,984	14,074	37,781
1974		569,958	13,026	50,807
1975		555,373	14,585	65,392

Although this opens many opportunities for kindergarten students, and transfers from non-public schools, it will also relieve overcrowding and eliminate the use of inadequate and unsafe facilities. However, some school districts may have spaces for special enrichment programs for the first time since World War II -- 30 years ago.

Estimates for increases in kindergarten enrollments are imputed in Table 8 as follows:

Year	Projected	Estimates Imputed Increase	Imput Incr Cumulated	Total
1971	59,288	2,000		61,288
1972	57,681	3,000	5,000	62,681
1973	55,791	3,000	8,000	63,791
1974	56,869	4,000	12,000	68,869
1975	56,781	3,000	15,000	71,781

The estimates indicate that about 80 percent of the potential births will be students by 1975. This will be an increase of 20 percent above the average of the last three years.

Increase in Secondary Students

The great impact in the first half of the 1970's will be on secondary facilities (grades 7 - 12). The largest increase will be about 16,000

Table 8

Projections for Public School Students Based on Three-Year Ratios - State of Massachusetts

	Actual 1970-1971	Ratios	Projected 1971-1972	1972-1973	1973-1974	1974-1975	1975-1976
Births (-6 yrs)	107.970	0.895	100.262	97.513	94.870	91.761	93.535
K (-5 yrs)	65.974	0.608	59.288	57.681	55.791	56.869	56.781
1	98.731	0.939	89.734	87.274	84.909	82.126	83.714
2	93.234	0.993	92.708	84.260	81.950	79.730	77.116
3	90.466	1.003	92.581	92.059	83.670	81.376	79.172
4	91.459	1.003	90.737	92.859	92.335	83.921	81.620
5	91.105	1.002	91.733	91.009	93.138	92.612	84.173
6	89.796	1.039	91.287	91.916	91.191	93.324	92.797
K-6	620.765		608.068	597.058	582.984	569.958	555.373
7	92.571	0.999	93.298	94.847	95.501	94.747	96.964
8	91.083	1.062	92.478	93.205	94.752	95.405	94.652
9	92.010	0.985	96.682	98.212	98.984	100.627	101.320
10	87.866	0.925	90.630	95.232	96.739	97.499	99.118
11	77.911	0.923	81.276	83.833	88.090	89.484	90.187
12	68.887		71.912	75.018	77.378	81.307	82.594
7-12	510.328		526.276	[illegible]	551.444	559.069	564.835
K-12	1.131.093		1.134.344	1.137.405	1.134.428	1.129.027	1.120.208
Decrease K-12					(-2.977	(-5.401	(-8.819
Elem Ungr	28.974		29.000	29.000	29.000	29.000	29.000
Sec Ungr	7.868		8.000	8.000	8.000	8.000	8.000
K increase			2.000	5.000	8.000	12.000	15.000
TOTAL	1.167.935		1.179.405	1.179.405	1.179.428	1.178.027	1.172.208

Projections were kept constant, but enrollment may very well increase consequently decreasing the grades.

Year
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969

* Estimate -
1970 not a

Source: Mas

le 8

on Three-Year Ratios - State of Massachusetts

1973	1973-1974	1974-1975	1975-1976
.513	94.870	91,761	93.535
.681	55.791	56,869	56,781
.274	84.909	82,126	83.714
.260	81.950	79.730	77.116
.059	83,670	81,376	79.172
.859	92.335	83.921	81,620
.009	93.138	92,612	84.173
,916	91,191	93,324	92,797
,058	582,984	569.958	555.373
.847	95.501	94.747	96,964
.205	94.752	95.405	94,652
.212	98,984	100,627	101,320
.232	96.739	97.499	99.118
833	88.090	89.484	90.187
018	77,378	81,307	82,594
347	551.444	559.069	564,835
405	1.134.428 (-2.977	1.129.027 (-5.401	1.120.208 (-8.819
000	29.000	29.000	29.000
000	8.000	8.000	8.000
000	8.000	12.000	15.000
405	1.179.428	1.178.027	1.172.208

crease consequently decreasing the grades.

Table 9

Births to Residents of Massachusetts

Year	Number	Difference since 1957 Number	Cumulative
1955	109,610		
1956	111,407		
1957	115,065		
1958	114,563	502	
1959	114,090	473	975
1960	114,018	72	1,047
1961	114,763	745	302
1962	112,342	2,421	2,723
1963	111,217	1,125	3,848
1964	107,970	3,247	7,095
1965	100,262	7,708	14,803
1966	97,513	2,749	17,552
1967	94,870	2,643	20,195
1968	91,761	3,109	23,304
1969	93,535*	(1,774)	21,530

3-year average	93,389
5-year average	95,588
6-year average	102,693

* Estimate - information for final count not available. Information for 1970 not available.

Source: Massachusetts Department of Public Health, Division of Health Research students in 1971, and the overall increase will be about 54,500 students for the five years. The annual impact projected for 1971 - 1975 follows.

Year		Grades 7-12	Differences Number	Cumulative
1970	Actual	510,328		
1971	Projected	526,276	15,948	
1972		540,347	14,071	30,019
1973		551,444	11,097	41,116
1974		559,069	7,625	48,741
1975		564,835	5,766	54,507

The estimates by superintendents of future needs for secondary school facilities in some respects reflect the increase in students (about 10 percent for 1971-1975), but from most reports the estimates fulfill past inadequacies of older secondary schools and the tremendous impact of students apparent in the enrollment history (Table 6, Appendix). In 1961, there were 366,864 students in grades 7 through 12, and by 1970 enrollments reached 510,328 students, a gain of 153,464 students or 41 percent. The reports from superintendents show a need for new instructional facilities that declines in 1974 and 1975 as follows:

Year	Instructional Rooms Number	Cumulative
1971	785	
1972	713	1,498
1973	1,111	2,609
1974	476	3,085
1975	280	3,365

Overall Decrease in Students

Table 8 shows that overall
enrollments in public schools beginni
a factor for the same rate of transfe
evident for the last three years.

However, the large decrease
make a slight decrease of students (a
opportunities for kindergarten and en
garten through 12 summary would be:

Year		Stude
1970	Actual	1,131,
1971	Projected	1,134,
1972		1,137,
1973		1,134,
1974		1,129,
1975		1,120,

This decrease in students s
overburden of facilities (10,697 inst
structed, then school needs will also

Number of School Facilities

In addition to the number o
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A current inventory of scho
available. The last complete invent
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crease will be about 54,500 students
ct projected for 1971 - 1975 follows.

7-12	Differences Number	Cumulative
8		
6	15,948	
7	14,071	30,019
4	11,097	41,116
9	7,625	48,741
5	5,766	54,507

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Instructional Rooms Number	Cumulative
785	
713	1,498
1,111	2,609
476	3,085
280	3,365

Overall Decrease in Students

Table 8 shows that overall (K-12) there will be a decrease in enrollments in public schools beginning in 1973. This projection provides a factor for the same rate of transfer from public to non-public schools evident for the last three years.

However, the large decrease in births for the past 12 years will make a slight decrease of students (about 17,197) apparent by 1973 and provide opportunities for kindergarten and enrichment in many schools. This kindergarten through 12 summary would be:

Year		Students	Decrease Number	Cumulative
1970	Actual	1,131,093		
1971	Projected	1,134,344		
1972		1,137,405		
1973		1,134,428	2,977	
1974		1,129,027	5,401	8,378
1975		1,120,208	8,819	17,197

This decrease in students seems to indicate that once the great overburden of facilities (10,697 instructional rooms) now required are constructed, then school needs will also demise.

Number of School Facilities

In addition to the number of students, the available educational facilities and the condition of the facilities determine the need for new construction. Table 10 presents this information.

A current inventory of school facilities in the Commonwealth is not available. The last complete inventory of facilities was conducted in the spring of 1962 as a part of a National Survey requested by the late President

John F. Kennedy.[1]

In February of 1965, a survey of the condition of public school facilities reported 36,400 instructional rooms in Massachusetts. By 1970, this number has increased to an estimated 45,100 rooms. Table 10 shows the number of instructional rooms constructed of combustible and fire-resistive materials before and after 1920. Since 1965, Massachusetts has decreased the number of instructional rooms in combustible buildings from 2,900 to about 2,750 and increased the number of rooms in fire-resistive buildings from 33,000 to 41,500 rooms. The use of non-permanent rooms has increased significantly (150 percent) because of enrollment increases and the difficulty in obtaining permanent facilities through bond elections.

Significant Deficiencies

Significant deficiencies in the instructional rooms were reported in the 1964-1965 study. Although about 82 percent, or 29,700 instructional rooms, were in buildings that had fewer than two deficiencies, 800 rooms, or 2.3 percent, were in buildings that had four or more. Inventory questions included:

1. Are any indications of structural defects evident? (Bulging, shifting, sagging, cracking, etc. of foundations, walls, roofs or floors.)

2. Does the heating system permit a temperature range of 68° to 74° to be maintained in instructional rooms?

3. Is the fire alarm distinctly different from program signals and audible throughout the building?

4. Are stairwells and stairways constructed of fire-resistive materials.

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1 George J. Collins, National Inventory of School Facilities, Spring 1962, Washington, United States Office of Education, 1963.

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rooms in Massachusetts. By 1970,
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School Facilities, Spring 1962,
ation, 1963.

Table 10

Instructional Rooms Constructed of Combustible and Fire-Resistive Materials Before and After 1920 in Massachusetts

	1965[1]		Estimate - 1971	
	Number	Percent	Number	Percent
Instructional Rooms	36,400	100.0	45,100[2]	100.0
Combustible	(2,900)		(2,750)	
Before 1920	2,000	5.4	1,800	
After 1920	900	2.6	950	
Fire-Resistive	(33,000)		(41,550)	
Before 1920	8,700	24.0	8,500	
After 1920	24,300	66.7	33,050	
Non-Permanent	200	0.4	500	
Off-Site	300	0.9	300	

1 George J. Collins and William L. Stormer, Condition of Public Schools 1964-1965, Washington: United States Office of Education, 1965, p.30.

2 Richard Barr, Statistics of Public Schools, Fall Survey, 1970, Washington: United States Office of Education, 1971. p.32.

5. Are stairwells and stairways properly enclosed so as to separate them from the corridor in order to prevent the spread of smoke or fumes?

6. Do exit provisions meet applicable State or local fire protection standards?

7. Is a sprinkler system or fire detection system provided in high fire ~~hazard areas~~? (Basements, storage rooms, etc.)

8. Does the electrical system meet usual demands placed upon it during the school day?

9. Is a sufficient amount of nonglare daylight and/or artificial light, uniformly distributed in desks, chalkboards and other pupil-work stations in instructional rooms? (approximately 30 foot candles or more)[1]

A further refinement of the deficiencies in 2,620 buildings shows that 830 buildings had no deficiencies, but 340 buildings had 3 or more deficiencies. Most of the deficiencies probably could be reconditioned or repaired; some however, could not without substantial investments in buildings that would still be old and not be the most economical use of tax dollars.

Table 11 shows the number of deficiencies in school buildings reported in the 1965 survey of conditions.

Table 11. Number of Deficiencies in 2,620 buildings Massachusetts - 1965

0	830	4	60
1	1060	5	20
2	380	6	10
3	240	7	10

In addition to the building conditions listed above, the schools in Massachusetts also have two sanitary deficiencies reported in the Federal study. Water pressure and supply outlets or hot water was unavailable. About 16 percent of the students attended schools with these deficiencies. Table 12 shows that most of these students were without hot water.

[1] George J. Collins and William L. Stormer, Condition of Public Schools 1964-1965, Washington: United States Office of Education. 1965 p.31.

Table 12. Students
Sanitary

Water pressure and s
outlets in buildings
not meet local or st
health requirements

Hot water is not ava
at most hand washing
lavatories

When site deficienci
cent or 5,900 rooms had either
means about 156,000 students o
schools with building or site

Table 13. Number o

Deficiencies in
Instructional Rooms

fewer than two
four or more
building and site

Overcrowding

In 1965, the survey
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[1] Ibid., Collins and Stormer,

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Table 12. Students in Schools with Deficiencies in Sanitary Facilities[1]

	Number	Percent of all Students
Water pressure and supply outlets in buildings do not meet local or state health requirements	11,400	1.3
Hot water is not available at most hand washing lavatories	134,000	15.0

When site deficiencies were added to room deficiencies, 16 percent or 5,900 rooms had either building or site deficiencies. This means about 156,000 students or about 18 percent of the students were in schools with building or site deficiencies.

Table 13. Number of Instructional Rooms with Deficiencies

Deficiencies in Instructional Rooms	1964-1965 Number	Percent
	36,400	100.0
fewer than two	29,700	81.7
four or more	800	2.3
building and site	5,900	16.1

Overcrowding

In 1965, the survey of schools reported a need for 5,000 instructional rooms to eliminate overcrowding in public schools. A computer analysis of the needs was also prepared to show how many students were affected by overcrowding of 30 or more students in a classroom, for the U.S. Congress.[1] Table 14 shows that 166,461 students, or 20 percent of the enrollment in Massachusetts, were in overcrowded classes. This overcrowding represented 20 percent of the students in Suburban schools, or 113,657 students. Table 14 also shows that this overcrowding was more prevalent (65 percent) in elementary grades (1-6).

[1] Ibid., Collins and Stormer, p.31.

Table 14. Number and Percent of Public School Pupils In School Plants with More than 30 Pupils Per Instructional Room[1]

	Number	Percent
Total Massachusetts	166,461	20.3
Urban or Cities	47,959	20.5
Suburban	113,657	20.3
Outside SMSA's or less Populated areas	4,845	17.5
Elementary (1-6)	108,700	65.0
Secondary (7-12)	57,800	35.0

Rate of Construction

The number of instructional rooms completed in the last five years provides some indication of the improvement or worsening of school accommodations in Massachusetts. Annual Reports from the Department of Education, Division of Research and Development, show the following construction of instructional rooms since the 1965 survey.

Year	Number Completed	Number Abandoned
1965-66	669	392
1966-67	814	161
1967-68	1,326	121
1968-69	1,787	162
1969-70	855	103
	5,451	939
Net increase 1965 - 1970	4,512	

A review of the student increases and needs at the beginning of 1965, the condition of existing facilities and the projected increases in students at the secondary level between 1970 and 1975 provide another way of looking at potential needs for construction. Exhibit II shows that student increases (174,836) to 1975 would require an estimated 10,423 rooms, if it could be assumed that the surplus in elementary facilities (872 rooms) could be used to eliminate some of the new needs by 1975.

[1] Ibid., Collins and Stormer, p.31.

Exhibit II also shows t
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er	Percent
51	20.3
59	20.5
57	20.3
55	17.5
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	392
	161
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s by 1975.

Exhibit II also shows that 5,000 rooms were needed to eliminate overcrowding in 1965. The condition of rooms reported in Table 10 indicates that major repair, renovation, remodeling, reconditioning and some replacements are needed for 12,000 instructional rooms in Massachusetts. This represents about 27 percent of the 45,500 instructional rooms in use during the 1970-71 school year. Finally, the rooms needed if transfers increase from non-public to public schools indicate that 1,570 to 3,040 rooms could be required.

In Exhibit III the needs are summarized, and the net number of additional rooms constructed since 1965 (4,808) are deducted from the 15,423 rooms required, to make a net total of 10,615 rooms. This assumes that students will report to schools so that one classroom is needed for 40 kindergarten students, 25 elementary students, 20 secondary and special students which allows for special scheduling factors at the secondary level. Consequently, this might be assumed to be slightly conservative. The instructional rooms reported by Superintendents and presented in Exhibit I was 10,697 -- this is very similar to the 10,615 obtained from past reports and future projections of needs, but this is not the whole story.

Superintendents omitted needs for transfers between 1970 and 1975 because they had no tangible evidence of change. The Supreme Court decision of June 28, 1971, came after the superintendents submitted reports of needs. Exhibit III shows that this need might range from 1,570 to 3,040 rooms.

Ideally when the condition of facilities is considered, it could be assumed that the taxpayers of the 1970's might try to improve and replace some of the deficient rooms. It was assumed that 12 percent should

Exhibit II

A Review of Needs for Instructional Rooms

(1965-1975)

A. Increase in Public School Students

	Kindergarten	Elementary	Secondary	Ungraded	Total
1965					997,372
1970	13,713	34,405	92,218	30,227	1,167,747
1975	5,807	-56,199	54,507	158	1,172,208
1965-75	19,520	-21,794	146,725	30,385	174,836

B. Estimate of Change in Instructional Requirements (Rooms)

2,440	- 872	7,336	1,519	10,423

C. Rooms needed to eliminate overcrowding in 1965.[1] 5,000

D. Condition of Rooms in 1965[1] and Estimates of change to 1970

	1965	Change	
Combustible constructed before 1920	2,000	- 200	1,800
Combustible constructed after 1920	900	+ 50	950
Before 1920	8,700	- 200	8,500
Non-Permanent	200	+ 300	500
Off-Site	300		300
	12,100		12,050

E. Transfers from Nonpublic Schools to 1975.

Increase to 25 percent	1,570
Increase to 37 percent	780
Increase to 50 percent	1,570

[1] George J. Collins and William L. Stormer. Condition of Public Schools. Washington: United States Office of Education. 1965.

be replaced, which would add an addit

With all conditions conside

rooms clearly exceeds the 10,700 esti

14,000 to 15,000 instructional spaces

Exhibit

A Summary of Instructiona

Massachu

New Students and Overcrowding

Need for new students to 1975
(Item B, Exhibit II)

Need to eliminate overcrowding i
(Item C, Exhibit II)

Less Net Constructed, 1965-1970

Superintendent's Report of Need 1971-

Additional Requirements

Transfers (Item E, Exhibit II)

Condition of Rooms (Item D, Exh
(12,050 - 12 percent)

Additional Needs to 1975

Total Need for Students, Overcrowdin
Transfers and Deficien

al Rooms

ndary	Ungraded	Total
		997,372
.218	30,227	1,167,747
.507	158	1,172,208
.725	30,385	174,836
rements (Rooms)		
,336	1,519	10,423
1965.[1]		5,000
of change to 1970		
965	Change	
,000	- 200	1,800
900	+ 50	950
,700	- 200	8,500
200	+ 300	500
300		300
.100		12,050
		1,570
		780
		1,570

Condition of Public Schools.
on. 1965.

be replaced, which would add an additional 1,500 rooms for new construction.

With all conditions considered, the need for new instructional rooms clearly exceeds the 10,700 estimate and could realistically be about 14,000 to 15,000 instructional spaces or rooms by 1975.

Exhibit III

A Summary of Instructional Room Needs by 1975

Massachusetts

	Instructional Rooms
New Students and Overcrowding	
Need for new students to 1975 (Item B, Exhibit II)	10,423
Need to eliminate overcrowding in 1965 (Item C, Exhibit II)	5,000
	15,423
Less Net Constructed, 1965-1970	4,808
	10,615
Superintendent's Report of Need 1971-1975	10,697
Additional Requirements	
Transfers (Item E, Exhibit II)	1,570 to 3,140
Condition of Rooms (Item D, Exhibit II) (12,050 - 12 percent)	1,500
Additional Needs to 1975	3,070 to 4,540
Total Need for Students, Overcrowding, Transfers and Deficiencies	13,767 to 15,237

TRENDS IN SCHOOL PLANNING

CHAPTER III - 14

The primary purpose of constructing schools is to provide functional educational facilities for the children and youth of Massachusetts. Historically, Massachusetts is known for innovations in developing education facilities. In the Colonial period of America, the first schools were "Dame" schools where one mother or adult would care for the children of several families. Massachusetts led the new world in emphasizing the importance of education by passing the Ol' Deluder Law in 1647 requiring every town of fifty households to provide a school. The primary objectives of the educational program were the three R's--Religion, Reading and Riting. Children ciphered (arithmetic) as an extra curricular activity after they finished their work with the three R's. These educational requirements led to the development of one- and sometimes two-room, red or white schoolhouses. All students of all ages were taught in one "open space" or classroom with a pot-belly stove providing the heat for winter. The school year was scheduled to enable the children and youth to harvest the crops and perform other chores.

In the large settlements the "monitorial" or Lancastrian system of education prevailed where a hundred students might attend school in one room. The first "team teaching" occurred in large schools where a master teacher used several submasters to teach large groups of students. To this day some principals of schools in Massachusetts are called "masters."

Massachusetts proudly established the first Latin Grammar School in the early 1600's and the first graded school almost two centuries later in 1847.

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The Quincy School of Boston provided the first subdivision by grade only 124 years ago. The idea behind the program was to put all students of similar age in one room or grade to simplify the work of a teacher. One of the prevailing theories of learning at the time was Locke's tabula rasa where the teacher knew all of the knowledge for a grade and told or lectured to the students. The students registered the knowledge on their tabula rasa and repeated back as much as they could remember.

Secondary or high school education started with the basic subjects of English, history, math, science and languages to prepare students for college and to provide a foundation of knowledge for all citizens. By 1965, the United States Office of Education reported over 1000 different subject areas of knowledge. By 1970, the critics of education were demanding more responsive and more interdisciplinary and innovative programs. Some of the new programs sound like the letters of the alphabet (PSSC Physics; IPI Individually Prescribed Instruction).

The one room or open space with several groups or classes of students, emphasizing a concept of individualized education, was introduced in the last few years and is causing great controversy in Massachusetts. Many teachers were not prepared to teach in open spaces and became reluctant to change without further research proving the educational benefits. Taxpayers and school building committees were looking for economies in the cost of schools and saw the elimination of walls and corridors as an excellent probability. Other methods of scheduling such as "open campus," extended day, curtailed or "double" session and work-study programs became, depending on a point of view, expediencies or extensions of the horizons of education. Each has an implication for school facilities in the future.

This chapter will discuss some of the innovations in education. The educational process responds slowly to societal trends but is currently faced with proposed changes in programs, teaching methods and grouping of students. Some ideas can be utilized effectively. The final section of this chapter describes some of the trends in scheduling which may result in increasing student capacity in existing facilities.

Influences on the Educational Process

School planning, design and construction are not isolated compartments of education or of American society. The design of school facilities extends curricular development; and school construction responds to new developments in business, industry, governmental policies, and societal pressures. For example, critical issues such as inflation, population waves, decaying cities, taxes, "systems" planning, poverty - all have an influence on current trends in school planning.

Man, according to sociologists, is a natural "follower." However, education responds slowly to societal trends because so much of the system is restrained by a lack of research, development plans and operational funds. Our system of education fails to educate itself, and school buildings lock in the old and keep out innovative adaptations.

What will the schools become? Essentially, most of education remains unchanged. (One million eight hundred thousand classrooms were constructed as single instructional rooms; less than two percent have two or more connected rooms.) The past continues to influence the educational process more than innovations. There is a teacher and learners grouped for "tax economy" into instructional units of twenty-five or thirty students and limited by negotiated contracts.

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Terminology for New Trends

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Imagination can supply some options to the issues and problems facing educators and school planners in older facilities. Annually however, about sixty to seventy thousand new instructional units provide some hope for developing responsive programs in compatible school facilities. Nevertheless, much remains to improve education and facilities. The path to improvement is through knowledge of new developments in curriculum planning, technology and organization, some of which come from the colleges. Adapting these accepted practices--commonly called trends--to local needs can help to improve the educational process.

Terminology for New Trends

In the business of school planning, the familiar educational terminology has been augmented by new descriptors which may be classified under five headings: (1) groupings of students, (2) utilization of staff, (3) new curriculum, (4) resource media and (5) time units. Each represents a bandwagon trend of our times. A few educators lead or innovate, the rest follow. The late Professor Paul Mort researched the lag in time in the 1950's and found a trend took fifty years to be disseminated throughout the field of education. Today it takes about five to ten years depending on the cost.

1. Grouping of Students

To discuss grouping of students, you must not only know homogeneous and heterogeneous, but also independent, track plans, preschool, nongraded, cross age, upgraded, special, gifted, work-study, small conference, large lecture, open space, flexible grouping, little schools, home bound, middle schools, educational parks, continuous progress, multiphased and integrated.

2. Utilization of Staff

From utilization of staff, one may propose: team teaching, differentiated staffing, discipline oriented, inter-disciplinary team, multiple-discipline, in-service, aids, para-professionals, supplementary staff, resource team and human engineering.

3. New Curricula

New curricula are like alphabet soup--PSSC Physics (Physical Science Study Committee), CHEM(Chemical Education Materials Study), CBA Chemistry (Chemistry Bond Approach), SMSG Math (School Mathematics Study Group), ESCP Physical Science(Earth Science Curricular Project), SSSP Physical Science(Secondary School Science Princeton Project), Humanities(combines art, music, literature, philosophy and history), IPI(Individually Prescribed Instruction), Inquiry Centered Psycholinguistics, SCIS(Science Curriculum Improvement Study), Diagnostic Testing and Teaching, coding and decoding words (reading), learner directed, the Humane program, and varied learning styles.

4. Resource Media

Resource media expanded to computer terminals, CAI (Computer Assisted Instruction), telephone lectures, information storage retrieval, simulation and gaming, language laboratories, systems approach, talking typewriters, electrowriters, DAS (Dial Access System), auto programming, ERE (Edison Response Environment), IBM series, light pens and continuous loop sound films.

5. Time Scheduling

Time scheduling terminology includes: variable, individualized, four-period week, skip-a-period, modular, extended, rescheduling, remedial, tri-mester, work-study, core, before school, all year and de-scheduling.

<u>The Short-Term Economy Trends</u>

One third of the school districts defeat bond issues each year because they do not choose to increase taxes. Procrastination is the most wasteful tax-drain of the post-World War II era, mainly because inflation has effectively taken away educational spaces or tax funds without providing any returns for investments. Other districts bring the cheapest solution to

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<u>Effective Trends</u>

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bond issues each year because ocrastination is the most wasteful ainly because inflation has effect- x funds without providing any bring the cheapest solution to

the provision of school facilities which they can plan. Each seems to be the perfect solution to school problems, temporarily -- as the planners and voters think. Each exemplifies to the world and to their children how unimportant education and children are. Educational neglect portrays other shortcomings in the community. Consequently, in the long run the district has more dropouts, fewer acceptances to colleges, and has unusual maintenance expenditures to piece together the construction deficiencies. Quality teachers may tell at a glance and refuse employment, or learn after a year or two of employment, that this is an undereducated community which pinches pennies and throws away dollars at the expense of underinvestment in the education of children.

Effective Trends

School planning and design are influenced by many factors. School facilities depend upon local educational policies; local, state, and federal financial responsibility; advances of business and industry; and other facets of society. Imagination, dissemination and experience lead the way to a solution for some of our problems, while other districts remain unchanged. In a pluralistic society where some school districts have ten or more times the wealth of poorer districts, change occurs unevenly. It is almost impossible to describe one state-of-the-art for planning schools. Each school community, operating within its own handicaps, develops its own response to the ongoing process of education. Implementation of new ideas must proceed cautiously enough to avoid revisions and refinements that are excessive and unnecessary.

What can we expect at the frontier of school design? Only a catching up on our educational lag and limited pioneering. Following is a list of some noticeable trends in education. Some are already accepted and will be found more frequently in new schools. Other trends are still controversial concepts (i.e., open space, media equipment for students, "open campus" and year-round school), but should be found with more frequency in the future.

Activity Areas are noticeable auxiliary spaces adjacent to or part of classrooms in elementary schools.

Aides and Volunteers supplement the instructional staff, bolster the supervision of children, and free teachers for more qualitative performances; consequently special additional space must be provided.

Air Conditioning of schools is essential for extended programs (year-round schools) throughout the summer and will be in nearly every school in the nation.

Alarms for sonic and heat detection provide security of life and property.

Art and the Expressive Arts (drama and music) will double in emphasis in the next decade.

Audio-Visual materials and equipment should be conveniently available for teacher or student use.

Auditorium-Lecture Rooms will be easily subdivided into half or quarter sections for large group teaching.

Auditoriums with audiences for indoor and outdoor viewing should increase in number.

Beams of laminated wood provide greater resistance to fire and heat as well as distinctive warmth and architectural splendor to school construction.

Bilingual Programs are increasing, and language laboratories will be provided for elementary and preschool education.

Buildings will fit functionally onto sites to reduce costs and improve aesthetics.

Carpeting for kindergartens and libraries adds acoustical and safety improvements to floor coverings. Other instructional spaces should also benefit from the special properties of carpeting.

Cluster Classrooms (open space) are the vogue with movable walls or storage partitions to subdivide the larger teaching space.

Color stimulates the psychological as well as the aesthetic environment of the learner.

Community Schools are increasing; they provide instructional programs for all ages and utilize school facilities from sun-up to sun-down, seven days a week.

Comprehensive Planning should serve to coordinate the needs of all the agencies of municipalities and especially schools.

Computerized Instruction is increasing in a number of instructional areas and as a business and vocational occupation.

Conference Space appears more often in architectural plans and designs.

Controversial Issues should be discussed more frequently in schools, and discussion space or a colloquium will be found in more schools.

Convertible Dropleaf Desks add flexibility to school furniture.

Corridors and Corridorless sch
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Courts relieve noise and conge
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Cubicles or Carrels for indivi
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Current-Event Instruction has
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Corridors and Corridorless schools are in evidence; wider corridors with gardens and colored glass have become more popular, but just as many new schools are eliminating corridors in favor of cluster classrooms and activity space.

Courts relieve noise and congestion as well as add to the aesthetic quality of the school.

Cubicles or Carrels for individual study have increased in usage and location throughout schools.

Current-Event Instruction has increased and should use teletype, newspapers, radio and TV.

Curricular Changes are proceeding at a rapid rate, and teachers are demanding more single-purpose specialized spaces, (art, music, math laboratories, reading laboratories and language laboratories).

Democratic Participation in preparing educational plans, school construction, and current operations of schools demands space for additional staff and meeting rooms.

Dining should become more of a socializing process, and spaces should be subdivided to reduce noises, add to comfort, and function as auxiliary instructional spaces at other times of the day. More and more dining facilities will expand to the out-doors, especially when air curtains are introduced to the schools.

Drop Outs are declining, and projected accommodations for senior high school have been seriously underestimated. Further improvements in holding power can be expected. Schools will need more flexible scheduling and a greater area for guidance counselors who will expand their interests into occupational placements as well as college placements.

Educational Television has improved, and teachers are using the medium more effectively. Realistically, television did not replace the teacher but made him more important as a planner, analyst and coordinator.

Electronic Teaching Aids are becoming more individualized, specialized and useful. Greater improvements can be anticipated, and more space will be needed to accommodate the equipment in classrooms and library resource centers.

Equalizing Educational Programs throughout a state means more consolidations of facilities in sparsely settled areas from grades 4-12; in the urban centers it means replacement of the older, fire unsafe structures constructed before World War I.

Equipment manufacturers will continue to set the pace and provide teachers and learners with tools to meet objectives long before the educators are aware of the manufacture or can squeeze out budget funds for purchasing the necessary school equipment.

Expansions or Additions to School Facilities must begin with the educational program and must integrate materials to make the additions look like they belong naturally, no matter how much time elapses between additions. Every space in the school should be planned for future expansion to an optimal size school.

Federal Responsibility for financing schools must increase from 1/4800 of the tax dollars collected to at least one-third of the construction and interest cost of schools.

Finance of Capital Construction must improve, particularly if the federal government is going to control interest rates as a buffer for economic inflations. The impact on local taxpayers must be equalized. Poorer districts should receive larger grants or have the backing of more secure state or federal resources.

Flexibility of space design has resorted to the large cluster of classrooms which can easily be partitioned to smaller or larger spaces at the touch of a button. Acoustical baffles are now a must, including carpeting. Zoned heating, air movements and air conditioning add to flexibility.

Furniture manufacturers will continue to set the pace and provide teachers and learners with greater choices to meet objectives long before the educators are aware of their manufacture or can squeeze out budget funds for purchasing the design improvements.

Geodesic Spaces should house additional educational functions as costs are reduced and planners become more familiar with this design.

Glass areas should have photoelectric cells to admit a constant quantity and quality of effective side lighting into the classrooms to avoid glare. Colors in glass will be interchangeable by dial control. Solar heat build-up has been reduced but will soon be non-existent. Research and development will continue to rally to the school glass market with quality improvements and price reduction.

Guidance facilities should be included in all schools, and suite areas should be increased to accommodate services for occupational placement as well as college placement. Some areas will be designed into instructional materials centers.

Integrated Building Components have made a major breakthrough with SCSD, and now the challenge has been clearly extended to architects and other manufacturers for new combinations of integrated components in the field of school construction.

Isolation Rooms similar to self-contained classrooms, but more likely small conference areas, will be needed near or in clusters of open space.

Landscaping should be planned for long-range improvements, with children and youth taking an active part in beautifying school grounds.

Legal problems are becoming more prevalent and more complex in the taking of land and the construction of schools.

Legal Education is needed -- to teach the fourth "R" -- responsibility under law.

Libraries are becoming more functional and increasingly the focal center of the school. Reading areas are expanding to courts and common areas. With audio-visual materials this space is now described as the instructional materials center (IMC) or library resource center.

Life-Survival Stations (swimming pools) are more commonly found in plans for new construction. They are desperately needed to teach the necessary skills of swimming and water safety.

Lighting Quantity is increasing to unprecedented levels; quality improvements are needed. Glare and high spots must be eliminated. Valance, indirect and color should be added.

Linkages with Colleges should be improve
improvements, experimentation, and in-se
ferences, observations and innovative pr

Master Planning should be encouraged for
school enrollment. Educators must becom
projections.

Modular Construction has reduced costs,
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Movable and Acoustical Storage Units sub
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these units.

Negotiations of working conditions have
the need for additional teaching spaces

Nongraded and Ungraded enrollments are a
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Occupational Orientation, guidance, cour
number of students who enter employment

Office Spaces for teachers are more comm
research, conference, library, planning

One-Room Schools (open space) have retur
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acoustical storage units.

"Open Campus" for study periods will requ
for student electives (typing, art, music

Outdoor Work Spaces for science, art, sho
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Planetariums may be found in a number of
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Plastic Styrofoam Construction is still
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Performance Contracting will increase, an
accommodate outside contractors in school

Portable Demountable Schools have proven
Functional design, attractiveness and rap
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Linkages with Colleges should be improved for student teaching, curricular improvements, experimentation, and in-service education. Spaces for conferences, observations and innovative programs should be provided.

Master Planning should be encouraged for an optimal educational program and school enrollment. Educators must become skilled in subject and enrollment projections.

Modular Construction has reduced costs, decreased construction time, and improved planning. Greater use and increased efficiency are needed in the future.

Movable and Acoustical Storage Units subdivide class spaces or enlarge areas quickly and easily. Improvements in designed units will increase the use of these units.

Negotiations of working conditions have decreased teaching loads and increased the need for additional teaching spaces and office spaces.

Nongraded and Ungraded enrollments are approaching 1 million students in elementary and secondary schools.

Occupational Orientation, guidance, courses and spaces are needed for the large number of students who enter employment directly after high school.

Office Spaces for teachers are more common, and they also serve as tutoring, research, conference, library, planning and reading centers.

One-Room Schools (open space) have returned, but in the seventies they sometimes accommodate as many as 400 to 500 students with and without movable and acoustical storage units.

"Open Campus" for study periods will require additional student learning areas for student electives (typing, art, music practice, science and shop spaces).

Outdoor Work Spaces for science, art, shop, drama and other educational opportunities will be common and become more functional in the future.

Planetariums may be found in a number of schools today. Quality schools constructed in the future will include a planetarium as a part of a special science complex in elementary and secondary schools.

Plastic Styrofoam Construction is still in the experimental phase of construction. Future technological developments, however, should provide a number of synthetic products for school construction.

Performance Contracting will increase, and space will need to be provided to accommodate outside contractors in school facilities.

Portable Demountable Schools have proven useful in fast growing school districts. Functional design, attractiveness and rapid assembly have increased their popularity. Exterior finishes of some are unsightly. A better design is needed to prevent unwanted vandalism which is attracted to isolated units.

Prestressed Concrete should reduce costs and add aesthetic grace to future designs for high fire-resistive construction of city schools.

Racial problems have increased the need for new facilities in urban centers to equalize accommodations of the finest suburban schools.

Relating Educational Spaces to each other will improve the coordination of learning experiences and lessen traffic problems. The house, learning block, or cluster will appear more often.

Remodeling of Schools should begin earlier in the life of buildings to add the extra facilities that make a qualitative difference in school accommodations.

Reorganizations of School Districts should reduce the 16,000 districts now operating schools to about 10,000 districts without closing existing schools completely. Major educational program benefits resulting from specialized facilities of an increase in numbers of students seems to occur from grade four to twelve. Kindergarten through third grade units of almost any size above ten students can be justified in sparsely settled areas.

Research on the use of facilities, functions and handicaps needs considerable attention.

Resource Centers are increasing in size and cost. Prominent central locations and decentralized units are available in a sufficient number of schools to produce enough feedback to guide plans for future educational programs.

Schools Scaled for All Ages and interests of users are necessary. Convertible features for the use of younger or older groups are needed for the latest revival of community schools.

State Departments of Education should encourage experimentation, and act as catalysts for better practices.

Student-Common Areas realized design potential and are no longer regarded as a fill.

Student-Staff Ratios have decreased, and consequently the capacity of existing schools must be recalculated periodically to assure the adequacy of program accommodations.

Student-Tutors will increase in all levels of educational programs.

Systems Approaches to Construction have proven that time spans may be reduced for construction, and coordination of the variety of tradesmen can provide cost benefits to taxpayers.

Teaching Machines of all variations are available for accelerating individual progress and for assisting absentees. Functional planning demands greater attention to details for better utilization of machines.

Team Teaching is becoming more common in larger schools and should be taking place in subdivided or divisible auditoriums and cafeterias in addition to convertible classrooms and specialized lecture halls.

Transportation Docks for daily attendance, field trips, rainy days, and handi-

capped persons will be safely

Walls, Movable Walls, and No
planners. Greater functional
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Workspaces for Faculty are be
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Year-Round School on a compul
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Trends in Scheduling

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ield trips, rainy days, and handicapped persons will be safely designed into the site plan of all schools.

Walls, Movable Walls, and No Walls are requiring more attention of school planners. Greater functional use of walls, better planning of movable walls, and wiser use of spaces with no walls are apparent necessities.

Workspaces for Faculty are becoming more common for planning and constructing training aids.

Year-Round School on a compulsory trimester or quadrimester will be developed in more school districts.

Educational facility planners and architects will discover very few startling ideas in the trend frontier of school plant design, but, realistically, this is what 99 percent of our school districts will buy in the decade ahead. Ideas have a way of reoccuring and repeating. Even the subterranean (underground) school has its forerunner, a cave. Development of technological know-how has to advance to bring many ideas to the reality of school budgets. Educators have always wanted divisible teaching spaces, but it is only recently that research and industry have produced partitions that will reduce sound transmission to acceptable ratios. Therefore, it is not unnatural to expect some improvements in the educational frontiers with the greatest effort directed toward making up the lag in the effective trends.

But problems remain. If educational opportunities are to be broadened and improved, the road ahead demands clearer and better supported mandates from the people and from our governmental bodies. Otherwise, architects and educators will only be able to accomplish whatever any adaptive human can attain within a system of confining handicaps.

Trends in Scheduling

More recently school districts have responded to shortages and lower yields from the relatively heavily burdened property tax by a number of alternative ways of conducting schools. The most important plans in use today are:

(1) curtailed sessions, or extended sessions, mistakenly called "double" sessions; (2) extended scheduling of an instructional day; (3) continuous school year or year-round school; (4) "open campus," similar to higher education scheduling; (5) work-study programs; (6) career opportunities; and (7) research projects.

1. Curtailed Sessions or Extended Sessions

Scheduling of students for curtailed attendance at schools was an expediency widely used after World War II. The most significant causes of the problem were the increase to four million births annually and a shift of population, particularly young families, from cities to suburbs. Few of the thousands of school districts had school facilities to accommodate the new students or had operational plans for constructing facilities despite: (1) the 5- or 6-year time lag between birth and school attendance or (2) the year or longer between issuance of building permits and completion of construction. The expedient for a lack of school facilities was to schedule curtailed sessions. One group of students used a classroom or the school in the morning, and a second group used it in the afternoon. In many states the regular session was shortened or curtailed by as much as one hour.

In Massachusetts, however, the State Board of Education has the power to regulate the number of school hours and days and to approve or disapprove "double" sessions. Students in elementary grades are required to attend school for five (5) hours or more; and in secondary schools the requirement is five and one-half ($5\frac{1}{2}$) hours. Consequently the use of a building in Massachusetts would be "extended" to 10 or 11 hours a day. In the winter students are frequently on a bus in the dark of morning or evening when curtailed sessions are used.

Some of the advantages include:

(1) Increasing the use of existing facilities.

(2) Scheduling a large b
(3) Providing more work
(4) Postponing tax incre

Some of the disadvantages

(1) Students and teacher
early morning of a c
(2) No place is availabl
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(5) The human fatigue fr
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curtailed sessions are used.

(2) Scheduling a large block of free time for students.

(3) Providing more work opportunities for older students.

(4) Postponing tax increases for needed new construction.

Some of the disadvantages are:

(1) Students and teachers tire in the afternoon or seem to be unawake in the early morning of a compact school day.

(2) No place is available for enrichment, remedial, or cocurricular activities, i.e., music, basketball, drama, and library research particularly.

(3) Operating and maintenance budgets which are about 90 percent of the cost of education are the same. Only debt service is reduced which is about 5 or 10 percent of a school budget.

(4) The cost of postponed school facilities might be 10 to 12 percent higher for each year that needed construction is postponed.

(5) The human fatigue from this scheduling usually causes problems of social interaction and a decline in perseverance and enthusiasm.

(6) Students and teachers develop bad habits (the hurry-up production that reduces the desire to improve details or to extend efforts).

Curtailed or extended sessions are an expedient reaction for failing to develop long-range plans for new school facilities or failure to assume fiscal responsibility for authorizing bonded indebtedness for construction of new facilities. Students always lose more than they gain, especially a good part of educational enrichment. Taxpayers also lose and always pay more for school facilities. It is never a recommended practice.

This practice enables the present generation to shirk constitutional and statutory responsibilities for maintaining adequate school facilities. This generation also passes the responsibility of improving education on to the next generation without maintaining an adequate starting foundation.

2. Extended Scheduling

Extending the scheduled operation of a school is used in many school districts. In this plan the use of the facilities is extended for regular school attending children for several hours each day; and extended to include Saturdays, evenings, and the summer months. Each extension is most often for part of the school enrollment, and the program may be voluntary or mandated.

Some of the advantages include:

(1) Improving the use of critically short facilities.

(2) Providing more opportunities for pursuing study interests when enrichment is one of the objectives.

(3) Avoiding new school construction for receding school populations.

(4) Continuing to schedule cocurricular activities.

(5) Providing additional work and salaries for teachers.

Some of the disadvantages are:

(1) There are compromises in scheduling.

(2) For increasing population areas, postponed school construction will cost more money.

(3) Operating and maintenance budgets will increase proportionately to the extended services.

There are more advantages than disadvantages to extending the use of school facilities. Slight increases in operating and maintenance budgets are worth the investment in extended services. The extensions should be carefully planned. Many districts already utilize extended scheduling, and every district could plan greater use of extended scheduling.

Potential savings (summarized in Exhibit I) might be between 4 to 8 rooms for 1,000 students, or 100 to 200 more students might attend a school designed for 1,000 students. The educational program and transportation schedule must

be planned to minimize inconveni

3. Continuous School Year

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* The University of the State of
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3. Continuous School Year

Continuous use of school facilities, or scheduling of educational programs year-round, is extensively used in graduate programs at universities - for the convenience of students and for extended use of facilities. Some districts have started programs, but the demands of parents to release students for family vacations have disrupted the continuity of educational offerings to the detriment of students.

Recent developments in California and New York have utilized quarterly scheduling plans where three of four groups are attending school at one time. Rockland, Massachusetts, has started a program for the first grades of school in 1970-71. Other districts are studying plans for year-round programs for students in early grades. More frequent vacations for students in kindergarten and early grades may be an excellent way of introducing a continuous program, may be beneficial to younger students and will reduce forgetting which accompanies long summer vacations.

A preferred cycling is usually nine weeks in school and three weeks on vacation. Advocates of this program cite many advantages, but no accumulation of disadvantages or research on extra costs is currently available.

Some of the advantages include:

(1) Increasing the utilization of facilities.
(2) Eliminating construction of some school facilities.
(3) Providing multiple opportunities, i.e., graduation one year earlier, extra learning time, new courses, make-up work, etc.
(4) Reducing "regressions" or "forgetting" associated with summer vacations.
(5) Providing additional work and salary for teachers during summer vacation periods.
(6) Improving reading scores. In Commack, New York, third grade students improved reading scores by several months.*

* The University of the State of New York. The Impact of a Re-Scheduled School Year. Albany, New York, March 1970. p. 97.

(7) Creating a change in present schedules.

Some of the disadvantages are:

(1) Costs of education will increase. Experience in some districts shows an increase of 10 to 20 percent of operating costs.* In elementary and secondary schools the demands on the time of many special teachers will increase by one fourth. Air conditioning becomes necessary in order to keep classrooms from becoming unbearably uncomfortable in summer. This is a one-time starting expenditure, but a good investment. All overhead (i.e., insurance, electricity, paper, etc.) will increase. Substitute custodians, bus drivers, clerical, cafeteria workers will be needed during vacations. Maintenance programs will increase slightly to provide convenient scheduling.

(2) Acceptance of a change to compulsory attendance in the summer requires special public information, understanding and assurances.

(3) Student activities require special scheduling arrangements.

(4) Transportation schedules will probably be less efficient.

(5) Town recreational services and library services may need to be increased all year.

(6) Special orientation and staff development are needed. Internal dissension was a major cause of the demise of the classic Newark All Year Schools, Commack, New York; the John Dewey High School in New York City also experienced undermining of efforts and public attack.

This program requires a special study group of staff members, parents, non-parent taxpayers, and students to visit districts using this approach to study the specifics of funding and development before initiating such an approach.

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* The Year Round School. Washington, D.C., The American Association of School Administrators. 1970. p. 19.

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The most profitable programs have started with (1) kindergarten where large spaces permit heat dissipation, (2) first and second grades where research indicates excellent retention of early reading gains and (3) voluntary summer programs.

A review of the spaces in most older high schools indicates that special facilities will still be needed, such as a library/instructional resource center and better educational integrity of program and space relations. Exhibit I shows that about 8 spaces could be reduced from a facility for 1,000 students. More spaces could be reduced when there are 3 or more special instructional spaces. For example, art usually has 2 and 2 would be needed all year round. Science might have a requirement for 6 spaces; therefore, 1 less space might be required. About 200 more students could be accommodated in a school for 1,000 students. Again special spaces prevent greater accommodations, although theoretically it would seem you could increase capacity by 25 percent.

4. "Open Campus"

The definition of "open campus" is illusory. It is more aptly described as "open study periods." It is more like programs that students have at college, yet legally the public school has a responsibility for all students for the time prescribed under present state laws and regulations.

Primarily, programs started because towns failed to plan and failed to vote bonding for new facilities. Consequently, to avoid split, curtailed or extended sessions, all study periods were released to provide additional instructional space. Some local merchants were delighted with sales of coke and pizza. The students loved the freedom, and faculty members enjoyed relief from supervising study halls.

One responsible school district in Massachusetts (Brookline) sought to change the lock-step of traditional education and to use the "total" resources of the community. It was felt that students would develop more responsibility for the use of non-instructional time.

Falmouth has developed some excellent student-centered programs, but restrictions of present high school facilities seriously limits a "university offering." The new Falmouth High School will have supplementary student spaces for improving typing skills and language skills, a large instructional materials center, small group discussions and study areas, science labs, space to edit publications, a math lab with computer terminals, music practice rooms, and a number of educational opportunities to compete with shopping and street walking.

Some of the advantages include:

(1) Providing more educational opportunities.

(2) Permitting students to make responsible choices.

(3) Providing planning and working time for teachers.

(4) Eliminating regimental study halls.

(5) Freeing some study spaces for instruction.

Some of the disadvantages are:

(1) Several new staff members will be required to supervise and arrange for supplementary activities.

(2) Parents do not always approve of new student freedoms.

(3) Some merchants prefer not to have students shopping all day.

(4) Insurance rates are destined to increase with more potential accident risks.

(5) Additional work spaces are needed in most high schools to conduct a quality program.

(6) Some students are not ready for this freedom and need more adult guidance.

The "open campus" provides more educ
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An advisory committee is suggested.
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5. Work-Study

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The "open campus" provides more educational opportunities for students and more responsibilities for choices. In Falmouth where the expediency was first used, more responsible action is evident. In Massachusetts Commissioner Neil V. Sullivan has prepared guidelines which the State Board of Education has approved for developing proposals for an "open campus" program.

An advisory committee is suggested. Objectives, evaluational techniques and accountable procedures are required to be submitted to the State Department of Education in the form of a proposal. Many districts find that initial programs with special privileges for seniors and selected students have proven more successful. In any event, parental approval for each student electing "open campus" activities in place of study time should be a mandatory necessity under current state compulsory attendance laws and regulations. The school is still legally responsible for all students during school hours. Guidance counselors and teachers should also be part of the approval process to make the program an earned award for responsible students. An analogy might be drawn between a driver's license which is a privilege that all citizens may earn and keep if they do not abuse it and "open campus" privileges. Those students unable to earn "open campus" privileges need special programs to develop interests into worthwhile activities and occupational orientations. Exhibit I shows that about 16 percent or one-sixth of the students would be unscheduled. This extends the utilization of the facilities by about 160 students for a capacity of 1,000. This would free about 6 spaces, and it might be possible to reduce space requirements accordingly. More responsible action is evident at Falmouth, where the new high school will add special instructional facilities to improve student interests and educational quality.

5. Work-Study

Initially, work-study programs were part of the apprenticeship training programs of medieval craftsmen. Antioch and Northeastern have excellent work-study programs at the college level. State compulsory education laws eliminated these privileges following World War I; of necessity during World War II and in vocational schools, the educational benefits were rediscovered. Some of the advantages include:

(1) Providing opportunities for meaningful work experiences.
(2) Correlating school and work.
(3) Experimenting with several occupations before final educational programs are completed.
(4) Freeing some facilities for other use.
(5) Developing responsible work-study patterns.
(6) Providing some additional earnings for students.

Some of the disadvantages are:

(1) Matching students' requirements with part-time work opportunities is difficult.
(2) Additional staff members are needed to find work opportunities, to guide student choices, and to supervise experiences so that students are not exploited but receive broad learning experiences at work.
(3) The cost of education will increase.

Programs of work-study are of proven value in modern education. Students in vocational and business programs have excellent opportunities for work-study experiences. Other students with saleable skills and parallel educational goals could also profit from this program. Again, objectives should be established by a small working committee which includes representation from business and students in addition to school officials. This program has excellent potential for development of better relations with business and responsive educational programs.

Increasing student accommodations or reducing space requirements for work-study opportunities are limited to seniors and vocational students. This

program could be extended to all
school. The data in Exhibit I sh
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6. Career Opportunities

The primary difference between pr
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Some of the advantages include:

(1) Making education more meanin
(2) Improving relations with the
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Some of the disadvantages are:

(1) Career professionals are ver
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(2) The number of opportunities
(3) Transportation to career stu
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(5) Scheduling to take full adva

program could be extended to all potential drop-outs and juniors in high school. The data in Exhibit I shows that 50 to 100 students could be accommodated or 2 to 4 spaces reduced. The potential value of this program for utilizing expensive vocational and occupational spaces is excellent.

6. Career Opportunities

The primary difference between programs for work-study and career opportunities is the lack of pay. Some districts view the career program broadly enough to permit potential lawyers to spend some days in courts, law libraries, law offices, penal institutions and governmental agencies to study the appointments and working activities of a career choice. Written reports are prepared; discussions conducted; and oral presentations are developed to assure accrediting associations that skills in English and social science are developing as part of a career opportunities program.

Some of the advantages include:

(1) Making education more meaningful.

(2) Improving relations with the community.

(3) Freeing some school facilities.

(4) Requiring less supervision of students than work-study.

Some of the disadvantages are:

(1) Career professionals are very busy and may find a series of student visits a nuisance.

(2) The number of opportunities in many towns may be limited.

(3) Transportation to career study areas may be difficult to arrange.

(4) The cost of this program is less than a work-study program but the program does require some supervision and meaningful reinforcement of learning and primary reading, writing and reasoning skills.

(5) Scheduling to take full advantage of free educational spaces will be difficult.

This is an excellent program which more schools should have for students. Objectives and guidelines should be developed by a small working committee of guidance, social science and other teachers as well as career professionals interested in starting this program. The number of free spaces will not be large.

It is more difficult to accommodate more students or reduce space requirements for programs featuring career opportunities. Some districts are beginning programs which permit approved absences for occupational explorations, but the time must be rescheduled. The data in Exhibit I shows a potential for 25 to 50 more students or a possible reduction of only 1 or 2 spaces.

7. Research Projects

Most notably Yale and Harvard have programs for seniors, and all doctoral programs at universities utilize the research project as an accepted educational experience. Dartmouth School District in Massachusetts uses this method of instruction in a middle school. Many other school districts have some classes developing research skills in required programs.

Some of the advantages include:

(1) Providing more opportunities for students to research projects of high motivation.
(2) Helping students to use several resources of knowledge to solve a problem.
(3) Encouraging students to explore more subject areas than the traditional five major subjects.
(4) Freeing some classroom space.
(5) Utilizing large instructional resource centers more fully.

Some of the disadvantages are:

(1) The same number of staff m
a limited number of spaces
(2) A well stocked instruction

This is another excellent progr
teaches very valuable research
center (IMC) is required to acc
school should have an IMC which
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Exhibit I shows a potential acc
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Summary of Potential Space Savi

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students to research projects of high

resources of knowledge to solve a problem.
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esource centers more fully.

(1) The same number of staff members are needed to conduct programs. Only a limited number of spaces could be saved.
(2) A well stocked instructional materials center is required.

This is another excellent program which individualizes instruction and teaches very valuable research skills. An adequate instructional materials center (IMC) is required to accommodate this program, but every modern school should have an IMC which should be fully utilized. The potential saving in school facilities will not be large, but the educational benefits to students will be high.

Exhibit I shows a potential accommodation for about 50 students and a reduction of about 2 spaces.

Summary of Potential Space Savings

Programs for rescheduling the school day in order to increase student accommodations are limited, and several precautions should be expressed. Adequate planning and experimental projects should precede a full scheduling of any of these programs. Parents should have ample opportunity to discuss and to understand the implications of suggested or planned changes. Some special facilities will be required to conduct some of the programs properly, and additional expenditures will be needed to start programs for planning, staff development and materials. The State Department of Education must approve all variations from the five (5) hour day of school required for elementary students and the five and one-half ($5\frac{1}{2}$) hours a day required for secondary students. All programs must also be scheduled for 180 school days. (Pennsylvania recently passed a more flexible requirement of 900 hours or 990 hours for secondary students each year.) Currently needed school facilities must be planned with space for all students if funds from State School Building Assistance are requested. Although Commissioner Neil V. Sullivan has requested study of the potential reduction of instructional spaces, policies and regulations must be approved by the State Board of Education. Preliminary discussions of some of the potential space savings indicate that the experimental programs have not had a sufficient period of experience to indicate continuity of programs for the life of all facilities and the willingness of school districts to provide funds to initiate adequately planned programs.

Exhibit I summarizes the estimates of potential increases in student accommodations or reductions in facilities for secondary schools. The poorest quality of educational offering is curtailed sessions. Program quality will also decline with extending the school day. Continuous school year has a potential for increasing capacity of school facilities by about 20 percent of the students, but parents need many assurances before programs are initiated. A combination of open-study periods (called "open campus"), work-study, career opportunities and research projects might increase capacity of school attendance by about 25 percent.

However, reductions in space requirements are improbable in many school districts because existing secondary facilities are overcrowded and poorly organized for instructional programs. The potential suggestions cannot eliminate the need for new facilities because the State Department of Eudcation has not had substantiating experience or research to rely on the commitment or continuity of the innovative programs for the life span of the school facilities (60 to 100 years). Consequently, this generation would be shirking constitutional and statutory responsibilities for main-

taining adequate scho

Operating budgets (ab staffing, supplies an changes but increased accommodated in schoo to 30 percent of 10 p the cost of education

The programs, however izing instruction and pursued.

1) Curtailed Sessions*
(½ Sessions)

2) Extended Day
(10 - 20 percent)

3) Continuous Year
(20 percent

4) Open Campus
(study periods)

5) Work-Study

6) Career Opportunities

7) Research Projects

(4) - (7) combined
(25 percent)

* Approval is required from

All programs must provide mini each day for secondary student

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taining adequate schoolhouses, to the detriment of future generations.

Operating budgets (about 90 percent of total school expenditures) for staffing, supplies and utilities would not be reduced by the suggested changes but increased in proportion to the number of additional students accommodated in school facilities. The potential savings are about 20 to 30 percent of 10 percent of school budgets or about 2 to 3 percent of the cost of education.

The programs, however, have important benefits for students by individualizing instruction and making education more responsive. They should be pursued.

Exhibit I

Estimate of Potential Increases in Student Accommodations or Reductions in Facilities for Secondary Schools

	1,000 Students Students	or Spaces	1,300 Students Students	or Spaces	1,600 Students Students	or Spaces
1) Curtailed Sessions* (½ Sessions)	1000		1300		1600	
2) Extended Day (10 - 20 percent)	100-200	4-8	130-250	5-10	150-300	6-12
3) Continuous Year (20 percent	200	8	260	10	330	13
4) Open Campus (study periods)	160	6	210	8	260	10
5) Work-Study	50-100	2-4	60-120	2-4	75-150	3-6
6) Career Opportunities	25-50	1-2	30-60	1-2	35-75	1-3
7) Research Projects	50	2	65	2	80	3
(4) - (7) combined (25 percent)	250	11-14	325	13-16	375	17-22

* Approval is required from the Department of Education by Chapter 71 of the General Laws.

All programs must provide minimal school time of 180 days and 5 hours for elementary students and 5½ hours each day for secondary students.

iv

THE SYSTEMS APPROACH TO SCHOOL CONSTRUCTION

AN INTRODUCTION TO THE SYSTEMS CONCE

CHAPTER IV - 1

The clear need for a more rational approach to the design, construction and alteration of buildings has led to widespread interest in the concept of systems. The systems approach is based on recognition of the essential relationships between subsystems and components in determining the overall cost and performance of buildings.

The "systems approach" is a strategy of problem definition and solution which emphasizes the interactions between problem elements and between the immediate problem and its larger context; it specifically avoids traditional methods of independent or ad hoc treatment of the various elements. To put it slightly differently, the "systems approach" is defined as a process based on viewing a problem as a set of interrelated, interdependent parts which "work together for the overall objectives of the whole."* It thus becomes the organizing principle for a design process wherein decisions may occur consistently and rationally, taking into account all relevant factors.

When applied to building problems, the systems approach results in a process whereby needs and resources can be related effectively to performance, cost and time.

A "building system" is a set of hardware and software building components which comprise a building production method. It may be further defined as a set of interrelated building parts with a base of information which

* C. West Churchman, The Systems Approach, Dell, 1968.

TION TO THE SYSTEMS CONCEPT

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structures the relationship between the parts and which determines how the parts may work together to accommodate the varying needs and objectives of a variety of building programs.

The definition of a building system includes not only the concept of a set of interrelated building components and subsystems, but also includes the requirements to which the system can respond. The performance range of the system is as important in understanding a particular system as the way its components fit together.

An essential distinction between the terms "systems approach" and "building system" must be made: A building system may or may not be created by the systems approach, and the result of a systems approach may or may not be a building system. Put another way, the objective of the systems approach is not necessarily to produce a hardware system, but rather to allow the careful balancing of all of the factors affecting the design, construction and life of the building sought. In many instances, for example, the best solution to a particular problem may be improving an aspect of the process; for example, reorganizing the conventional construction sequence.

The "hardware system" comprises the physical components of a building. The hardware is often referred to as the "kit of parts." The "software system" is the rules and procedures for applying the hardware system. Software, the non-physical components of a building system, is often referred to as the "set of rules."

It cannot be overemphasized that a "building system" in the broad sense includes both hardware and software systems. It thus encompasses the total building process, from the request for shelter to the fulfillment of that request with a completed object. In this way, analysis of all related aspects of building and not simply the construction method is undertaken; this permits greater coordination of tasks, possibly greater cost savings and other benefits not realizable with conventional emphasis on the building method, which accounts, after all, for only a small part of the total cost and effort required to produce shelter.

"Industrialization" means the organized conversion of raw materials into products by capital-intensive activities such as mechanization and automation, as opposed to labor-intensive activities such as organized handicraft. Organized handicraft is not industrialization, even though we include all related hand trades when we speak of the "building industry." Mechanization refers to the use of machines, controlled by and assisting men in manual labor. Automation refers to mechanization controlled automatically by other machines, such as computers. Men control the production machinery indirectly by instructing the computer through programs.

Basically, then, the systems approach is concerned with how to look at the building process; industrialization concentrates on how to organize the process in order to achieve an improved level of productivity. Although the systems approach can be used independently, no effective industrialization can occur without the collective exploitation of systemization and dimensional coordination of all building subsystems and components. The systems approach is necessary because, in all cases, the degree of mechanization needed in manufacturing and assembling subsystems and

components is determined through
widest possible application of t
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must be coordinated, their inter
facilitates combining in a singl
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Glossary

Recent interest in and populariz
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are defined below:

ADAPTABILITY: the capacity of a
during its lifetime.

BUILDING SYSTEMS INTEGRATION: t
building components, traditional
combined performance through con

CLOSED SYSTEM: a building system
subsystems has been predetermined
particular air-conditioning or li
with a specific set of structural
options in other component areas,
building must use specific produc

COMPATIBILITY: the state of func
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se, in all cases, the degree of
nd assembling subsystems and

components is determined through extensive work planning. To ensure the widest possible application of the procedures and products of an industrialized process, and thereby improve the level of productivity, all components must be coordinated, their interface conditions predetermined. This facilitates combining in a single building products made by different manufacturers, without waste or custom-fitting of parts.

Glossary

Recent interest in and popularization of the systems approach has brought into common usage many words and terms which describe aspects of that approach. Some of the more complex of these were discussed above; others are defined below:

ADAPTABILITY: the capacity of a building to accommodate changing uses during its lifetime.

BUILDING SYSTEMS INTEGRATION: the simultaneous development of a group of building components, traditionally treated independently, to improve their combined performance through controlled interaction.

CLOSED SYSTEM: a building system wherein the juxtaposition of the basic subsystems has been predetermined in a specific way so that, for example, particular air-conditioning or lighting or partition products must be used with a specific set of structural components. There might be certain options in other component areas, but a significant proportion of the total building must use specific products for the better part of the subsystems.

COMPATIBILITY: the state of functional, economic and aesthetic coordination between two or more subsystems or components.

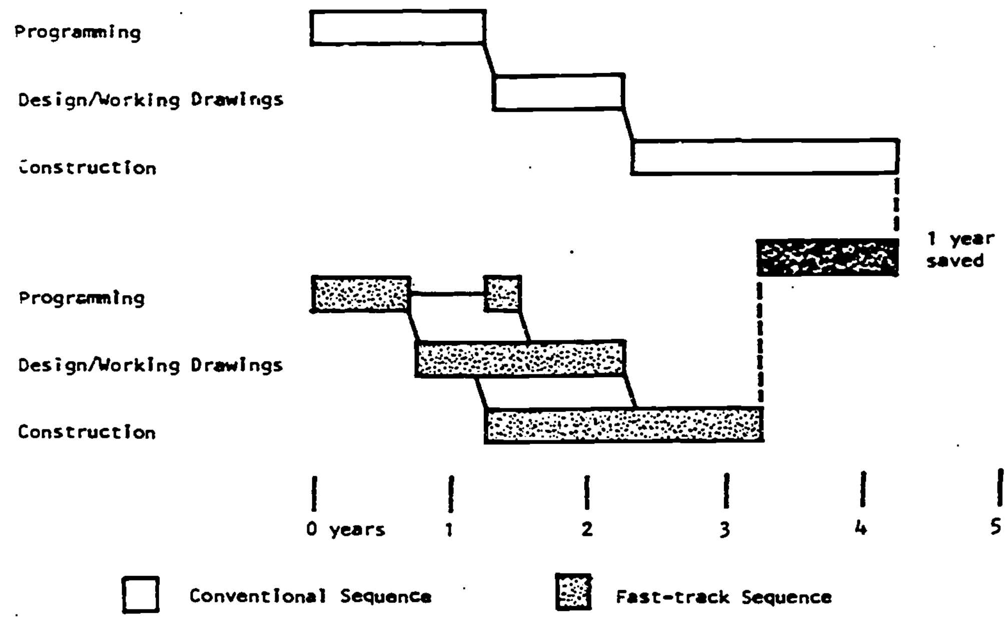
COMPONENT: a coordinated group of parts forming a portion of a building subsystem.

COST-BENEFIT ANALYSIS: the simultaneous comparison of alternatives in terms of performance and cost.

DIMENSIONAL COORDINATION: the organization of dimensions to enable subsystems, components and parts to be used together without modification.

FAST TRACK (PHASE-OVERLAPPING): a systematic procedure whereby different phases of the design and construction periods are overlapped so that some begin before others are completed.

The main objective of this is to shorten overall project time, which is particularly important at a time when construction costs are escalating at current rates. Chart 1 shows a phase overlap schedule in simple form, compared to the conventional process.



FIRST COST: construction cost

INCOMPLETE SYSTEM: a building sys ponents do not encompass the full building production method.

INTERFACE: a common boundary betw or subsystems. The end of one sub of another.

LIFE COST: total owning cost duri construction, operation, maintenan

MODULE: a unit of size used as a construction of building parts and

OPEN SYSTEM: a building system in than one proprietary design and wh source. The subsystems are dimens

PERFORMANCE REQUIREMENTS: the per system must provide in order to me of user requirements into design c

PERFORMANCE SPECIFICATIONS: the f ments in technical terms for submi with an existing product meeting t

PREBIDDING: a process used in sys and installation of subsystems are general contract work.

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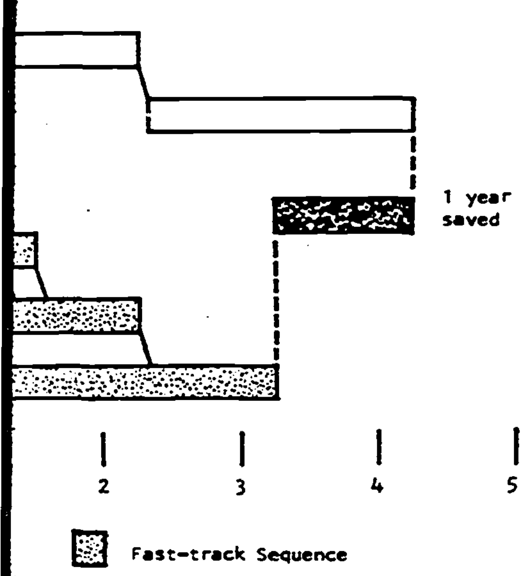


INCOMPLETE SYSTEM: a building system whose hardware and software components do not encompass the full range of items included in the total building production method.

INTERFACE: a common boundary between two modules, components, parts and/or subsystems. The end of one subsystem or sub-activity and the beginning of another.

LIFE COST: total owning cost during life span of a building including construction, operation, maintenance and alteration costs.

MODULE: a unit of size used as a basis for standardizing the design and construction of building parts and materials.

OPEN SYSTEM: a building system in which the subsystems can be of more than one proprietary design and which can be procured from more than one source. The subsystems are dimensionally coordinated and interchangeable.

PERFORMANCE REQUIREMENTS: the performance characteristics that each subsystem must provide in order to meet project objectives; the translation of user requirements into design criteria for specific building components.

PERFORMANCE SPECIFICATIONS: the formal statement of performance requirements in technical terms for submission to industry, which can respond with an existing product meeting the criteria or with a new product.

PREBIDDING: a process used in systems building in which bids for a supply and installation of subsystems are requested prior to bidding for the general contract work.

RATIONALIZED TRADITIONAL SYSTEM: a building system which optimizes the use of conventional building products.

SUBSYSTEM: an interdependent group of components performing one independent function, e.g., the HVAC subsystem; an element of a building system.

SYSTEMS ANALYSIS: examination of the effects of the interactions between the elements of a system on the individual performance of elements and on the total performance of the system.

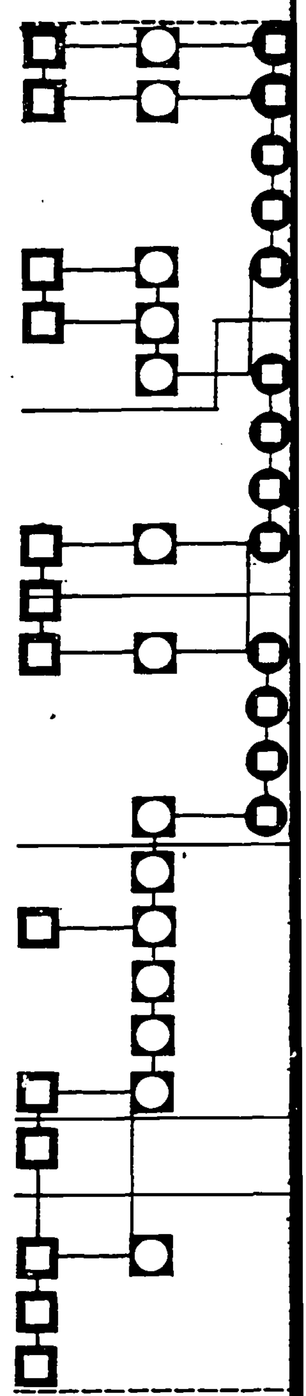
USER NEEDS: those requirements originating in the needs of various users that must be met by the programming, design, construction and operation of a building.

ADVANTAGES OF SYSTEMS

CHAPTER IV - 2

The advantages of a systems approach in school construction lie mainly in the thoroughness of the planning. All job activities from programming and funding to construction and planning for later modification are viewed as a single process and thus the organization and execution of the project can be more efficient. Thorough analysis facilitates more efficient scheduling as well as anticipation of potential difficulties. A systems approach, of course, can be used up to a point in conventional construction, but when combined with the use of building systems, it has even more significant advantages. The chart on this page compares conventional and systems approaches and shows the relevant differences in the two processes.

The advantages of systems building are the following:*



TRADITIONAL APPROACH TO BUILDING

Linear process; little problem prediction.
Little utilization of contractors and industry at design stage.
Functions fragmented; poor continuity from design to construction.
Building process subject to delays and interruptions for review and approvals.

Increased Flexibility

An integrated building system is the result of a study of how building elements are put together. To provide for flexibility, the study includes how to add to and subtract from the building. A great deal of planning and coordination (part of the total systems approach) is required to do this, but the resulting system makes it quicker, simpler, cheaper and quieter to make changes.

Materials and details are chosen or designed to go together in a variety of ways. Standardization is employed to ensure that the same products

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* The following discussion is adapted from Systems Analysis for a "New Generation" of Military Hospitals, Vol. 9 Appendix: Building Systems in Military Hospitals, a report completed for the Advanced Research Projects Agency of the Department of Defense by Arthur D. Little, Inc. Vol. 9 was prepared for ADL by SRS Consultants, Inc. and Campbell, Aldrich, and Nulty, Architects.

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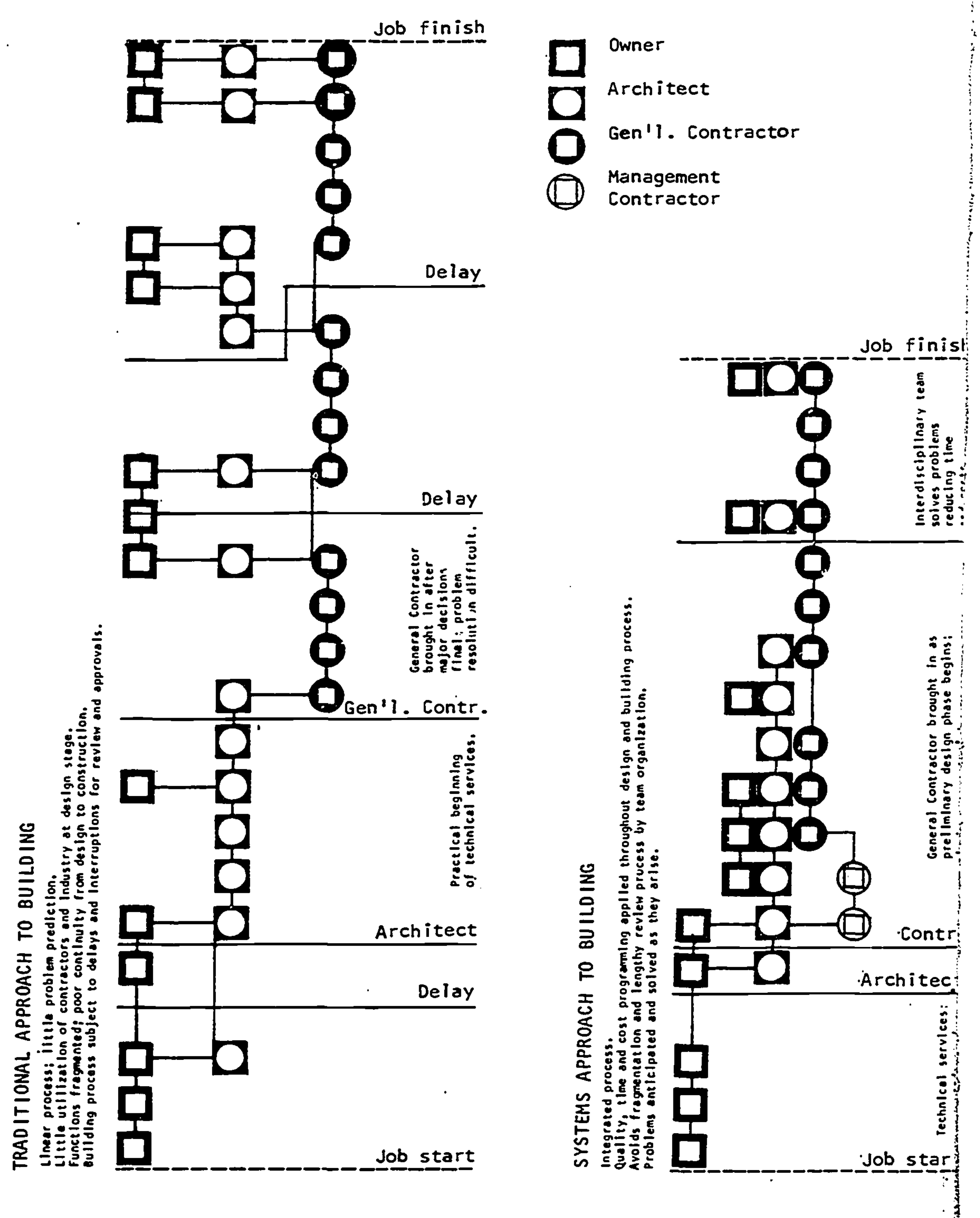

Both diagrams on same time scale beginning on the same day.

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can be used everywhere. Access is provided at the places where it is needed. Costs of products are correlated with their frequency of change, so that resources are not wasted on elements which need to be replaced frequently, and also so that quality is not shortchanged on elements that need it. Prefabrication is employed to achieve the necessary level of quality control to insure that interchange of standard parts is possible. The system is also correlated with plans to locate structure and services in ways that do not inhibit change and growth.

Reduced Design and Construction Time

There are three ways in which building systems can be used to save time:

Time is saved on design and working drawings. The primary gain is in the working out of subsystems relationships. Since a rationale for this will already exist, planning can be carried out, knowing that as long as the constraints imposed by the system are observed, the parts will fit together. This removes from the architects and engineers the burden of one of the least efficient, most time-consuming, and least rewarding aspects of the job. It also means that many structural, dimensional and other decisions are already made. Time on working drawings is saved because standard details can be used. Standardization insures that there will be fewer special conditions, that details will have been well worked out, and that the time required for working out and drawing details will be greatly reduced. (Non-system elements and details will still exist, of course, and will be treated conventionally.)

Time is also saved on construction. The major gain is through the use of prefabricated parts. All buildings are prefabricated to some extent

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major gain is through the use
are prefabricated to some extent

(elements such as windows, doors, mechanical equipment, etc.), but a systems building includes a great deal more. Prefabrication saves time by carrying out in the factory operations which would otherwise be carried out on the site by time-consuming hand labor. Because components can be designed on a modular basis, the necessity for trimming to size can also be eliminated. Because procedures can be more clearly predetermined, scheduling can also be tightened, eliminating some slack from the program.

In addition to savings on the design and construction operations themselves, the two phases can be overlapped (telescoped), saving more time. Ordinarily, construction begins only when drawings and other contract documents are complete. Construction can begin much earlier, however, if a layout exists which is based on planning principles related to a building system.

One way to do this is to divide the construction contract into two parts -- the first for the fixed elements, the second for the movable and disposable ones. Since the fixed elements are designed as a standard matrix to receive any internal layout, first phase construction can proceed and even be completed before the entire plan is finalized. Accurate programming and preliminary planning assures that the final plan will fit the confines of the structural frame and building envelope, and the use of standard dimensions assures that all parts will fit regardless of arrangement. Besides reducing the total time, the postponement of the internal planning until closer to completion gives less time for the plan to become obsolete, and reduces the number of change orders.

Reduced Costs

Building systems improve cost effectiveness on initial construction by increasing prefabrication, reducing site labor, cutting construction time, enabling an earlier start, facilitating cost control techniques, and allowing more contractors to compete. The major savings, however, may be long-range savings from improved flexibility.

1. Total ownership costs

   Total ownership costs are the lifetime capital cost plus those operating costs which can be attributed to the building. Lifetime cost is the initial project cost plus the cost of changes over the life of the building. The most meaningful measure of building cost is ownership cost spread over the life span of the building.

   A system-built school usually costs the same as or less than a conventional school. In the rare cases when a system-built school does cost more, it is because of higher performance, especially in the realm of flexibility. Since flexibility can reduce the cost of changes, the long-range cost of even this system school may be less than the conventional. The system school has a longer useful life span and does not have to pay the unmeasurable price of changes not made.

2. Prefabrication and the reduction of site labor

   The increased use of factory-made components decreases the use of site labor, one of the most expensive and inefficient parts of the job. Wages in the building trades are presently skyrocketing, with some recent union contracts being signed for increases totaling 90 percent over the

   by contrast, are rising only

   Time, therefore, strongly fa

3. The cost of time

   Time is money. A saving in

   capital for that period -- a

   work, this is interim financ

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   In this period of runaway in

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4. Cost controls

   Building costs are notorious

   practice of underestimating

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   Building systems facilitate

   The use of the standard deta

   on future jobs, and permits a

   materials and techniques to

   change. The result is more

   realistic future cost estima

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* Engineering News Record, June

** Architectural Record, October

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totaling 90 percent over the next three years.* Factory wages, by contrast, are rising only at the rate of the cost of living. Time, therefore, strongly favors a switch to more prefabrication.

3. The cost of time

Time is money. A saving in construction time saves interest on capital for that period -- a significant savings. In civilian work, this is interim finance. Government jobs do not have interim financing, but this does not change the fact that the money spent is essentially borrowed money and interest is being paid on it.

In this period of runaway inflation, another saving from quicker processing and construction is the lower contract price resulting from advancing the construction date one or two years.

4. Cost controls

Building costs are notoriously difficult to predict. The chronic practice of underestimating costs (with resultant later "cheese-paring") has been criticized** but continues nevertheless.

Building systems facilitate the creation of a data bank on costs. The use of the standard details and components provides feedback on future jobs, and permits a process of continuing evaluation of materials and techniques to select those to retain and those to change. The result is more cost-effective buildings and more realistic future cost estimates.

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* Engineering News Record, June 4, 1970, p. 45.

** Architectural Record, October, 1968, p. 169.

Improved Quality and Performance

Building systems can improve quality and performance in three ways:

User needs can be identified systematically and translated into performance criteria. Until user needs are clearly defined, it is impossible to be sure they are being satisfied. Performance specifications go beyond simple building specifications. For instance, there is no point in specifying high sound reduction for partition systems if a lightweight door negates the benefits of the partitions. And more fundamentally, exactly why and where sound reduction is really needed must be understood. On a normal project, limitations of time and money prevent questions such as these from being investigated thoroughly. A systems study can identify the needs and evaluate all the alternatives, and establish how products may be used together effectively. The results of this analysis can then benefit all future projects. Quality will be assured in the places where it matters.

Replacing hand work with factory-produced articles reduces human error and insures a uniform level of quality. A machine can produce higher-quality finishes, and bulk buying may permit better materials to be used.

Thirdly, adequate preplanning of costs can help avoid the all-too-frequent last-minute cutting or "cheese-paring," so that the intended level of quality can be maintained. If any cuts need to be made, it will be known in advance and the program can be adjusted accordingly.

EXAMPLES OF SYSTEMS IN USE FOR SCHOOLS

CHAPTER IV - 3

Historical Background

The 1960's marked the emergence of the systems approach in school construction in the United States. It developed in response to the rapidly increasing school-age population (postwar baby boom), the competition for limited and restricted public construction funds, the growing pressure for broad educational innovation, and the construction industry's inability to meet the resultant demand by traditional methods.

A model for a solution to this problem already existed in the experiences of postwar England, when a rapid increase in school-age population, coupled with extensive reconstruction needs, created a construction demand which could not be met with conventional methods. Rational analysis of the situation showed that industrialization of part of the construction process was essential to provide the volume of construction required in the time available.* Thus a system of integrated hardware components was developed for schools to derive the benefits of bulk orders and the continuity of production assured by a sustained building program.

There was a parallel between the Britain of the '40's and '50's and the America of the early '60's. In 1961 an occasion arose to apply the systems method in a number of rapidly growing suburban school districts in California. A dynamic group of people committed to the swift completion of the schools required by the districts worked with educators, architects and representatives of industry to draft the first American school systems program, called School Construction Systems Development (SCSD).

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SYSTEMS IN USE FOR SCHOOLS

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Since SCSD, there have been numerous systems projects involved with educational facilities in North America. Differing legal and administrative structures have been created, various bidding and construction procedures have been tried, and alternative approaches to building systems have been tested; further, the systems approach has been extended to encompass other building types. Capsule histories of the most important of these systems projects follow. Of necessity, the treatment of each is cursory at best, but it should serve to acquaint the reader with the "state of the art" in the early 1970's. The summaries should provide valuable background material for those contemplating or planning systems projects.

Objectives

The main objectives of all seven projects discussed in this chapter are, of course, the goals of systems building in general. These are:

1. to reduce costs by reducing construction time and taking advantage of the possibilities of an aggregated market,
2. to increase the adaptability of educational buildings and improve the quality of the educational environment.

A number of the projects had additional specific goals. SCSD, the first systems project in the United States, was interested in aggregating projects into a large enough market to induce industries to develop systems at their own expense, with the long-term goal of creating a genuinely competitive climate for systems bidding. Schoolhouse Systems Project (SSP) decided to procure SCSD products through volume purchasing in order to introduce the systems development concept to Florida. The Metropolitan Toronto School Board Study of Educational Facilities (SEF) had the long-range goal of furthering the development of a "North American building system" which would be able to offer several compatible alternatives for each subsystem.

The Great High Schools (GHS) program, which was never completed, had a unique objective, namely, to eliminate de facto segregation in Pittsburgh by centralizing the City into five high school attendance districts. It was also thought that improvement of city schools might help stop the flow of middle class residents to the suburbs.

The British Columbia project is only in its initial stages, but it was included in our discussion because its objectives and scope have obvious parallels to the situation in Massachusetts. It was the intent of the British Columbia School Trustees Association to establish a continuing program of monitoring school construction and to carry out careful planning of human and material resources on a regional basis.

SCHOOL CONSTRUCTION SYSTEMS DEVELOPMENT (SCSD), CALIFORNIA

The first American school systems program, SCSD, had to deal with most of the problems later systems projects have encountered; none of SCSD's successors have been completely free of its influence. Its product development program caused American manufacturers to work together in a way they had not previously done. The program created a handful of coordinated products for use in four subsystems. These products have spawned over 200 more coordinated building components.

Organization

SCSD was initiated in response t
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Procedure

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<u>Organization</u>

SCSD was initiated in response to the needs of a rapidly growing school district in San Jose. Three new high schools were to be built in the district under the state aid program, which imposes severe budgetary restrictions on proposed facilities. Representatives of the Educational Facilities Laboratories (EFL) and of the School Planning Laboratory at Stanford University convinced the superintendent of the district that an industrialized-component building system could provide high quality schools at moderate cost.

A large grant from EFL aided the initiators in establishing an aggregated market. Thirteen school districts combined to form the First California Commission on School Construction Systems, which had an immediate need for 22 schools, or $20-$40 million worth of buildings. This guaranteed market was an incentive for manufacturers to develop the required products. Administered by the Stanford University School Planning Laboratory, SCSD consisted ultimately of a project coordinator (an educator), a project architect, four additional architects, an architectural assistant, a consulting engineer, and a financial consultant from the State Department of Finance.

<u>Procedure</u>

After the market was established, educational needs were studied to ensure an appropriate response. Problems were identified by conducting extensive interviews with architects, union officials, manufacturers and educators. Taking into consideration user needs and industry capability, decisions were made on flexibility, atmospheric control, lighting standards and acoustics. Vertical and horizontal dimensional modules were selected.

Performance specifications, which state in technical terms what a particular component must do, were initially written for four subsystems: structure; heating, ventilating and air-conditioning (HVAC); lighting/ceiling; and interior partitions. Casework and lockers were added later. An important aspect of the SCSD performance specifications was the requirement that manufacturers state compatibility with other subsystems and delineate the cost penalties inherent in possible combinations.

The bidding was a complicated process, partly because of the newness of the approach. Before the bid period, a two day "prebid" conference was held at Stanford to interest manufacturers in the SCSD program and to acquaint them with the new procedures, especially with the use of performance specifications in an architectural context. The conference also gave manufacturers the opportunity to meet each other and form alliances.

During the bid process itself a mid-term review session was held, partly to clarify any potential misunderstandings and partly to "arrange marriages" among component manufacturers to insure the required compatibility. After a bid development period of five months, bids were received, and winners were nominated by the commission on the recommendation of SCSD. The legality of performance specifications was contested by a losing bidder in a court case from which the commission emerged successful.*

A mock-building of 3,600 square feet was built at Stanford using SCSD components in order to test performance and work out interface conditions. After this period of testing and "debugging," a catalog of components was developed for use by individual architects on individual SCSD schools.

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* Virginia Metal, a partitions manufacturer, was low bidder in that component category but was rejected on the basis of a clear inability to meet the performance specifications. The company brought the case to court and lost.

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Evaluation

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It was the responsibility of each local school board to hire its own architect, to monitor the design, and to manage the bidding and building of each school in its jurisdiction. The general contractor on each job was responsible for management and coordination of all the work, but for the construction and cost of non-systems elements only.

Evaluation

The thirteen SCSD schools which were eventually built represented a sharp reduction from the original program of twenty-two. The schools are varied in design, which shows that a system of building components is flexible enough to accommodate various architectural interpretations.

While SCSD provided a fixed price for the components, it could not guarantee the prices for a whole school, since the SCSD components account for only about half the cost of the building. The certainty about the cost of SCSD components, however, provided the opportunity for school men and architects to use this cost saving on other things which they could not previously afford. Some superintendents involved in SCSD have commented: "You don't spend less, but you get more for what you spend."

The results of SCSD in terms of project delivery time are inconclusive. Some projects had shorter than conventional delivery times and some did not. It is probably that much potential advantage was lost because SCSD was a first-time effort. Generally, SCSD components met the performance specifications and flexibility requirements. It is true, however, that users have only passively exploited the higher-quality environment and have made little use of the available flexibility. This may be because the educators have failed to educate the users.

Because it was the pioneer school systems program in North America, SCSD set a number of precedents for all future programs of this kind. The use of performance specifications as contract documents is now standard procedure. Indeed, the SCSD performance specifications were used as the basis of the specifications of at least several other projects.

Other procedures which have become standard include market aggregation for product development, bulk purchasing, and mandatory interfacing.

The SCSD program had some side effects as well. While nominated manufacturers worked on the SCSD system, the unsuccessful bidders were developing and marketing their products elsewhere. Thus components became available on the open market, and hundreds of facilities have since been built without the necessity of establishing a consortium or other formal mechanisms. The systems approach became a vital element of the building climate in North America.

SCHOOLHOUSE SYSTEMS PROJECT (SSP), FLORIDA

The SSP building program achieved its limited goals of cost savings and reductions in construction delivery time through bulk purchasing. Rather than developing new products, SSP simply used without modification the products originally developed for SCSD.

Organization

The Schoolhouse Systems Project was organized in 1966. Conceived and coordinated by the Florida State Department of Education in Tallahassee, SSP is headed by the State Commissioner of Education, an educator and an architect. Because of its sponsorship by the state agency, the project

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Procedure

In October, 1966, a feasibility study w
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spared individual school districts the task of legally organizing themselves into a client group. Although there was no development work, SSP went through two SCSD procedures: bulk bidding and performance specifications. The program administrators intended to buy products developed for SCSD and other systems projects through volume purchasing.

<u>Procedure</u>

In October, 1966, a feasibility study was initiated, and a program based on the findings and recommendations was begun in July, 1967. In that month performance specifications were issued for four component categories. Between October, 1967, and October, 1969, thirty separate school projects were bid with a construction budget of $30,000,000 and an area of around 2,000,000 square feet, or more than 20 percent of new school construction in Florida. for that period. These projects comprised three main SSP programs and a number of smaller ones. The three main programs (280,000; 485,000; and 541,000 square feet) were bid by December, 1968. The following spring the Commissioner's Advisory Committee on School Building Research* recommended a moratorium to allow time for evaluation. Meanwhile, the Department of Education could extend aid to any local districts organized to receive bids and administer bulk purchasing programs themselves. Three such programs (475,000; 79,000; and 61,000 square feet) were carried out. During the moratorium, performance specifications were revised and user requirements for kindergarten through 12th grade rewritten. The fourth main program, SSP-4, was scheduled for bidding early in 1971.

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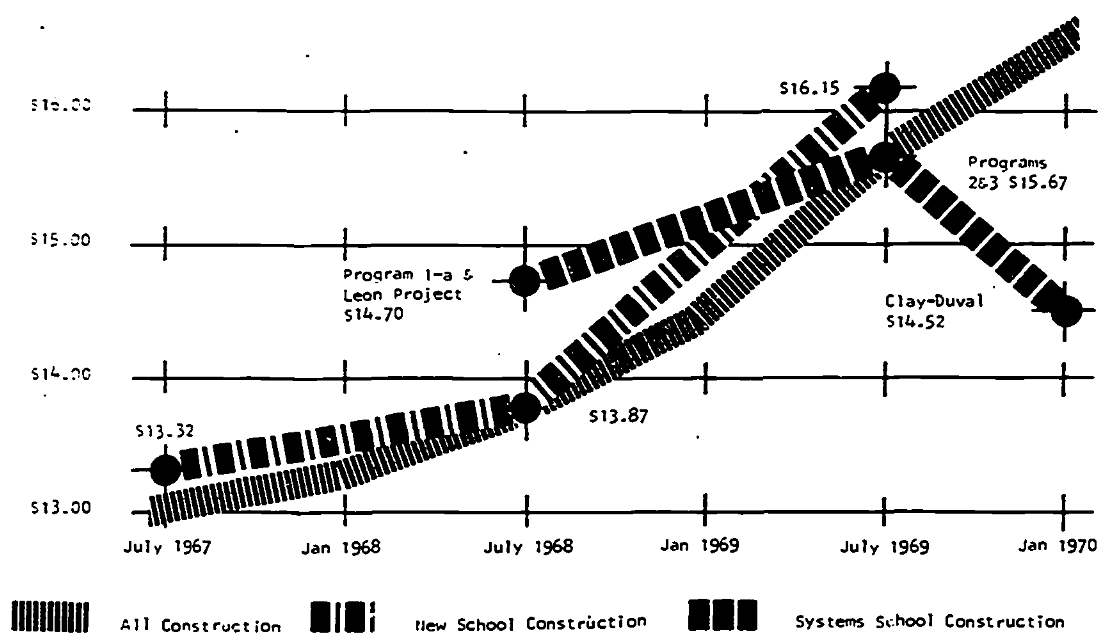
* This group, headed by State Senator Ralph Poston of Miami, included members from the Associated General Contractors, the Building Trades Association, the Florida Engineering Society, the Florida A.I.A., the Florida School Board Association, the Association of County Superintendents of Schools, and the Florida State Legislature.

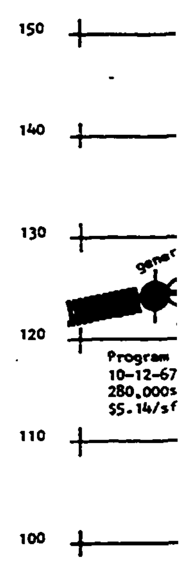
Evaluation

SSP can be considered a successful program. The project delivery time of systems-built schools was 44.6 percent shorter than that of conventional schools. While costs of school construction in Florida have risen by as much as 40 percent a year, the costs of systems schools have actually declined, as the following chart shows:



FLORIDA CONSTRUCTION COSTS

Some interesting information on cost has emerged which is worth discussing in detail. There is evidence that when components were bid for 500,000 square feet of construction for the SSP program, the cost of the prebid systems was as much as 20 percent lower than the cost of conventional construction for the same square footage, as shown in the following chart. Nevertheless, the total cost of the schools which used these prebid systems was only 3 percent lower than conventional examples.



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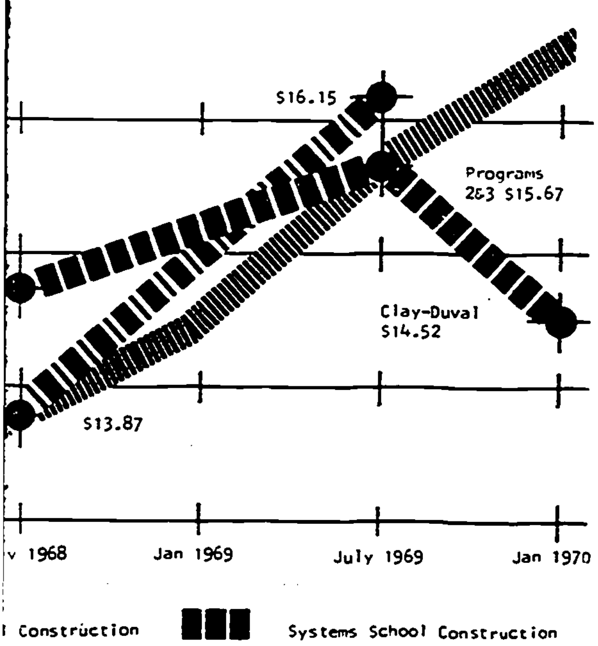

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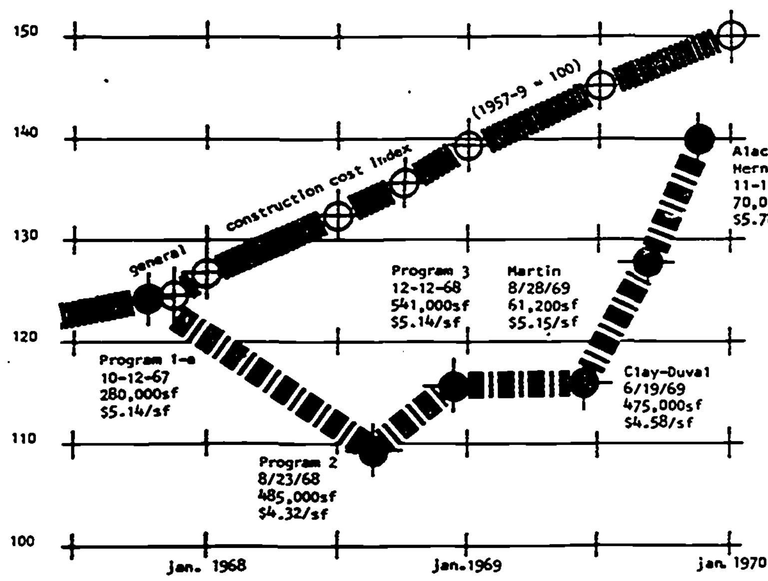

SSP SYSTEMS COSTS (STRUCTURE, CEILING-LIGHTING, HVAC)

One reason for this may be that budgets are generally prepared for schools without taking into consideration whether systems will be used or not. When an architect saves money on systems, he can use the cost savings to improve the quality of the environment and better meet program requirements. This corroborates the SCSD superintendent's view of increased value for similar costs.

SSP has made the systems approach widely accepted in Florida. Besides the programs mentioned above, two new programs have been initiated. User needs studies are nearly complete for a program for universities and community colleges and are in progress for a program of portable, temporary systems buildings for educational uses.

GREAT HIGH SCHOOLS (GHS), PITTSBURGH

The GHS program was an ambitious and far-reaching program which involved not only systems development but also a restructuring of the Pittsburgh high school system to eliminate de facto segregation. It is a good example of a program of high technical potential which the vagaries of politics interrupted.

Organization

The decision to reorganize Pittsburgh's high school system into five campuses made adopting a systems approach highly practical by guaranteeing a sufficiently large market for systems components. Formally announced by the Pittsburgh Board of Public Education in 1966, the Great High Schools project actually began two years earlier with a site location and physical planning study by Urban Design Associates of Pittsburgh and a lengthy analysis of Pittsburgh's educational needs by the Center for Field Studies of the Harvard Graduate School of Education. After the City of Pittsburgh passed a $50 million bond issue for building new educational facilities and remodeling old school plants, the board named the architects and educational specifiers for the project. The team of project consultants included educational consultants, coordinating structural engineers, coordinating mechanical and structural engineers, building systems consultants, cost consultants, and architects.

Procedure

Preliminary research included studies on the integration of mechanical and electrical services, electronic teaching aids and related equipment, intra-project communication, the Pittsburgh school food service, construction scheduling, and a comparative cost analysis. After a thorough review of city and state codes and of the GHS educational specifications, performance criteria

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The system components were divided into major and minor, depending on their significance to the building as a whole. Major components were structure, HVAC, lighting/ceiling, partitions, exterior wall and glazing, and service distribution. Minor components were cabinets, laboratory furniture, furniture, carrels and educational equipment, lockers, and exterior furniture and equipment. The design team directed its primary effort toward the major components, but determined the best design, manufacturing and installation procedures for the minor components as well. The systems consultant prepared performance criteria to be used as a design guide by the design consultants in developing the basic building subsystems. These criteria served as the bridge between educational specifications and design solutions.

In deciding how best to develop and implement the GHS system, a number of procedural alternatives were considered. The alternative selected for the major components was termed "Volume bidding, consultant design team." In this process, the design work on the desired item is performed by the owner's design team and volume purchasing is used to procure it. The design cost is thus abosrbed by the owner rather than the manufacturer. This is a particularly effective approach when the manufacturer is not equipped to do the necessary conceptual work and when a development team exists from the beginning of the system study.

The subsystems were to be bid prior to detailed facility design. This sequence has many advantages, especially for estimating costs and providing accurate information on which to base design. Construction scheduling can be speeded up because manufacturing work can proceed in advance of the construction process.

Evaluation

The GHS project was never carried out to completion, primarily because of an unforeseen change in the political climate of the City of Pittsburgh. When the project was undertaken, there was tremendous enthusiasm for immediate action. Ironically, the ambitious and careful development phase of several years' duration changed enthusiasm to cynicism, and the project could not be implemented. The political structure which created and fostered the GHS program has long since been supplanted, and the desire to integrate a fragmented community seems to have disappeared. The inability of the project designers to respond more rapidly is at least in part responsible for the collapse of GHS.

STUDY OF EDUCATIONAL FACILITIES (SEF), TORONTO

The SEF program is one of the major successes of school systems development. Based on the SCSD program, it has gone far beyond SCSD in many respects. It is generating a wide range of coordinated building products that will become available for general use on small projects as well as large.

Organization

In 1965, educators in Toronto began to study the feasibility of applying the SCSD approach to their problems. This resulted in the establishment of SEF in late 1965, with initial funding from EFL, the Metropolitan Toronto School Board and the Ontario Department of Education. The permanent project staff is headed by an academic director, a technical director, and an executive officer, and includes four architects, four research officers and their research assistants, as well as a 23-member advisory committee comprising both architectural and educational personnel.

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Several sequential systems programs are planned, each of which will involve the selection of a new building system. SEF bidding and evaluation procedures will be updated and revised as necessary. Although in the first SEF program thirty-one projects were originally committed for construction, this estimate dropped to twenty-four schools because the province grew short of funds. One test school was built in 1969, eleven other schools were begun in 1969, and twelve schools were begun in 1970, comprising a total of 1.3 million square feet. At present, three more schools totaling 210,000 square feet are under construction in an extension of the program. A second major SEF program will be initiated in 1972.

Procedure

Subsystem bidders were required to "prequalify" themselves by proving their ability to fulfill program demands. Each bidder had to provide information on his financial base, available technical and productive skills, production capability, proposed management and personnel, and arrangements with labor for production and installation. The bid package itself included a description of the subsystem, evidence of fulfillment of performance specifications and mandatory interface requirements, a base bid, and estimates of annual operation and maintenance costs over a five-year period.

The SEF performance specifications were based on SCSD documents. Since "mandatory interface" was specified, each bidder was required to list two compatible bidders for each subsystem with which a mandatory interface was required. Because bids by consortium were specifically discouraged, there was an exceedingly wide range of subsystems combinations from which to select the SEF system. A computer was used to analyze the cost structure of the 13,000 potentially compatible bid combinations. Of these, the 30 lowest bid combinations were fully analyzed, with particular emphasis on performance, cost structure and interface conditions. The subsystems were chosen on the basis of the best overall value, with a balanced emphasis on quality and cost. Ten bidders were designated by the Metro Board as probable subsystem contractors for the following subsystems: structure, atmosphere, lighting/ceiling, interior space division, vertical skin, plumbing, electric-electronic distribution, roofing, carpet and casework.

The Roden Public School (1969) provided the first full-scale test of management procedures and of the first SEF building system. All subsequent schools were built or are being built under fixed-fee management contracts with the general contractor. The subsystem contractor and general contractor are held mutually responsible for delivery and installation of the subsystem components. SEF monitors construction to check performance and maintain the SEF target rate of 100,000 square feet per month.

Evaluation

It is generally felt that the second SEF building system will produce more impressive cost savings than the first, since the experience gained in the last few years should serve to make management more efficient and the system itself better. It is noteworthy that the schools participating in the first SEF program make up only 30 percent of construction committed for 1969-71. Hence there remains a large market beyond these projects. There are many possibilities for combining traditional and systems building, so school boards can make ample use of the work done for SEF.

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The original target cost for SEF subsystems was $19.10/sq. ft. (Canadian dollars). Although lower than prevailing construction rates, the target figure was met. In order to obtain bids which were not inflated and to protect bidders from rising costs, SEF included in its contracts an escalation clause which provided for a gradual increase in prices. This was based on the assumption that supply and demand would remain stable. High interest rates, however, subsequently reduced the volume of local construction and conventional prices have remained constant or have decreased. Therefore, the escalation clause has added to SEF costs rather than stabilizing them. A new methodology must be developed to cope with this problem.

RECHERCHES EN AMÉNAGEMENTS SCOLAIRES (RAS), MONTREAL

In many ways, the RAS program is similar to Toronto's SEF program. It differs, however, in its bidding procedure, using the "integrated component system" approach (consortium bidding). This has resulted in a sophisticated set of highly coordinated products which are excellent when used together, but which may have limited application outside Montreal.

Organization

RAS, a Montreal systems project undertaken and sponsored jointly by the Montreal Catholic School Commission (MCSC), which presently builds approximately 50 percent of Montreal's schools, and EFL, is being conducted by L'Institute de Rechêrches et de Normalisations Économiques et Scientifiques (IRNES), a Quebec research firm. Its task from the outset was to investigate the entire range of educational problems in Montreal, from site selection for schools to educational requirements. The project goal was the development of the RAS building system. The MCSC has tried to involve the provincial Department of Education throughout the process in hopes of reducing potential barriers to the widespread use of components later. The initial scope of the project was twenty-one school plants worth over $40 million (Canadian). By the end of the next decade, MCSC intends to have built an additional seventy-five RAS schools in the Montreal region. RAS is staffed by an executive director, technical director, pedagogical director and various architects, engineers and other specialists.

Procedure

After educational and performance specifications were prepared, the following subsystems were developed and bid: structure, HVAC, lighting/ceiling, interior partitions, and electric-electronic distribution. These subsystems account for 40-60 percent of the total building cost of each school, depending on the type and complexity of the facility. RAS requested linked bids with documented compatibility. In soliciting consortium bids, RAS encouraged manufacturers to get together and submit integrated packages of compatible subsystems.*

Bidders of each subsystem were required to submit physical descriptions of their systems with drawings showing interface conditions with the other four subsystems. Required cost figures were a unit price schedule, a lump-sum bid and estimates of annual operations and maintenance costs for the four schools. Because it had been decided prior to bid submission

* For an evaluation of the pros and cons of different bidding procedures, see the chapter on procedural alternatives.

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that all bids higher than the RAS target figure would be eliminated, only three submissions were considered. The final selection was made on the basis of three factors: performance, construction cost, and operation and maintenance costs.

The low bidder in three out of five subsystems was nominated for contract award by IRNES in March, 1969. The bid represented a savings of 12.8% over conventional construction costs. Political difficulties within MCSC delayed the actual signing of the contract beyond the 120-day acceptance period. For this reason the MCSC commissioners made alterations in the program as originally outlined. The new program called for a separately contracted ninety-day development period financed by MCSC and followed by review and evaluation. Upon inception of the construction period, MCSC would withhold 10 percent of the payment certificates as reimbursement for the cost of development. Development contracts were finally signed in December, 1969.

The 90-day development phase included construction of a full-scale system mockup of two 20' x 30' structural bays and full testing of dimensional and functional compatibility of all components. The mockup also serves to introduce architects and engineers to the system.

Because the 120-day binding period following successful bidder nomination expired without the signing of contracts, the original unit price figures were invalidated. Therefore, IRNES had to negotiate with the subsystem contractors to establish new component unit prices. An escalation formula based upon the escalation indices of the Canadian Bureau of Standards will be used to keep prices current.

In addition to supplying the hardware, component contractors are obliged to prepare production and delivery schedules for all projects in the program. The RAS construction target is 150,000 - 200,000 square feet per month. Production and delivery schedules are to be coordinated with the CPM of the general contractor of each project, who shares responsibility with the architect for project scheduling.

While originally all schools were to be finished by the end of December, 1972, the schedule has been delayed. A number of schools are presently under construction, and 1.5 million square feet have been committeed.

ACADEMIC BUILDING SYSTEM (ABS), CALIFORNIA and INDIANA

Developed for universities rather than public schools, ABS is a software system for coordinating already existing building components. The program is not involved in product development, consequently saving much time and money and avoiding complications and special bid procedures.

<u>Organization</u>

The ABS program is being conducted jointly by the University of California and Indiana University. The goal of the program is to develop a building system suitable for a full range of university academic building types from simple classroom buildings to sophisticated research laboratories with high service requirements. A systems consultant is doing the research and design work for the Universities.

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In 1967, when the ABS program was conceived, the University of California and Indiana University were building approximately $90-$100 million worth of academic buildings per year. Thus ABS intended to follow the pattern set by SCSD and ask industry to finance the development of new components in return for a large-volume commitment. By 1969, however, when the ABS program was funded and under way, the construction programs of both institutions had changed radically. Under these circumstances, a new program was devised that would not depend on volume commitment by the institutions and was not aimed initially at component development by industry.

<u>Procedure</u>

The ABS building system was designed to "rationalize" (coordinate and make compatible) already available components and methods. Studies were done to assist the universities in making optimum use of their resources. Performance specifications and cost targets related to performance have been established for the following subsystems: structure, HVAC, interior partitions, lighting/ceiling, and utility distribution. The system provides a variety of application possibilities allowing each of the subsystems to meet a range of performance requirements which vary with cost. The ABS building system does not restrict the owner to a particular manufacturer's product and does not necessitate volume commitment. Adherence to the system "rules" should provide the following advantages:

1. More accurate prediction of costs;
2. A management tool allowing faster and more accurate space planning and budgeting;

3. Buildings with lower life costs, because changes can be made faster and more economically;
4. The ability to proceed confidently with design and construction before academic programs are established;
5. The ability to reduce design time because of basic design and construction decisions inherent in the system.

Evaluation

Although it grew out of financial constraints, the ABS approach to building has some significant advantages over the more usual systems approach. First, the program can move much faster towards completing a building, because the difficult task of writing performance specifications to be used as bid documents and the long development period are made unnecessary. In other systems programs these two activities have represented two or more years of work.

Second, the ABS program is adaptable to the requirements occasioned by climate, geography and local skills. Initially, the system is not dependent on a particular manufacturer's building components, a circumstance which minimizes problems of procurement when the program is transferred to other states. The ABS design is a software system. Final decisions which may affect cost and quality are made by the local designer, who can utilize his knowledge of local capabilities and preferences.

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Third, the ABS program is flexible. It establishes cost and performance data and the range of user requirements within which the system can be effective. The ABS design rules match available components with cost and performance objectives. At any time, component development by industry can be introduced where the need is felt. The ABS program, then, provides a disciplined catalog of procedures and design concepts with which the institution can, in effect, fashion a building system program to suit its own needs and conditions.

BRITISH COLUMBIA

At the beginning of 1970, the British Columbia School Trustees Association (BCSTA) School Construction Systems Committee was formed to study the possibility of a school systems program in British Columbia, and to propose a structure to organize and administer such a program if it seemed both feasible and advisable. With the enthusiastic support of both the BCSTA and the Provincial Government, the seven-man committee studied the problem and its many implications and, after ten months of work, published its findings.

The Committee's Report on School Construction Systems consists of a thoroughly worked-out proposal for a school systems program to be undertaken in British Columbia on a province-wide scale. The proposal responds to British Columbia's particular needs, which in certain respects are analogous to those of Massachusetts. Although it is not clear when the program will be implemented, the proposal bears examination both because of its applicability to Massachusetts and its analytic thoroughness.

In British Columbia, school building is the local responsibility of 80 autonomous school boards who presently make their own decisions about construction. Because it was considered extremely desirable to leave as much control as possible in the hands of local trustees, the BCSTA SCSC emphasized the development of an organizational structure which would encourage school districts to participate in a systems program while retaining as much local control of school building as possible. Recognizing the importance of local "self-determination" with respect to both educational facilities and strategies as well as the need for systematic facility procurement, the committee proposed the incorporation of a centralized School Building Authority (SBA) to develop and manage a systems school building program for British Columbia.

Organization

The SBA would be operated jointly by the School Board of British Columbia and the Provincial Government. It would fulfill the following functions:

1. Determination of the scope of the school building market on a five-year basis, to be updated annually;
2. Dissemination of educational specifications and space standards to teaching authorities and annual reevaluation of the specifications;
3. Collection and evaluation of information about performance of systems schools;
4. Preparation of performance specifications for schools, updated on the basis of evaluation (3);

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5. Bidding of systems components every two years;
6. Inventorying of all educational spaces in British Columbia on a continuing basis, with special attention to obsolescence; and
7. Marketing of surplus systems schools (if, for example, school population in a district should decrease) for other uses.

The SBA would be headed by a five-man Board of Directors, two chosen by the Ministry of Education and two by the BCSTA (representing the local boards), with the fifth member elected by the four appointees. As representatives of both the Provincial Government and the local districts, this Board of Directors would be involved chiefly in policy-making. They would establish a cost-control procedure and report to both the Minister and the BCSTA annually. Their other responsibilities would include: provision of advice and services to all school districts equally; assurance of local control to the individual districts; direction of the administrative and development staff hired to implement the systems program; translation of the Department of Education curriculum changes into special requirements; and, if applicable, reflection of these changes in revised spatial requirements. The initial development staff for implementing the systems program would comprise an architectural director, an education director, and secretarial help. Consultants would be hired for technical advice and services as required.

Financing the Authority

It is felt that the development costs of both the building system and the procedures should be borne by the local districts and the Provincial Government in the same ratio as the capital cost of construction (see

Procedure below). To pay for research and development, the SBA would try to get an independent grant in addition to an advance from the Provincial Government. This advance would be repaid out of a levy on construction under the systems program. The local boards and the Provincial Government would also share operating costs in the same ratio as they share capital costs of construction.

Participation by individual school districts in the school systems program is intended to be optional, with the district deciding whether to commit construction to the SBA. Provincial Government grants for capital construction are to be based on the cost of providing a standard systems school of guaranteed quality in a given locality. The local referendum for capital construction, now a necessary step in facility procurement, would be abandoned for construction done under the SBA but retained for "non-sharable capital" and non-SBA construction. If a locality desires a facility more expensive than a standard systems school, and if it can raise the necessary extra money, it may still participate in the program but must hold a referendum to approve the extra expenditure. If, on the other hand, a district decides not to participate in the program at all, the provincial Government will only share the cost of construction to the value of its share of a standard systems school.

Objectives

The objective of the proposed program is to assemble a volume of construction large enough to take advantage of management efficiencies and procedures which will insure economical utilization of resources while providing better, cheaper, more flexible school plants. Implementation of the proposed

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systems program is expected to have the following specific advantages for the school districts involved:

1. More flexible schools of guaranteed higher quality for the same or lower costs;
2. Substantial reduction in planning, approval and construction time;
3. Continually updated educational and building specifications;
4. Continual monitoring of school construction, including updating of all parts and procedures every two years;
5. Central authority to gather market data and coordinate bulk procurement of components;
6. Realization of the potential saving inherent in mass production and purchasing of coordinated components; and
7. Availability of components for school construction on a continuous basis.

For the province of British Columbia in general, the program is expected to provide the following:

1. Consistent quality of educational environment throughout the province;
2. Control on the quality of construction and on construction expenditures;
3. Predictable, orderly demands on human and material resources;
4. Careful planning of capital requirements and precise prediction of capital demands for two years, with reasonably accurate predictions for up to five years;
5. Elimination of the extensive supervision and plan checking now required, freeing the Department of Education Planning Division staff to work on educational trends and district problems related to growth;

6. Financing of building research and development costs as a charge against buildingsconstructed; and

7. Establishment of model for techniques and cost savings applicable to other public construction like small hospitals and government offices.

Procedure

1. Entitlement of Construction

The entitlement procedure is a method of determining the amount of new academic space a district needs; it is based on pupil population growth and population shifts. School boards would be required to submit their building needs annually on a five-year projection basis to the School Building Authority, stating educational space needs in gross square feet per pupil. Gross requirements would be based initially on the sums of the net areas specified in the School Building Manual, a document which allocates space requirements to various academic functions. Adjustments would then be negotiated between the school board and the Department of Education. Once the amount of space needed by a school district was determined and stated in gross terms, the figure would be applied to the cost of a systems school to determine the share to be borne by the Provincial Government.

2. Procurement of Educational Facilities

The participating district would then proceed with construction without further approval. Using its own educators and architects, the district would determine with full local discretion the configuration of its entitled space that best reflected its educational philosophy and needs. Although the architects would have to work within the discipline of a system, the system would be sufficiently flexible to allow considerable

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architectural variety. Upon the completion of schematic designs the SBA would call for bids on the various systems components and evaluate the bids for the local district. Bids might be aggregated in convenient regional packages.

3. Performance Specifications

Components would be prebid on the basis of performance specifications. Using criteria developed by the BCSTA School Construction Systems Committee, the SBA would write performance specifications for the entire province. The SBA would be responsible for the continual upgrading and revision of standards, based eventually on the evaluation of the performance of the new systems schools.

4. Educational Specifications

The SBA would undertake a study of educational requirements for public schools in British Columbia to insure that the dimensions and locations of systems components did not inhibit the development of local strategies and that the facilities offered a good educational climate. Further, the SBA would provide assistance to school districts in the development of procedures for educational planning and writing specifications. SBA would also encourage extended community use of educational facilities by providing buildings suitable for this purpose without detriment to the educational program. Finally, it would consider providing space within educational plants for community services. Local districts would be responsible for preparing their own educational program and specifications. The SBA would not tell anybody what to do, but would make sure that the local boards knew what they were doing.

5. Monitoring

The SBA would be responsible for gathering information on the architectural and educational performance of schools. It would collect data on the following factors annually: the adequacy of gross areas of square feet of space for educational programs, light levels and sound transmission qualities, and comfort levels of heating and cooling.

Evaluation

The British Columbia proposal contains a thorough analysis of the educational construction needs of the province. Both central and local governments have greeted it with enthusiasm and acceptance. At the annual meeting of the BCSTA in October, 1970, the report and its proposals were approved, empowering the School Construction Systems Committee to proceed. The legal mechanisms have been prepared. With proper financing the program will get under way without any loss of momentum.

PROCEDURAL ALTERNATIVES IN THE USE OF SYSTE

CHAPTER IV - 4

Introduction

One of the main objectives of a school systems program, whether undertaken by a consortium of independent school districts like SCSD, by a municipality such as Toronto, or by a state such as Massachusetts, is the improvement of the dollar value of the educational facilities to be built. The central task of the program is to provide the structure or organizing principles which can bring about this objective most effectively. The software component, or "set of rules," is an essential element of a building system, guiding its use and structuring its implementation. It insures that full advantage is taken of the benefits of the systems approach.

The systems program is a set of interrelated procedures which provides the following:

1. More accurate prediction of construction costs;
2. A management tool allowing faster and more accurate space planning, budgeting and procurement of new buildings;
3. The ability to reduce total project time and costs.

In all systems programs there is a sequence of steps leading from educational specifications and projection of needs to the construction of facilities. The following broad categories encompass the major tasks.

1. User needs and educational specifications
2. Performance specifications
3. Product selection
4. Market aggregat
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4. Market aggregation
5. Bidding procedures
6. Construction scheduling

There are several alternative approaches to each of these tasks. Each alternative has inherent advantages, disadvantages and particular implications for or relationships to other procedures. The alternatives must be carefully analyzed to determine which would be most appropriate for a particular program in light of local conditions and constraints.

This section explores and evaluates the range of possible procedures and their relationships to each other. From this range of procedural alternatives, a school systems program may be formulated which best suits the unique needs, resources and goals of the state of Massachusetts.

The User Needs Study

A systems development program should begin with a detailed study of user needs. The user needs study focuses on spatial requirements for people, their activities, equipment and storage, taking into account educational, environmental and aesthetic needs. This research generates the system, and the system's success depends on the accuracy of the analysis of the user needs data.

Because in past programs great emphasis has been placed on user needs studies, there now exists a large body of data on basic user needs in educational facilities and on changing trends in education. Program directors planning systems projects may use existing information either exclusively or as a foundation to which specific information may be added as appropriate to their constituency. There is no convenient formula, however, for translating user needs into performance criteria. Based on its evaluation of user needs, each program must determine its own performance specifications.

Educational Specifications

User needs are usually stated in terms of "Educational Specifications," or those statements of performance which embody the educational attitudes and objectives of the system program's educators. The development of these educational and spatial requirements involves several tasks. Space standards are established that relate student population or student activities to square footages. Quantifiable environmental requirements--temperatures, relative humidity, light levels, sound transmission characteristics, and so on--are determined and codified. General questions of instructional programs and groupings are addressed. Educational objectives and user activities are examined in light of their physical implications. A data system is developed to store information in a highly usable form. Finally, an administrative structure is created to manage the above activities and implement decisions.

There are three basic administrative approaches to the preparation of Educational Specifications:

1. Traditional: Private architects or systems analysts are secured as consultants to an existing administrative apparatus.
2. Intra-systemic: An entirely new department is created or an existing department is restructured to perform the above tasks.
3. Extra-systemic: A self-retir
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3. Extra-systemic: A self-retiring task force is created and empowered to use a range of resources from the existing bureaucracy to outside consultants.

In practice, these variations are imprecise, and most projects are a combination of these types. The suitability of one type or another depends on the existing legislative and administrative context.

It is essential that educational specifications and planning receive proper attention on both regional and local levels. Witnin the systems program, special provision should be made for continuing review and updating of these standards, undertaken either by a central agency or on the local level. The main advantage to local preparation of educational specifications is the assurance that the educational policies formulated will relate directly to local needs. An approval process might be used by a central agency prior to the construction of a systems school to insure that the localities have undertaken adequate educational planning and are aware of the implications of what they are doing.

Performance Specifications

Performance specifications are technical statements of what the solution (a building system) must do, not what it must be. In a systems program, they are the second important end product of the user needs study. They are the translation of qualitative statements about user needs and requirements into quantitative criteria against which the performance of the final component systems can be measured and evaluated. Establishment of performance specifications is an extremely complex process, requiring thorough studies of known criteria performance, and occasionally the creation of new criteria.

In the SCSD project, for example, it was found that no criterion existed for the maximum force desirable to manipulate an operable wall. Observation showed that existing walls were not being used because they were too difficult to open. Some simple experiments showed that if the force necessary exceeded 25 pounds, a teacher might begin to slip. This criterion was put into the performance specifications, and manufacturers responded with ingenious retractable sealing devices which made the partitions easy to operate without diminishing their acoustic effectiveness.

It would be a gross oversimplification to say that performance specifications spring full-grown, as it were, from the user needs study. A number of other factors must be taken into account. These are:

1. Codes and regulations: Any proposed system is subject to state codes and other relevant documents of public safety.
2. Requirements intrinsic to the system: This includes especially considerations of component dimensional modules, space planning modules and their implications for component coordination.
3. Compatibility requirements between subsystems: The need for subsystems to be designed compatibly leads to specifications of mandatory interface which, in effect, cross-reference interrelated subsystems.
4. Labor and contractor influence: Concerns relating to potential jurisdictional disputes among trades may influence performance documents, at times taking precedence over design considerations.
5. Predicted industry capability: Specified criteria must be compatible with industry's capacity to respond with products in an acceptable cost range. This information usually comes from talks with manufacturers during specification writing and cost studies of existing educational facilities.
6. Design requirements: Both t
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6. Design requirements: Both the project or program team and participating architects influence performance documents. They invariably play an important role, especially in terms of aesthetics.

Although the writing of performance specifications is an essential task in a systems program, the documents do not have to be created "from scratch" every time. As a point of departure, a program may (and most have) adopt almost verbatim the performance specifications of SCSD and SEF (SEF was itself based on SCSD). Modifications may be made to suit local needs and changing requirements; the documents, furthermore, may be updated or revised as necessary throughout the program. The project performance specifications are a dynamic element in a systems program.

As translations of needs into technical language, performance specifications represent a balanced judgment between the owners' needs and resources (budget), and the building industry's capability in the context of development and production costs. Thus performance specifications may be seen as a technical expression of the products to be developed and/or used. They have a vital relationship to the market and bidding procedures discussed below.

The use of performance specifications is advantageous for the systems program because it assures that desired levels of performance are achieved and encourages continuous product improvement by industry. There are, however, other possible bid document choices. Briefly, specifications may take the following forms:

1. Products specified in detail: conventional specification of one acceptable existing product, no divergence permitted, no product development necessary, known level of performance specified.

2. Specification of three products "or equal": three products named as exemplary of component quality specified, some divergence permitted, little or no product development permitted, minimum level of performance specified.
3. Performance specifications: system program specification of quantifiable performance levels, wide product divergence permitted, product innovation and development as necessary.
4. Combination of the above (some conventional, some "or equal," some performance specifications).

Product Selection

The identification of user needs and formulation of performance specifications are directed toward the procurement of hardware components which provide the required performance. There are two alternative procurement methods for a school systems program. The first of these is not directed towards component innovation or product development by industry, but uses "off-the-shelf" components. Presently, there exists a range of hardware items sometimes referred to as the "North American open building system." It consists of products developed for SCSD, SEF and RAS, as well as products developed over the years to take advantage of the market created by numerous small systems projects. The building subsystems for which these products exist are: structure; heating, ventilating and air-conditioning (HVAC); lighting-ceiling; demountable and operable partitions; electric-electronic distribution elements; exterior (vertical) skin; and cabinetry, furnishing and carpets. The "off-the-shelf" approach is particularly applicable when the funds for product development are not available or when a volume market

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cannot be aggregated. Attention is directed toward the integration of existing components and the optimum utilization of available resources.

The second approach is concerned with new product development to meet the demands of the performance specifications. Product development has several obvious advantages over the off-the-shelf approach. With a large aggregated market, it can encourage innovations which may provide higher performance products at lower costs. Furthermore, it exploits the tremendous research and development potential of industry. The major disadvantage of product development is time. It takes a minimum of eighteen months longer to develop products than to buy them off-the-shelf. First, an extra six-month period is spent writing innovation-oriented performance specifications, a task involving continuous contact with industry to assess their capabilities and probable component costs. This is followed by a bid period of at least twelve months during which product development by industry occurs. In systems programs where time is a crucial factor, as ultimately proved to be the case in the GHS program, product development may be an undesirable procedure.

A further possible disadvantage of the product development approach is the cost of development. Without a sufficiently large guaranteed market as an incentive for industry, the sizable financial risks attendant on product innovation would have to be borne by the owner. In general, money for this is not available to public authorities. Clearly, the prerequisite to any realistic program of product development is either an aggregated market or the recognition by industry of a large potential market to justify their investment in development.

There are three ways of procuring development work on behalf of a school systems program:

1. development contract,
2. in-house development team,
3. direct development by industry with the market as an incentive.

The development contract (assuming that funds are available to pay for it) protects the owner's right to innovation and thus hampers and discourages later exploration of the market by industry. While relatively simple to organize, the in-house development team approach is limited because it does not take advantage of the building industry's immense capacity to participate in research and development activities.

The most advantageous way to develop products is to have the development work done and paid for by participating manufacturers under the guidance of the project team. This was the method used in the SCSD, SEF and RAS programs. Involvement of the manufacturer in the design and development of components is desirable in many respects. He has intimate knowledge of production technologies, materials, labor constraints, and other relevant factors best understood by those involved in production on a day-to-day basis. Furthermore, products developed by each manufacturer remain his property, and can be exploited by him. At the same time the owner gains the benefit of the development work at minimum cost to him.

Market Aggregation

Market aggregation is a procedure which relates the award of a single contract to more than one job. Two different types of market aggregation are pertinent to a school systems program.

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The first type involves the association of a group of school districts in order to provide a sufficient volume commitment to encourage industry to undertake research and development. Without the aggregated market incentive, it is unlikely that industry will embark on a product development program.

A number of factors determine whether market aggregation will be successful. Different building subsystems require different volume commitments to assure profitability to industry. Thus, for example, when the product to be developed is a new precast concrete structural system, the aggregated market will have to be extremely large. On the other hand, if the product to be developed is relatively simple, such as school furniture, the aggregated market can be as small as a single school district.

Another consideration is the extent of product development desired. If the scope of development is extremely ambitious, such as the creation of a totally new structural subsystem, the aggregated market commitment will have to be substantial. If, however, the scope of product development is a matter of making minor changes in already existing products, such as changing the modular dimensions of casework from 24" and 48" to 20," 30" and 60," the aggregated market can be comparatively small.

The second kind of market aggregation is "bulk purchasing," or the acquisition of existing products and installation services on a scale greater than a single job. The rationale for bulk purchasing is the assumption that substantial cost savings may result. Small cost savings are indeed made available by bulk buying. Since manufacturers often state prices in terms of quantity, the precise cost advantages of bulk purchasing of components may be calculated.

Improved management techniques are a necessary facet of a successful bulk-purchasing program. These can effect significant cost savings, but not if their establishment and administration are more costly than the potential savings from bulk purchasing. In other words, the economies of a program of market aggregation must be weighed carefully against the time, money and effort necessary to organize and implement it.

Bulk purchasing of installation services is a slightly more complex problem In various systems programs, school projects have been grouped and bid as a package. Although this has been successful in some cases, its implications with respect to contractors and management should be evaluated and understood. A large package of school buildings frequently means that smaller contractors cannot get bonding for work, whose scope is beyond their usual capacity. This may mean that a more experienced contractor is encouraged to bid on the package than might bid on a single project, and that the work he does will be done better, faster and cheaper. In some instances, however, smaller contractors offer the best prices and highest quality, so a course of action which eliminates them from contention should be examined with local conditions in mind. Furthermore, it is possible that a bulk bidding program which excludes small contractors will not interest larger contractors either. This usually necessitates strategy revision and a rebid, which are both costly and time-consuming, resulting in delays of up to a year in project completion.

A number of alternative strategies of market aggregation have been tried over time. Briefly, they are:

1. Independent consortium: E.g., SCSD, the independently organized group of thirteen school districts which formed the First California Commission on School Construction Systems.

2. Already existing aggregated market Toronto School Board with fiscal j and RAS, the Montreal Catholic Sch 50 percent of Montreal's schools.
3. Voluntary participation in a schoo British Columbia program and SSP, tive structure is organized and lo participate with such incentives a delivery time, and lower costs. T dously in scope from several commu state.
4. Mandatory participation in a schoo a central agency with absolute pow ticular area.

Bidding:Procedures

The bidding process is particularly aff are essentially four procedural pattern designer must choose the one that best s constraints. These are:

1. Conventional
2. Phased bidding
3. Subsystems prebidding (two-phase)

1. Conventional

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2. Already existing aggregated markets: E.g., SEF, the Metropolitan Toronto School Board with fiscal jurisdiction over five local boards; and RAS, the Montreal Catholic School Commission which builds about 50 percent of Montreal's schools.
3. Voluntary participation in a school systems program: E.g., the British Columbia program and SSP, Florida. The legal and administrative structure is organized and local school boards are encouraged to participate with such incentives as improved quality, shorter project delivery time, and lower costs. This type of program can vary tremendously in scope from several community schools to an entire region or state.
4. Mandatory participation in a school systems program: This implies a central agency with absolute power over school building in a particular area.

Bidding Procedures

The bidding process is particularly affected by the systems approach. There are essentially four procedural patterns from which the systems program designer must choose the one that best suits his objectives, resources and constraints. These are:

1. Conventional
2. Phased bidding
3. Subsystems prebidding (two-phase)

1. Conventional

In this bidding pattern, installers bid on the basis of working drawings and conventional specifications which prescribe the use of particular products "or equal." All bid competitively on essentially the same item, and after contracts are awarded, construction may begin. Building system products may be introduced into this process but are used just like any other product combination. One advantage of this procedure is its wide acceptance by the building industry. Because the products specified and their unit prices are known, a more accurate and usually lower cost estimate may be made in the bid. Trades can bid separately on all the relevant work in the contract; for example, a concrete contractor can bid on all the concrete work on the job.*

A major disadvantage of conventional procedure is that when products "or equal" are specified, bidders often try to substitute products which are not, in fact, equal in all respects. It is extremely difficult to argue the matter of "equality," with the result that items of lower quality are often substituted. Another disadvantage is that conventional procedure does not make use of the ingenuity of manufacturers to meet performance specifications. Specifying products severely limits the range of component alternatives at a possible sacrifice of cost savings and performance. In a systems building, compatibility among the various building subsystems is a central objective upon which the proper functioning of the facility depends absolutely. In conventional bidding, when a bidder wants to substitute an alternative to the product specified, there are no mechanisms other than the "or equal" clause which guarantee this essential compatibility. This can result in terrible problems either during bidding or, even worse, after contract award, during construction.

* This is not the case in subsystems prebidding (see below).

2. Phased bidding

In this procedure, constru relatively small bid packages w vide sufficient lead time to ke has some significant advantages be tailored to the particular c contractor capabilities, labor Packages may be bid on the basi specifications. The developmen time reduces the chance of obso contractor permits relatively l The quantity and quality conten by the owner or architect in li Since each package is much smal tract, many small contractors w enhancing the competitive situa

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2. **Phased bidding**

In this procedure, construction work is broken up into a series of relatively small bid packages which are released only as required to provide sufficient lead time to keep construction on schedule. This technique has some significant advantages. The scope of the various bid packages can be tailored to the particular characteristics of the project, e.g., local contractor capabilities, labor conditions, overall job schedule, etc. Packages may be bid on the basis of conventional documents or performance specifications. The development of each package at the latest possible time reduces the chance of obsolescence. Delayed bidding by each specialty contractor permits relatively low contingency factors in bid calculations. The quantity and quality content of each successive package can be adjusted by the owner or architect in light of current costs and budget estimates. Since each package is much smaller than the typical total construction contract, many small contractors who would normally not be bondable are eligible, enhancing the competitive situation.

On the other hand, phased bidding has the following disadvantages: As construction begins, there is no guarantee of the final cost of the building equivalent to the traditional prime contractor's lump sum bid. This means that unless the phasing and work itself is extremely carefully monitored, the available money may run out prior to project completion. The owner/architect must deal with a series of individual contracts rather than with a single prime contract. (This can be alleviated by the adoption of a slightly different procedure using "project management".)

If a phased bid program is poorly administered, the results can be disastrous, with conflict among several contractors on the ground at the same time, and so on.

Successful management of phased bidding requires a serious team effort among persons generally accustomed to more traditional procedures. Sophisticated management is required to administer this form of program. Although this can be developed over time, it is difficult to initiate. Finally, it is questionable whether the scale of work involved in most school buildings justifies so complex a procurement procedure. Undoubtedly certain schools are large and complex, but in general, phased bidding is probably not a desirable approach to school construction.

3. Subsystem prebidding (two-phase)

Prebidding refers to a process used in systems building in which bids for the supply and installation of subsystems are requested prior to bidding for the general contract work. Prebidding existing systems components can be successfully accomplished using only performance specifications and schematic building plans. It may take place upon approval of preliminary design and the completion of other necessary documents.

The procedure originated in system development programs such as SCSD, in which it was necessary to designate the subsystem team, establish costs, and perform development work before individual projects were designed and bid. At present, prebidding on performance specifications is used in single or multiple projects using developed components, usually SCSD derivatives. The intents are three: first, to establish costs of major subsystems in advance, assisting the architect in cost control during the detailed design work; second, to designate the subsystem suppliers and installers in advance so that they can work with the architect in the completion of estimating and design work; and third, early designation

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Bidding: Issues

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1. Prequalification of bidders
2. Prebid conferences
3. Interface procedures
4. Lump sum vs. unit prices
5. Contract award

1. Prequalification of bidders

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may assist some subsystems suppliers (notably structural) in materials ordering and scheduling, thus speeding up the total job schedule.

The timing of the allocation and the availability of funds for federal and state projects may be a significiant constraint to subsystem prebidding. If, for instance, planning and design funds are made available in one fiscal year and construction funds become available on July 1 of the new fiscal year, it may be too late to prebid the subsystems without delaying building construction for a whole year. A prerequisite to a successful program of subsystem prebidding, then, is a fiscal structure which permits it. A second problem which arises in prebidding is related to bidding by various trades. When subsystems are taken out of the ordinary scope of work on a construction project and prebid, some categories of work are split up and must be contracted for by several contractors instead of one. For example, in addition to concrete work in the structure subsystem, there may be some concrete in the non-system portion of the building which is bid on conventionally. In addition to the potential problem of having two concrete contractors on the job, perhaps simultaneously, costs for that particular trade may increase.

Bidding: Issues

There are a number of issues concerning bidding in general. These are:

1. Prequalification of bidders
2. Prebid conferences
3. Interface procedures
4. Lump sum vs. unit prices
5. Contract award

1. Prequalification of bidders

This is a means of evaluating bidders according to the following criteria: financial capacity to undertake a program, technical and productive skills, proposed management and personnel, and arrangements with organized labor for both production and installation of components. It assures the owner that the winning bidder can meet his contract with quality work. Although in certain cases prequalification is politically difficult, it is desirable especially in the large contract situation because it eliminates bidders who cannot produce. In single-school projects it is probably not necessary, since many suppliers and installers are capable of meeting the requirements.

2. Pre-bid conference

This is a meeting between the bidders and the owner/architect team prior to bidding. In subsystem prebidding or management contracting it may be very important to explain the purposes and uses of relatively new procedures such as performance specifications, as well as the content of the specifications. Since an information session allays fears of innovation and clarifies potential misunderstandings, the bids may be lower. A second potential benefit of the prebid conference is that it provides an opportunity for component manufactuters and suppliers to get to know each other and form alliances for subsystem coordination. As a program gains acceptance and momentum in an area, and as procedures become familiar, the prebid conference is no longer necessary.

3. Interface procedures

When products are not specified in subsystem prebidding, a method must be developed to insure that the components which are bid are dimensionally and functionally compatible. This integration process is at the heart of the systems approach. Two alternative procedures are used to insure compatibility. The first, known as the "integrated component system" approach, requires that subsystems be bid as packages with documentation of compatibility. The other approach, called "mandatory interface," requires that each bidder specify at least one product in each subsystem with which his product is compatible, and that the details of compatibility be worked out after contracts have been awarded. When all bids are submitted, they are arranged by "compatible bidders" and scrutinized for cost and performance. In all likelihood, where will be a great number of possible combinations.

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in this case the "mandatory interface" is less an assurance of existing compatibility than a promise that subsystems will be made compatible after contract award.*

There are several reasonable arguments both for and against each of these interfacing alternatives. Whereas the "integrated component" approach, also called "closed system," insures compatibility prior to bid, the "mandatory interface" or "open system" method permits a high interchangeability of components which can result in both higher package performance and lower package cost. Whereas the closed system guarantees a higher level of initial integration, the open system requires a lengthy testing period when compatibility is worked out. Thus the closed system approach can be said to reduce post-bid development at the expense of future modifications, while the open system approach permits future interchangeability at the cost of lengthier post-bid development. Whereas it is likely that a closed system approach will yield only a handful of well-worked out packages whose costs are acceptable,** the open system approach may result in a huge number of allegedly compatible building systems.*** If the latter approach is elected, details of how to handle the flood of possibilities must be worked out in advance.

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* In the SCSD project, for instance, the Lennox HVAC bid was a rather conventional dual duct package. In the development period, it was found to be neither compatible with Inland's structure nor particularly flexible. Because the mandatory interface agreement committed them to compatibility, the elegant Lennox multi-zone system was developed by SCSD project staff and Lennox engineers. The price was fixed by Lennox's original lump sum bid.

** There were only three in Montreal's RAS.

*** There were 13,000 in Toronto's SEF.

There is a compromise approach to the problem of interfacing. This procedure, used in the SCSD project, is basically a mandatory interface model. It requires bids which state compatibility with other components to show how their subsystems relate to one another technically, albeit not in the detail of the integrated component package, and to provide cost data about that relationship. This, in effect, forces manufacturers to meet during the bid period and consider seriously matters of coordination at the time they enter a systems program. On the other hand, it does not limit severely the alternative subsystem combinations, and provides adequate cost and performance information for thorough bid evaluation. Furthermore, although mandatory interfacing is the procedural model, bidders are allowed to submit bid packages of integrated subsystems. This approach permits manufacturers several choices and had positive results for the SCSD program.

4. Lump sum vs. unit prices

Cost information may be submitted on the bid form in several ways. A base or lump sum bid is always required and is the basis of contract award; it may or may not be accompanied by unit prices. If unit prices are submitted later, they must, of course, add up to the lump sum bid. Although the owner may find it useful to look at unit prices before award, there are some disadvantages to requiring them at this time. Unless the nature of the system is known, bid documents which require unit prices are nearly impossible to prepare in that they must anticipate and provide for all possible component alternatives. This is an extremely lengthy procedure. While it is questionable whether non-winners should be required to put this kind of work into their bids, the task of preparing unit prices

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5. Contract award

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fits quite naturally into the design development phase. In small projects, unit prices can be required from winning component contractors within as short a time as seven days after contract award.

When unit prices are not required with the bid submission, particularly when the program includes a development phase, the system producer can take advantage of what he has learned during development when he prepares his unit prices. In fact, on the basis of the development period he would probably have to revise his unit price estimates anyway. Further, he may trade off rather freely among items in his unit prices to assure the correct lump sum at the end of the process.

5. Contract award

In a systems program, bids include both cost and performance data. In a large-scale program, evaluation of bids on the basis of both cost and performance criteria rather than cost alone has several significant advantages:

a. The owner may trade off cost/performance alternatives among the various subsystems.
b. The owner may find that variations from performance specifications are justified on the basis of his economic evaluations.
c. The owner may give credit to systems which significantly exceed performance specifications in certain areas, such as maintenance guarantees.
d. The owner may be sure that the levels of performance of subsystems he chooses are compatible, that he does not, for example, pay for the high performance of one subsystem which will be downgraded by the lower performance of the subsystem with which it is combined.

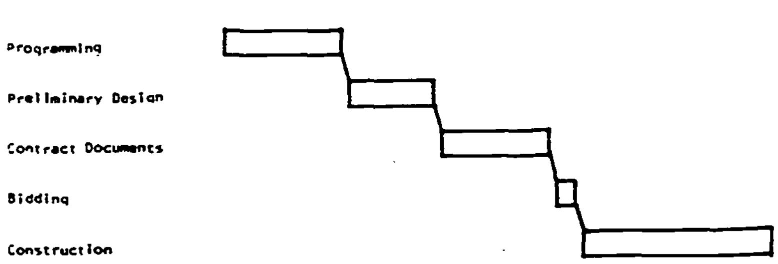
In short, evaluation on both bases enables the owner to award the contract to the producer who offers him the best cost/performance relationship. It should be noted that for legal reasons performance is usually evaluated separately from and prior to cost. For small individual projects, selection of subsystems by price is ordinarily adequate. Many products meet conventional specifications or standard performance specifications, and selection of winner by price alone is much quicker than incorporating systems of penalties and bonuses.

Project Scheduling

There are many different ways to schedule systems program. These currently used models are:

1. Traditional scheduling: Sequential scheduling with building systems;
2. Two stage (multi-stage) bidding: systems prebidding;
3. Phase-overlapping (fast tracking): overlapping scheduling with building systems.

1. Traditional scheduling

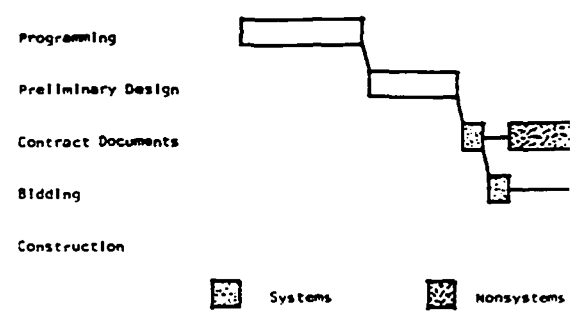


CONVENTIONAL SCHEDULING WITH SYSTEMS

In this model, building systems are used as if they were an architect-designed product combination. Advantages lie in better-quality buildings and possible reductions in project delivery time.

2. Two-stage bidding or systems prebidding

Key subsystems are selected prior to des drawing phases; they are bid competitively f design and completion of bid documents.



SYSTEMS PREBIDDING

When key subsystem components have been chose advantages in his design work. He knows the and installation costs. He also has the assu delivery schedule for these products will be

Prebid contracts may be integrated with other of the following ways:

a. Assignment to the general or releva the subsystem contract(s).
b. Coordination and supervision of all of the owner.
c. Management, coordination and supervi management contractor.

Advantages of this scheduling approach over c the following: The architect's time and reso

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2. Two-stage bidding or systems prebidding

Key subsystems are selected prior to design development and working drawing phases; they are bid competitively following approval of preliminary design and completion of bid documents.

SYSTEMS PREBIDDING

When key subsystem components have been chosen, the architect has several advantages in his design work. He knows the chosen products, their prices and installation costs. He also has the assurance that the construction delivery schedule for these products will be met.

Prebid contracts may be integrated with other construction contracts in any of the following ways:

a. Assignment to the general or relevant construction contract of the subsystem contract(s).

b. Coordination and supervision of all contracts by a representative of the owner.

c. Management, coordination and supervision of the project by a management contractor.

Advantages of this scheduling approach over conventional scheduling include the following: The architect's time and resources are used more efficiently by enabling him to work with known products and standard details. Cost control is improved through earlier availability of prices. The construction schedule is compressed due to one use of industrialized components and the consequent reduction in on-site labor. Finally, a long lead time before the delivery deadline is given to component manufacturers to ensure that hardware arrives on schedule.

3. Phase overlapping or fast tracking

In this procedure, different phases of the design and construction work are overlapped so that some begin before others are completed. The main objective of this is to shorten overall project time in response to escalating construction costs.

Typically, fast tracking divides the construction process into the following phases:

a. Site work and foundations (site improvements, site utilities, foundations and basements);

b. Shell and exterior skin (rough structure, HVAC equipment and distribution mains, service mains, ceiling grid and exterior walls);

c. Interiors (finish structure, HVAC and service laterals and controls, partitions, finish lighting-ceiling, casework, floor finishes and all remaining finish work).

This procedure begins with programming work to establish the gross size of the building. Information is gathered to make initial decisions about siting and configuration. Schematic design begins as soon these decisions are made and ends when building configuration, location and height are established. At this point, design development work starts. As it

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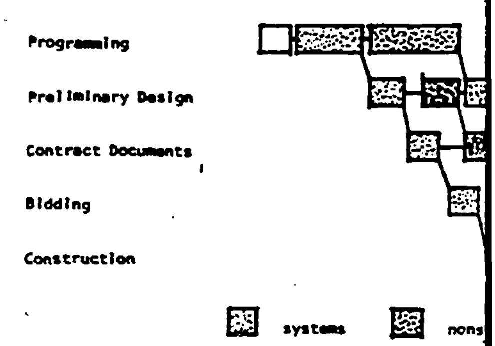

FAST-TRACK SCHEDULING

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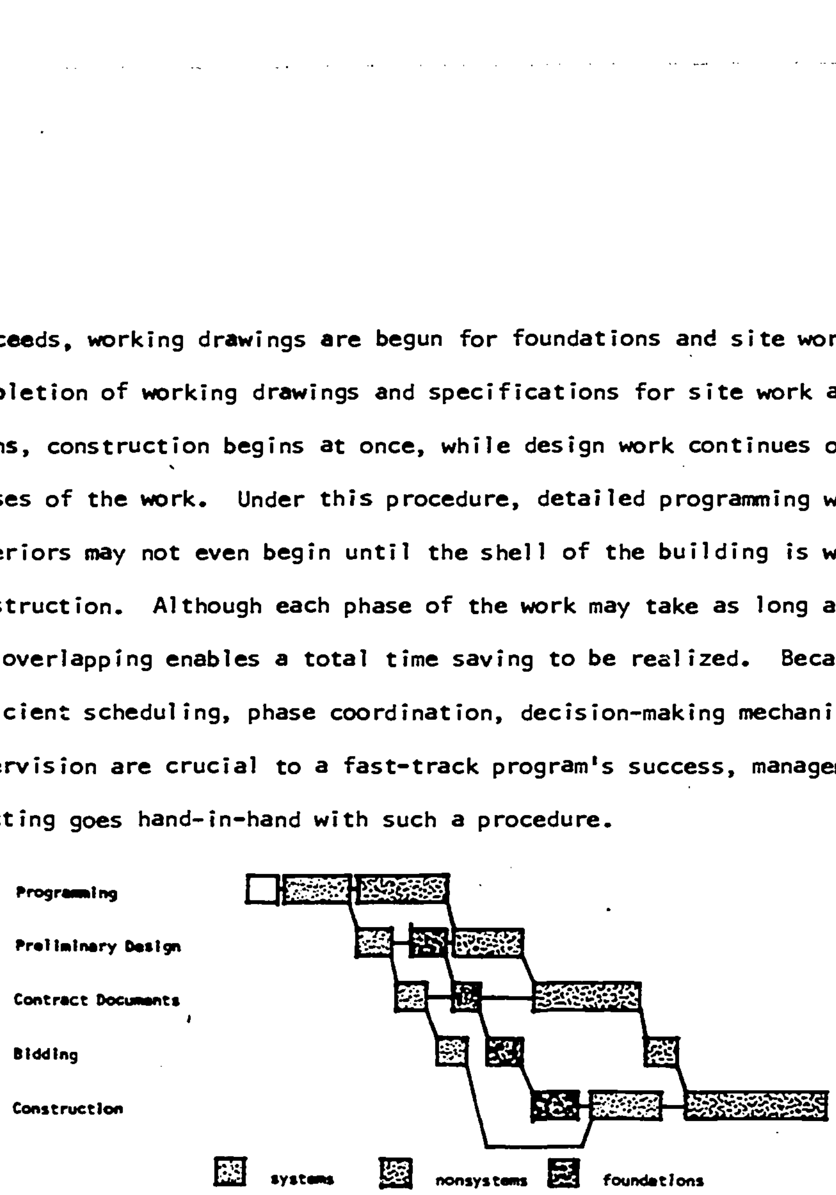

FAST-TRACK SCHEDULING

Fast tracking has several distinct advantages for educational facilities projects. First, it can reduce project delivery time dramatically regardless of time savings effected by office efficiency, on-site labor reduction, etc. Second, fast tracking postpones detailed programming of interior spaces until late in the construction process, often until just before occupancy. This reduces the risk of program obsolescence at the time of building occupancy, and enables the users to formalize their detailed program requirements with accurate knowledge of the nature of both the building and their own needs.

A potential problem of fast tracking lies in the nature of most existing decision-making and approval processes. Problems can arise because of traditional educational bureaucracies, bonding restrictions, resistance to new techniques on the part of educators, architects and contractors, and other factors. Clearly, if this procedure is selected for a large systems program, the many potential problems must be worked out in advance and in detail. An encouraging point is that fast tracking has been used with great success in a number of school projects to date.

PROJECT MANAGEMENT

CHAPTER IV - 5

Every use of building systems to date has demonstrated that owners will reap significant benefits from the technical advantages of industrialized construction if they are integrated into a complimentary group of management systems. Projects which have not used industrialized construction, have demonstrated that equal or even greater reductions in cost, time and general management problems can be achieved by using modern management approaches. Moreover, these approaches conform to the restrictions of current public laws affecting construction.

The purpose of this chapter, therefore, is to outline those management approaches and concepts which should be applied immediately to Massachusetts school construction and continued through any future systems building program; maximum advantages being attained through a consistency of procedure. The core concepts are the following:

1. The owner (school board, superintendent, building committee or construction agency, etc.) must recognize that he is the key member of the project development team. Only the owner can select and organize the proper team of designers, educational consultants, construction consultants, etc.; provide the final decision-maker for the project. Since he cannot really delegate any of these roles, he must be prepared to deal effectively with each.

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2. A corollary of this first concept is that the project team should have the capability to deal effectively with all of the project problems. Because of the rapidly growing complexity of design and construction, many owners and design teams have not been able to provide all of the required capabilities. Project cost and time management skills and construction experience are currently the most common areas where the typical team needs assistance.
3. All of the team's capabilities should be brought to bear at the earliest possible time. As a project is developed, the team has fewer and fewer alternatives available. This is particularly true of construction knowledge, for cost, and related factors can best be reduced and controlled by decisions made during programming and conceptual design.
4. By providing the team with all of the capabilities required and by bringing them all to bear at the earliest point in a project, it is possible to integrate programming, design and construction into a single project delivery process. This integration is a major improvement over the fragmented process which has led to so many of the current problems of school construction.

The approach which has gone farthest in incorporating the above concepts is construction or project management. This new area of specialized services has been discussed in detail by many public agencies. The United States Department of Health, Education and Welfare and the General Services Administration are just two of the major agencies that have issued recent statements strongly recommending the use of project management services techniques.

Project management is a general term which refers to an alternative to lump sum general contracting for a project. It may be used in conjunction with any of the three bidding procedures discussed in the preceding chapter. Project management procedures have been used for many years in large-scale industrial and commercial work, in industrial work primarily to save time, and in commerical work of a speculative nature to start construction of buildings such as offices before major tenants are signed up and their requirements determined.

These procedures are now starting to be applied to public work because of their potential advantages. If fast tracking (see Chapters IV-1 and IV-4) is to be used on a major project, the services of a Project Manager become almost mandatory, for the flexibility of sub-contract bidding and the continuous coordination of work cannot be effectively handled by any other means.

The essential difference between the Project Management process and general contracting are two: first, the Project Manager is selected earlier in the total process than the general contractor; and second, the Project Manager is paid a fee for his management, estimating and coordination services. Part of this fee covers his services as a consultant member of the design team, if he is selected early enough to join it. His selection as early as possible allows him to exercise his particular expertise throughout the design process. As a design team member, he can be particularly effective in assisting the architect in estimating costs, evaluating materials and determining construction methods.

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Since the Project Manager is selected on a fixed fee percentage basis, savings achieved during the progress of the work through innovative practices or favorable sub-bids are passed on to the owner. When the Project Manager is selected, the scope of any estimating and consulting work must be clearly defined and a payment method agreed upon. A typical pattern is a lump sum for personal consulting, estimating, network scheduling and materials evaluation, with additional compensation for direct staff labor cost, overhead and profit.

The presence of a Project Manager may preclude the need for an overall prime general contractor, his function being to serve as owners' representative. As such, he should avoid doing any actual construction work with his own forces that may cause a conflict of interest. Especially, he must not perform any work in competition with bidding contractors. As the current law requires that there be such an overall prime contractor, legislation would be required to allow this form of operation.

Systems components may be prebid before the Project Manager is selected if the long lead time for the development, production and delivery of the components would upset the compressed schedule for the project. In this event, the owner is required to contract with the component contractor and possibly other subcontractors for an early award. When a long lead time for the component is not required, and the Project Manager has been assigned, it is preferable that the Project Manager himself invite proposals on behalf of the owner from the component contractors (actually a subcontractor) in accordance with performance specifications and general conditions prepared by the executive architect.

Some general contractors may object to the Project Management procedure, claiming that this eliminates freedom of action. They may also resent the publication of their fees and other administrative costs. This must be evaluated carefully in each local situation.

Because the Project Manager assumes a consultant role and will work alongside the architect at the design phase, the relationship between the architect and the Project Manager is critical. Team members must have mutual respect and work well together, or most potential benefits will be lost.

Where properly implemented, Project or Construction Management services can help unify the programming/design/construction phases. The design team is generally responsible for designing an "environment" and preparing instructions to build; and the contractor is generally responsible for physically developing this "environment" in accordance with the instructions. Project Management services bring important additional capabilities in the form of detailed construction knowledge to the development of the design and contract documents as well as to the implementation of these documents.

Specifically, there are five basic aspects of this service: project management advice and counsel; construction cost management; progress management; communications management; and on-site coordination, expediting, administration and control. All of these services can be effectively implemented within the context of the current public laws and restrictions on public school construction.

Project Management Advice and Counsel

Every project must have someone who can provide or obtain objective advice on the broad range of problems which face every project. Affirmative action plan structure, contractor default actions, labor relations, and many other areas must be dealt with based on experience. Since most educational construction purchasers are laymen, some member of the project team must fulfill this role.

Construction Cost Management

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Progress Management

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Construction Cost Management

Costs can be managed to obtain the most from each dollar of the budget. Thus, cost management implies more than control. Careful budgeting and control estimating are important tools, but the team must also make cost a meaningful parameter in decision-making. Project management provides this additional dimension through value engineering, analyses of the problems and potential of the local construction market, cost-time analyses, and many related services.

Progress Management

The most dramatic changes in the management of public building projects have come about in an attempt to reduce the long time (and in an inflationary period - the cost) required to complete a new facility.

Building systems are one of the approaches which have helped achieve significant design and construction time savings; concurrent scheduling or "fast-tracking" of design and construction, however, has been the more commonly applied technique (see preceding chapter). This approach, which has long been employed in private construction, has only recently become common on public projects.

Concurrent scheduling is achieved by overlapping actions; beginning a second activity at an appropriate intermediate stage of the first activity. Thus, overall completion time is reduced over the time it would have taken to do each serially.

When these techniques are combined with careful scheduling, schedule monitoring and expediting, it is often possible to reduce normal project duration by more than 12 months.

In cases where construction begins before the completion of design, it will be necessary for the owner to make an earlier commitment to the design concept and to the funding of construction work than has been the practice recently.

Communication Management

Effective communications is an important aspect of well-managed projects. A number of project procedure manuals and information systems are now available. When these systems and procedures are properly implemented and maintained, the project team is able to have the information necessary for successful management.

On-Site Coordination, Expediting, Administration and Control

Most projects require something more than an observer or administrator on-site. The owner must have an on-site representative who is responsible only to the owner's interests, to act as a manager. This is particularly important on projects where design and construction have been overlapped and there is more than one prime contractor.

These techniques do not, of course, represent any radical departure from existing capabilities. Instead, they represent the intelligent ordering of capabilities and techniques which have already been developed and tested.

A growing number of firms are now offering these services as a supplement to the traditional team including a growing number of architects and engineers, project management consultants, and general contractors.

Every project is different and selection must be geared to the specific needs. In some cases an expansion of the architect-engineer's staff is appropriate. In others, a professional manager with strong pre-bid

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capabilities is needed. Where the emphasis is on construction coordination a general contractor might be qualified. In all cases, however, the project manager should be selected as a professional, for he cannot have any interest in conflict with those of the owner. In other words, the owner should select on the basis of qualifications rather than the basis of a fee bid.

"Time is money" has always been true in the development of projects. In the current period of rapidly inflating costs in the construction industry, capital costs are increasing by 8% to 12% per year in most areas and this truth is more insistent than ever.

The chief diffuculty with traditional design-build procedures is that they are time consuming. To overcome this, two strains have developed in major project construction. The first is an effort to compress project construction before design is complete and is commonly called "phased construction."

The second derives from the first and is an effort to add to those talents traditionally available during the design phase additional skills which will help assure that the project costs and time goals are met.

This overall management context can be implemented to reduce the problems faced on projects employing either, or both, conventional and building systems construction.

It is estimated that the utilization of professional project management on school projects can reduce construction cost by as much as 8% following present statutory procedures. A significant part of this potential saving is based upon the use of phased construction. Under a type of organization which could affect maximum efficiency in all aspects of the school development process even greater savings could be achieved through project management. These savings would approximate 10% to 12%. In either case there would be an offsetting cost for project management of approximately 3%. This cost would reduce the savings achieved to an overall net of between 5 and 9 percent.

STANDARD PLANS: AN ALTERNATIVE TO SYSTEMS?

CHAPTER IV - 6

Standard plans were first prepared for one-to-four-room schools in the late 1890's, and the idea of standard plans once had considerable appeal. Theoretically, they have two advantages over conventionally designed schools. First, standard plans could incorporate more careful design and architectural factors in each school by enlisting superior talent and other resources to produce the plans. Second, the design costs for a single school could be reduced in direct proportion to the number of schools actually built from the same standard plan.

Yet as school enrollments increased and school programs became more complex, the use of standard plans decreased. A recent United States Office of Education survey revealed that "of the 50 states, 25 had never used standard plans and 15 states, that had at one time used them, had abandoned them. Of the remaining 10 states, 9 had old plans available but did not recommend them..."*

Two examples of this disenchantment with standard plans are worth mentioning because they are supported by careful research and analysis. In 1952, the California Assembly Interim Committee on Education reported that "the idea of stock plans has been extensively explored and the preponderance of available facts and opinions has prompted us to reject stock plans proposals as neither sound nor economical."**

* Dr. Wesley Apker, "Stock Plans, Common Components--Alternatives to Rising School Costs?" mimeographed memorandum for Washington State Department of Public Instruction, Aug., 1970, p. 1

** Ibid., p. 1.

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* Ibid., p. 1.

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More recently, in 1960, the Consultant for School Facilities to the Washington State Department of Public Instruction reported that "enough evidence has been gathered over the years to warrant the general conclusion that the stock plan alternative to lowering school construction costs is not viable."* In short, the stock or standard plans approach has failed to provide a satisfactory method for constructing schools. The reasons for its failure shed light on the advantages of systems building vis-à-vis standard plans.

We selected the State of New York for analysis of the standard plans approach because New York has had the most experience with standard plans and thus provides the greatest source of data. The New York Standard Plans Program was first established in 1960. Its broad purpose was "to reduce construction costs, including design work, by providing local school boards and school officials with ready-made plans which embody sound construction principles at lowest cost, consistent with the attainment of desirable educational objectives under physically healthful conditions."**

The New York program produced nine standard plans: three for elementary schools, three for junior high schools, and three for senior high schools. Each plan was developed through collaboration among private architects, the New York State Architect's Office, and the State Department of Education's Division of Education Facilities Planning. Each plan represented an average 1971 construction cost of roughly two million dollars, exclusive of land, site work, and fees.

* Ibid., p. 1.

** Governor Nelson A. Rockefeller, July, 1963, in foreword to The Standard School Plans, State of New York brochure.

In the period during which these standard plans have been available, they have been used to construct only two schools: a senior high school and a junior high school which is now used as a middle school. Although New York's standard plans offered theoretical advantages of both careful design and lower design costs, in practice they proved expensive and unwieldy. There are five major explanations.

First, the initial cost of producing standard plans for a variety of educational programs and site conditions is high. No accurate figure on the costs of New York's set of nine standard plans is available, since their cost was "buried" in the State Architect's general appropriation. However, one million dollars was appropriated and actual expenditures to date are estimated at roughly $700,000. Since only two schools were ever built, and since each required substantial expenditures for additional architectural work, this must be considered expensive design work.

Second, New York's experiment with standard plans reveals that an architect must still be hired by the local board for all site and foundation design work, and to complete working drawings and specifications for the building itself. The New York standard plans were designed for conventional foundations and site work, but adaptation of the plan to each site had to be undertaken by the architect for the school project. Other changes in the standard plan were necessary to incorporate variations in the numbers of students and classrooms or in the proposed educational program. One of the two schools built with New York's standard plans, the high school, required forty additional drawings showing departures from the original standard plan. Moreover, so many different alternative

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* See Appendix IV - 5.

finishes were provided for each of New York's nine plans that substantial architectural services would be necessary to construct a standard plan school even without making major changes.

Third, the New York State licensing law is ambiguous about the extent of the local adapting architect's liability for errors in the standard plans. It is possible that a local architect might be held totally liable for the design of the school even if his involvement were limited to choosing from among "equal" alternatives provided by the state. This question of responsibility was impossible to circumvent. As a result, architects have tended to use New York's standard plans solely as a guide for their own designs or have ignored the standard plans altogether.

Fourth, the break-even point for a standard plan program is high. This fact is important, since laymen tend to assume that the architect's fees are automatically reduced under a standard plan program. According to a rough economic analysis of the New York program,* however, we estimate that the break-even point for a standard plan program would be between one and two dozen schools. Anything less than this number would result in a net increase in cost. This was the effect of New York's experiment. Only two schools were ever built, and the architect's fee was 6 percent of construction costs in addition to the cost of producing the standard plans. Furthermore, some architects, unsuccessfully approached to use the plans, would not reduce their fee to less than $4\frac{1}{2}$ percent even if <u>no</u> changes were to be made.

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* See Appendix IV - 5.

It is interesting to speculate about what course New York's standard plans program might have taken if using the standard plans had been made mandatory. For without mandatory participation there is no guarantee that the break-even point will be reached. From New York's experience, it is clear that the break-even point may not be reached and that the net cost of the standard plans approach might therefore be greater than the net cost of designing custom schools.

We have thus far detailed four explanations for the expense and unwieldiness of standard plans: the initial cost of producing a sufficient variety of standard plans is high, an architect is still required for adaptation and completion of the standard plan, state licensing laws may deter architects' enthusiastic participation, and the number of schools which must be built to break even on total costs is quite high. A fifth explanation reflects the rapid change in school design and building technology.

New York's standard plans represented, and still represent, acceptable but uninspired designs. However, none incorporates many features, such as instructional materials centers, found in modern school designs. And none even approaches the open-plan design which many educators now favor. This tendency toward obsolescence, probably more than any other factor, has prevented standard plans from successful or widespread use. Specifications also become obsolete very quickly, particularly for hardware, control mechanisms, lighting, heating and ventilation. Before a school could be built from a standard plan, considerable revision of the specifications would be required. Yet that revision becomes an additional cost and requires additional time. Unfortunately, standard school plans inevitably

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"freeze" educational programs and architectural specifications, while educational ideas, design ideas, and building products continue to change. Without doubt, standard plans require continuous revision and updating to keep abreast of technological developments, building products, and educational programs.

The basic problem with standard school plans, then, is that they are actually "components" whose scale is that of an entire building. They are expensive to design, require continuous revision or modernization, need a high volume of use to repay their design costs, and are not sufficiently adaptable to the varying conditions encountered in each individual school project.

Systems buildings, by contrast, incorporate standardized components which are small enough not to impede the variety with which they may be combined. A systems school is designed only once, by the architect hired to design that individual school. It can have almost any configuration, and thus can respond to the full range of conditions, standards, and educational programs encountered in Massachusetts or any other state. Its components reflect the most recent technological development, since each school is designed for whatever products are currently on the market. And because it is a systems school, it will include maximum flexibility for future rearrangement of interior spaces.

SYSTEMS EXPERIENCE IN MASSACHUSETTS

CHAPTER IV - 7

Even without the stimuli of a statewide program, more favorable laws and other incentives, an increasing number of schools are being designed and built within the Commonwealth using systems components. The material in this chapter has been drawn from the experiences of a number of architectural firms which have designed at least one such school each. Their projects include buildings for all grade levels from kindergarten through college, as well as a variety of urban and rural sites, entirely new buildings as well as major additions to existing schools, and several different approaches to the use of systems components themselves.

As might be expected of any situation where new techniques are being tried, these schools fall short of being unqualified successes. The school building delivery process is too complex to be revolutionized overnight without major outside intervention. Architects, building committees, contractors and governmental agencies are all feeling their way along an unfamiliar pathway. Despite their drawbacks, however, each project represents solid value for its price, frequently incorporating amenities not ordinarily found in otherwise comparable conventionally constructed schools.

The basic approaches to systems building taken by these architects and their clients vary from the pragmatic use of "off-the-shelf" components in an otherwise conventionally-constructed building to extensive developmental work aimed ultimately at both modifying currently available hardware and the production of new components.

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At one extreme, the architects for one multi-building project developed a hybrid building intermediate between conventional and true systems construction by incorporating systems components into the work whenever it appeared that they would offer an optimum performance-cost balance, but without necessarily pursuing the implications for integration and flexibility as far as in many other systems buildings which have been constructed. The components used include steel structure, rooftop air-handling equipment, and lighting and acoustical ceiling elements. A couple of examples can show their approach very clearly:

- The structural system was originally developed by a bidder in the California (SCSD) program and is thoroughly compatible with integrated ceiling and demountable partition systems. Most of the partitions in this project, however, were designed to be constructed of concrete block or studs and gypsum board in the conventional manner and permanently fixed into place. The ceilings were coordinated to the five-foot square structural module, but were otherwise conventional.
- Similarly, packaged rooftop air-handling equipment was specified, but the units were connected into a conventionally designed and constructed ductwork system. The need for relocatability was not seen to be sufficient to justify either flexible terminal ductwork or integrated fixtures to provide for illumination and air outlet locations over the entire ceiling area. Air diffuser grilles were attached to rigid permanent ductwork brought down through the ceiling with no special attempts made to eliminate cutting and fitting of the acoustical tiles, exactly as in a conventionally-built structure.

Other uses of systems components have been specifically directed toward achieving the cost and time advantages possible with a fully coordinated set of parts. Some projects have simply incorporated already existing components, while others have been part of programs specifically aimed at developing new solutions to design conditions. Probably the most ambitious such program to date is the so-called BOSTCO program of the City of Boston Public Facilities Department, which is unique among this study's sample. Unlike the other systems experiments, which seem to have been architect-originated, it is an owner-originated program.

Extensive research was done in this program to establish the feasibility and validity of the systems building concept for the needs of Boston schools. From the results of these studies came the decision to construct two prototype systems buildings, one a new elementary school and the other a semi-autonomous addition to an existing middle school. The Public Facilities Department intended that these schools demonstrate the following points:

- Systems construction is currently feasible in Boston.
- Systems construction is able to offer reductions in project delivery time and cost over conventional methods.
- Systems buildings are more flexible and adaptable to change than conventional structures.
- Buildings using systems components can be esthetically comparable or superior to conventionally-built schools.

In order to simplify the design, selection and approval process, it was decided to use an already existing group of systems components rather than to develop an entirely new set for the two prototype buildings. After due consideration the components which were used in the Toronto (SEF)

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program were selected. Accordingly, the two buildings incorporate the full range of SEF components, including steel structure; integrated ceilings; heating, ventilating and air-conditioning equipment; exterior walls; interior partitions; and much of the electrical work. Both schools are currently under construction. Schedules allow eleven months to complete one project and fourteen months for the other.

The City of Boston plans further work toward the development of systems components which will represent significant improvements over the existing hardware in responding to the unique conditions existing in the Boston area. The City feels that the market represented by its projected school building needs is sufficiently large to provide the incentive for manufacturers to modify existing products and develop new ones.

The approaches of other architects to components vary. One firm, which has designed schools using systems components for a number of clients, works closely with groups of components manufacturers to take full advantage of existing hardware and to develop new items, making use of their joint knowledge. Others, perhaps due to their smaller volume of school work, use only existing hardware components.

The variety of approaches taken to the use of the components themselves is reflected in the specification and bidding methods employed. In general, it is not possible to specify and bid systems buildings under the existing law without serious design, specification and legal compromises. One set of such compromises relates to the statutory categories of filed sub-bids. These categories are generally material-oriented ("acoustical tile," "painting," "electrical work," etc.), while systems components are functiororiented ("integrated ceilings," "interior space division," "exterior skin," and so on). This makes the conventional specification of systems components very cumbersome, since each component must be conceptually broken down into its constituent parts which are then apportioned among the appropriate sub-bid categories. A number of architectural firms have chosen to resolve this problem in a different manner. With the approval of the sub-contractors' association, they have specified and called for filed sub-bids in such new categories as "integrated ceilings." The legality of this procedure appears to be questionable, since it removes portions of the work required to be in specific sub-bid categories from them. Doubtless because this approach works to the advantage of all parties concerned, no one has yet challenged it.

The decision to use specific manufacturers' components in the Boston prototype schools led to another unusual bidding situation. With unique products required for many portions of the work, it was necessary to make use of a clause in the state's bidding laws which allows a public client to specify a single item in place of the usually-required three or more when such action is in the public interest.* The way in which this provision was invoked in the Boston case is illustrative of the general procedure.

The Public Facilities Commission passed a resolution stating that in its best-informed judgment, based upon the facts presented to it by its consultants, a certain group of specific components used as a system conferred unique advantages not made available by any similar group of components, and therefore had no equal. The public interest would best be served, the Commission found, by suspending the requirements for substitutability in order to obtain the benefits to be derived from the use of the system, and the Commission ordered this done.

* General Laws, Chapter 30, Section 39M

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This is basically a simple mechanism, and not difficult to employ. Its use has been comparatively rare, however, due to a combination of factors: school committees and their architects are not fully aware of its existence; mild harassment by suppliers who are likely to be excluded from consideration is difficult to avoid; the procedure drastically limits competition, which means that its use involves a substantial risk of additional costs for the items included; the procedure leaves the owner open to criticism for potential favoritism.

Although there has been some attempt to use performance-oriented specifications for systems components, they are cumbersome, not well-suited for individual schools, and of questionable legality at this time. Nevertheless, one architectural firm has apparently used performance specifications with some degree of success. This same firm has also experimented with "disappearing columns" -- structural designs which allow the spans between columns in a precast concrete building to be long or short, depending on the contractor's structural system. They report good results in allowing more qualified suppliers to bid on their projects than would have been the case with a design based exclusively on either long-span or short-span systems.

It is perhaps not surprising that in only a few of the situations discussed here was it possible to go beyond the introduction of systems components to achieve organizational or procedural innovations. Market aggregation, component prebidding and other procedures associated with large multi-building systems programs are not generally applicable to individual building projects. In one case, however, an interesting approach to design was taken. A very tight project schedule had been established which allowed the architects a bare minimum of time in which to design the school and prepare contract documents. In order to meet these demands, the project design team moved out to a school in their client's district and set up shop in the library. For two periods of a week each, they worked in close and continuous contact with the building committee, school administrators, teachers, students and interested members of the general public. This working method, occasionally referred to as a "charette" or "squatters," was able to compress greatly the amount of time required to arrive at a design which fit the client's needs. At the same time it maximized the input of data and decision-making at a time when the project was still sufficiently fluid to be able to incorporate new input and change with relative ease. Very little time was spent transmitting or waiting for information and decisions, either by the architect or by the building committee, since the work was done with all parties present and interacting.

That situation was the exception, however, rather than the rule. Far more typical was another case where the client has great difficulty making final decisions, with the result that an open-plan school was redesigned and changed to a more conventional layout viturally at the last minute. At an earlier point during the design process, the client opted to forego state construction aid rather than attempt to satisfy the School Building Assistance Bureau concerning site and building areas. When it became evident at a later date that SBAB approval was a necessary step in securing state authorization to borrow funds outside the city's statutory debt limit, further redesign,

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accompanied by further delay, was required to secure that agency's approval and to modify the drawings accordingly. These and other related factors are estimated to have almost doubled the elapsed time from the start of design to the release of the project for bids. It appears that achieving the savings in design time made possible by systems building will require some modification of the client's decision-making process in order for the savings not to be dissipated through indecision and the excessive time this wastes.

The financial success of these projects, expressed in the bid prices received from contractors, varies from excellent to disappointing. One school was bid approximately 7 percent under its budget of $3,000,000, while another, also budgeted at about $3,000,000, came in 26 percent high.* · :al conditions, the amount of other work let out to bid at the same time, whether or not the budget is realistic in the first place, and the general unfamiliarity of contractors with systems building are all partially responsible for the great variation in bid prices. Most of the schools in the study's sample are estimated to require about a year to construct, representing a significant anticipated saving over the eighteen months and more required for conventional construction. None of the buildings in the sample has been completed as of this writing.

The experiences of these architects and their clients point up a number of situations where change is needed in order to realize the benefits which are available to school districts through the use of systems building:

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* Despite this overage, the square-foot price was in the vicinity of $39, which was close to the price of another conventionally-constructed school bid a short time earlier in the same city. The systems school, in addition, was air-conditioned, while the other was not.

- Unfamiliarity with the purported time-saving potential of systems building leads contractors and their suppliers to make conservative estimates of construction times and place high prices on unfamiliar items and processes.
- The only legally acceptable means of specifying a particular set of components, so-called "flat specification," appears to restrict competition to the point where there is a serious risk of incurring additional costs.
- The client's decision-making process can seriously delay the progress of the whole job. It (and the architect's response, in many situations) must be modified to provide earlier decisions and a more rapid response to unexpected situations, and to minimize "mid-course" changes of any major aspect of the project.
- The provisions of the filed sub-bid law should be changed to make the use of categories for systems components unequivocally legal.

The picture which is emerging from the use of systems school building in Massachusetts to date is encouraging. Despite problems stemming from the newness of the method, there are strong indications that already systems construction is beginning to show savings in both time and money over conventional methods. These problems can be expected to diminish in importance as the various parties to school construction become increasingly familiar with the potential and limitations of systems building.

V

ANALYSIS: IMPLICATIONS OF SYSTEMS SCHOOL CONSTRUCTION

IMPLICATIONS OF SYSTEMS SPECIFICATION, BIDDING, CONTRACTING PROCEDURES

CHAPTER V - 1

The construction of a public school building in Massachusetts todav is governed by various General Laws intended to provide fair competition for bidders of public works. In their present form, these laws date from as early as 1939, but they have been updated by several amendments as well as a judicial and administrative gloss on their interpretation. Major statutory references, which have been cited in Section II, Chapter 1, of this report, are to Sections 44A-44L of Chapter 149 and Section 39M of Chapter 30. It is the purpose of this chapter to describe the extent to which these laws restrict the use of systems in the specifying, bidding and contracting of school building construction.

Both the evidence within the statutes themselves and the legislative history of these enactments indicate that the purpose of the laws relating to fair competition for bidders on construction of public works is as follows: It is preeminently in the public interest that the letting of contracts for large public works be undertaken on an open and competitive basis without either the appearance or actuality of favoritism. The emphasis upon protection of the public from "fraud and favoritism" was found by the Supreme Judicial Court to be of at least equal importance to other virtues of "competition" in its analysis of the bidding provisions of one municipality in Sweezey v. Mayor of Malden, 273 Mass. 536 (1931). It must be acknowledged, however, that there is an underlying assumption that the greater competition fostered by the bidding procedure mandated in the public bidding statutes

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will result in a lower price to the public. This chapter will consider the extent to which these purposes may be satisfied under a procedure which allows systems construction.

The first mandate of the public bidding laws with respect to public schools is that

> [E]very contract for the construction, reconstruction, alteration, repair or demolition...estimated to cost...more than $2,000... shall be awarded to the lowest responsible and eligible general bidder on the basis of competitive bids in accordance with a procedure prescribed by the statute....

The reference to "a general bidder" immediately demonstrates that the public bidding statutes, both explicitly and implicitly, are based on what may be called the theory of the general contract or unitary contract. Under that theory, the owner has a contract only with the general bidder to whom an award is made, or the "general contractor." The general contractor, in turn, hires subcontractors in a manner rigorously detailed by the statutes: The subcontractors do not have, in legal terms, privity of contract with the owner but only with the general contractor. The virtues of this working method are apparent: The owner is not charged with arbitrating among various trades but, in theory, need look only to his general contractor for the finished product. In practice, largely because of the detailed procedure for subcontracting set forth by the statutes, this theory has broken down. It should be pointed out, however, that the same statutes do provide a means by which, under certain circumstances, strong awarding authorities may insist that the general contractor adhere rigorously to his responsibilities.

Immediately following the mandate for award to the lowest and eligible responsible bidder (the definition of this term will be treated presently) is another mandatory requirement, one which poses the initial and basic problem for fitting systems construction into present specification, bidding and contracting procedures. The statute in G. L. c. 149 sec. 44A thus continues as follows:

> The awarding authority shall prepare for bidding purposes a sufficient number of sets of plans and specifications so that there will be available without cost or charge, except for a deposit for return of the same in good condition, two complete sets of plans and specifications for each general bidder requesting same and one complete set of plans and specifications for each sub-bidder requesting the same.

And the tandem statute in G. L. c. 30 sec. 39M(b):

> ... [S]pecifications for contracts awarded pursuant to the provisions of [G. L. c. 149 sec. 44A to 44L] shall be written to provide for full competition for each item of material to be furnished under the contract [with the exception to be considered below]... Every such contract shall provide that an item equal to that named or described in the said specifications may be furnished; and an item shall be considered equal to the item so named or described if (1) it is at least equal in quality, durability, appearance, strength and design, (2) it will perform at least equally the function imposed by the general design for the public work being contracted for or the material being purchased and (3) it conforms substantially, even with deviations, to the detailed requirements for the item in said specifications. For each item of material the specifications shall provide for either a minimum of three name brands of material or a description of material which can be met by a minimum of three manufacturers or producers, and for the equal of any one of said named or described materials.

The legal effect of these interdependent statutes is that the architect considering the design of the school must normally employ the type of specifications which have been described in this report as detailed specifications rather than performance specifications. While it is perfectly clear that there is no firm distinction between detailed and performance

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specifications and that certain grey areas may exist under which the purposes of a performance specification may be met by artful drafting of a detailed specification, it is of little doubt that the authors of the present public bidding laws in Massachusetts intended that detailed specifications be the rule and performance specifications by far the exception. If there were any doubt in this matter, it is resolved by the section of the fair competition laws which deals specifically with the sub-bidding procedure within the area of the unitary or general contract. Under G. L. c. 149 sec. 44C, the following appears, and it may be considered the third mandate of the present contracting fair competition laws:

> Every contract...shall include the specifications and, if deemed necessary or convenient by the awarding authority, plans, detailing all labor and materials to be furnished thereunder. Such specifications shall have a separate section for each of the following classes of work if in the estimate of the awarding authority such class of work will exceed $1,000. [Seventeen enumerated classes of work and an eighteenth optional class follow.]

Interestingly enough, a technical reading of this statute would make the detailed <u>specifications</u> mandatory and the <u>plans</u> optional. The practice, of course, has been to have both plans and detailed specifications with cross-references. In any event, setting forth the <u>detailed</u> as distinguished from <u>performance</u> specifications seems to be without question what was in the minds of those who drafted and frequently amended the Massachusetts fair competition laws. Indeed, the option to eliminate plans is rendered doubtful by a later provision in 44C, namely:

> Each separate section in the specifications prescribed or provided for by this paragraph...shall specify by number each sheet of plan showing work to be done by the subcontractor under that section, and shall require the subcontractor to install all materials to be furnished by him under such section...

From the three mandates quoted above, it strongly appears that the systems method is incompatible with the present Massachusetts law to the extent that performance rather than detailed specifications are preferred in systems bidding. It should be noted, however, that some systems are compatible with detailed specifications. As the technology advances, more systems may well develop in this direction. But the fact remains that the greater flexibility and innovation generally associated with systems construction would probably be encouraged more by performance than by detailed specifications.

There are other mandates in the present law which reinforce the legal incompatibility of systems with existing procedures. The seventeen enumerated specific trades include several which, in most systems building, should not be separated into specific sub-trades but combined into a systems or subsystems bid. Thus the filed sub-bid for "acoustical tile" cannot be separated from "electrical work" if an integrated ceiling system or subsystem is to be designed. Similarly, "roofing and flashing," "metal windows," "waterproofing, dampproofing and calking," "lathing and plastering" and possibly other filed sub-bids would have to be partially merged in a wall system. The author of a systems specification must be equally concerned, for example, with the "heating, ventilating and air conditioning" filed sub-bid and its relationship to the systems building which he is designing.

Some of the mandates with respect to specific filed sub-bids may be partially softened by a practice which has emerged (not as a result of systems building but of unrelated pressures upon owners to commence construction before plans and specifications are completed) in which a series of general filed sub-bids have been invited for the same project. The series of bid invitations

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has commonly begun with a foundations bid which may include work for a general contractor and certain common subcontractors, notably waterproofing, and possibly plumbing, electrical and masonry. This development, referred to as fast tracking, is justified more by practice than a specific authorization in the statutes and has suggested to some commentators that systems bidding can be harmonized with Chapter 149 procedures simply by establishing a procedure for a series of systems contractors, each of whom is, in Massachusetts parlance, a "general contractor" with one or more subcontractors bound to him.

The practice of serial bidding of a project, however, has not been entirely encouraging. It is obvious that one of the crucial advantages of the unitary contract, namely, the avoidance by the owner of a diffusion of responsibility, is lost. For example, the general contractor following the foundation general contractor (if he is not the same person) may well wonder whether the work already completed is indeed in conformance with the original specifications and the specifications upon which the second contractor bid. At the same time, the foundation contractor does his work and leaves the site before possible inadequacies in his work may become apparent. Also, if there is to be overlapping in time in systems bidding, it is likely that there will be different firms of the same sub-trade on the building site at the same time. This may not be an always manageable situation with respect to responsibility, efficiency and possibly union relationships.

Even with the limitations described above, certain types of systems or subsystems may be incorporated into what would otherwise be a traditional Massachusetts public bid for a school building. The most successful efforts at combining a systems method with the traditional filed sub-bid method have been made using systems fabricated off the construction site. Such items may be deemed "materials" within the definition found in G. L. c. 30 sec. 39M which includes, more accidentally than with particular intent, "any article, assembly, system or any component part thereof." The limited number of systems to which this exclusively off-site attribute applies is such that the resulting bidding procedure is still essentially that of a traditional Massachusetts filed sub-bid project with the owner simply owning more of the equipment than he normally does. It is not a complete systems procedure.

Still further problems exist for a systems project under Massachusetts law. It is clear from the analysis in this report that systems design, or a procedure approximating a systems project, requires a high degree of pre-qualification of the systems and subsystems components to be considered in any competitive project. Yet pre-qualification is neither specifically nor inferentially authorized by the present Massachusetts bidding statutes as they relate to school buildings. Indeed, the mandate that all sub-bidders and bidders requesting plans must be furnished them provides a clear implication against pre-qualification. Moreover, G. L. c. 149 sec. 44E requires that any person be furnished a bid form upon request. Other statutes allowing pre-qualification in public work other than schools (essentially on a financial basis) apply only to projects of the Department of Public Works and the Metropolitan District Commission (G. L. c. 29 sec. 8B) and raise an additional implication that the General Court did not intend to authorize pre-qualification with respect to any other public bidding work.

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Without pre-qualification, it seems impossible to predict at all accurately which of the mathematically large number of possible interfaces between and among systems and subsystems can be the basis of a meaningful bid and therefore an enforceable contract. The descriptions of the various systems projects contained in this report show that pre-qualification in one form or another was a feature of each project. This is not possible under present Massachusetts law. To the extent that occasionally the matter may be resolved by holding open crucial interfaces as allowances, the amount of competitive bidding becomes less. In any case, the result is not a true systems project.

The only manner in which the present Massachusetts bidding procedures can be harmonized with true systems bidding is the employment of the exception to full competition contained in the present statutes. Such was the procedure followed by the Public Facilities Commission of the City of Boston in a recent project described in Chapter IV-7, and these exceptions may be followed by any owner willing to make the required documentation and to meet the inevitable objections of those who feel the limitation of competition may either result from a motive of favoritism or cause a financially higher bid or both. The exception is set forth in G. L. c. 30 sec. 39M as follows:

> (b) ... [S]pecifications may be otherwise written for sound reasons in the public interest stated in writing in the public records of the awarding authority or promptly given in writing by the awarding authority to anyone making a written request therefor, in either instance such writing to be prepared after reasonable investigation.

In effect, this exception eliminates the restrictive features described above (although even it does not allow pre-qualification as such). Proceeding under the exception is, truly, an acknowledgment that systems bidding cannot be undertaken with the provisions of the fair competition law in full effect.

Because of the incompatibility of the present Massachusetts statute and the requirements of systems bidding, this study has concluded that bidding on systems projects must be allowed to proceed under a new fair competition law while Chapter 149 section 44A-44L and G. L. c. 30 sec. 39M remain in effect for essentially non-systems projects. The opportunity will still exist for those projects which partake of some systems attributes but which are still essentially traditional Massachusetts school building projects to integrate an occasional system through pre-purchase of it as a material.

Any new fair competition law with respect to systems bidding must preserve, however, the two purposes of the present fair competition law: the avoidance of the appearance or the actuality of favoritism and the protection of public finances through competitive bidding.

The avoidance of favoritism can be achieved through a rigorous pre-qualification procedure open to all persons. Wide dissemination of systems and subsystems information, a full research and development program, a series of prebid conferences, a flexible definition of systems and subsystems, and a prebid appeals procedure are all essential to an effective competitive systems bidding procedure. The key to avoidance of the actuality or

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appearance of favoritism is openness and the opportunity to appeal, and both are essential to protect the public interest and instill public confidence.

With respect to the objection that the economies of full competition might be lessened through a competitive systems bidding procedure which includes pre-qualification, consideration should first be given to what economies are actually obtained by competition. Even under the present statute, it is notable that awards to both general contractors and subcontractors must be made only to the lowest "eligible and responsible" bidder. Eligibility and responsibility, as well as the related notion of competence, are defined as follows:

> ...[T]he words 'lowest responsible and eligible bidder' shall mean the bidder whose bid is the lowest of those bidders possessing the skill, ability and integrity necessary to the faithful performance of the work and it shall certify that he is able to furnish the labor that can work in harmony with all the elements of labor to be employed on the work. Essential information with regard to such qualification shall be submitted in such form as the awarding authority may require.

With respect to sub-bids, the awarding authority is authorized to reserve

> the right to reject any sub-bid on any sub-trade, if it determines that such sub-bid does not represent the sub-bid of a person competent to perform the work as specified...

Hence, under the present statute, the awarding authorities have great power, if they have the time, interest and technical and governmental support to invoke such power, to determine whether a monetarily low bidder is truly the lowest eligible and responsible bidder.

The problem has been that the exigencies of completing the work within a time schedule--and uncertainties that documented evidence of lack of skill, ability, integrity, and competence can survive what may be a protracted administrative or judicial review--often force owners not to invoke their powers of disqualification after bid. In addition, disqualifying a low bidder may give rise to an accusation of favoritism with respect to the next bidder. The importance of the present statute, however rarely invoked, is that the drafters recognized that the lowest monetary bidder may not be the most economical with respect to the protection of public finances.

Hence, the matter of pre-qualification is related to the financial effects of competition. If pre-qualification for systems bidding is as rigorous, fair and open as is suggested in this report, the protection of the financial interests of the owner will result from the award to the lowest pre-qualified and hence eligible bidder. While there will always be contractors available who may demonstrate their desire to work for a lower price, an effective pre-qualification system will allow an owner with ability and integrity to insist that the final bid or series of bids awarded to the lowest eligible bidder whose eligibility has been established through fair and open pre-qualification.

To the extent that a systems bidding procedure moves away from the large number of filed sub-bids presently required under Massachusetts bidding law, cost savings may reasonably be anticipated. The authors of this report estimate that the savings may amount to as much as five percent of the bid price.

This estimate of cost savings is based on an analysis of several bids under the present bidding procedure for Massachusetts schools and on discussions

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with contractors and professional estimators. There can be no mathematically certain proof of a bid saving because under present Massachusetts law bidding may not be done except through the filed sub-bid procedure, yet there is considerable independent evidence that savings can be realized. First, the general contractor includes in the percentage which he adds to his bid for overhead a considerable factor, often as much as ten percent, for his responsibilities in dealing with a multiplicity of subcontractors. Since under the filed ~~sub-bid~~ law he must deal with subcontractors without pre-qualification, the general contractor necessarily will not wish to err on the side of carrying an inadequate amount for contract administration.

Costs are also increased when the contractor feels that, because of potential competition, he must carry the sub-bid of a firm in which he does not have total confidence. In such cases, he has the option of requiring that the sub-contractor be bonded to him, and the cost of these bonds (normally one percent of the sub-bid) is ultimately borne by the awarding authority.

Under a system of open pre-qualification, there will be fewer uncertainties about sub-contractors and suppliers and consequently less justification for the loading of contingencies into a general contractor's bid. Interviews with contractors indicate that, to the extent that specification is "tight," contingency elements may be reduced; but to the extent that there is uncertainty as to what procedures will satisfy the designer, the owner ultimately pays an inflated contingency item. Prebid conferences and the pre-qualification procedure itself should lessen the uncertainties and consequently the amount of a contingency factor.

On balance, therefore, it seems to the authors of this report that approximately a five percent saving can be achieved by reducing the overhead for multiple sub-contract administration, sub-bid bond costs and contingency costs for construction uncertainties.

With the introduction of rigorous and open pre-qualification, the revision of present sub-bid categories is a comparatively minor though vital matter. Thus the various technologically feasible systems can be defined and, as technology progresses, redefined, so that the general contractor or the series of general systems contractors will be dealing with fewer subsystem contractors than with subcontractors under the present filed sub-bid law. The general contractor may become a manager of systems contracts, the details of which, in the design and pre-qualification phase of the project, have been worked out more in advance of the actual bidding than can presently be the case. Only in this way can the fast tracking and sure economies of systems bidding be achieved while maintaining, in the public interest, fair dealing and competition.

SYSTEMS METHODS AND PRESENT BUILDING CODES

CHAPTER V - 2

The successful introduction of large-scale systems school construction into Massachusetts will require a careful study of the existing framework of codes, agencies and approvals to determine the areas where changes would return smoother, more economical design and construction of school buildings. In general, the Massachusetts codes affecting school construction appear to be reasonable, although in many instances modifications would benefit not only a systems building program but the entire school design, construction and renovation process. Two general areas in which improvements could be made are organization and specific code provisions.

Procedural and Organizational Changes

One of the important requirements for any successful large-scale systems building program is sufficient uniformity of building codes to avoid the necessity for modifying components from one job to another and to avoid the extra costs incurred by designing components to the most stringent code provisions, which may exist in only a few scattered places within the market area. Since 1968, when the Board of Schoolhouse Structural Standards code (Building Regulations for Schoolhouses) was extended to become the primary code for all school construction within the Commonwealth, Massachusetts has had such a uniform code for school buildings. With the exception of local zoning boards, the various regulatory bodies affecting school construction are statewide in scope.

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There are, however, different secondary codes and regulatory agencies (about a half dozen of the latter are involved in the design and construction of a typical school) than is desirable for smooth and rapid processing of approvals. At the present time, it is the responsibility of the local district, usually acting through its architect, to determine which agencies and codes have jurisdiction over its project and to take the necessary steps to secure approval. In addition to the time and cost required for all this processing, the existence of so many secondary codes, covering heating boilers, gas appliances, swimming pools, sewage facilities, access for the physically handicapped, and so on, makes it inevitable that jurisdictions will overlap and that other inefficiencies will occur. Consolidation of the various agencies' code and approval functions into a single, unified procedure would appear to be a desirable step, with the primary benefit being a smoother, better coordinated and probably more rapid approval process.

Uniform interpretation and a speedy appeal procedure, discussed as desirable reforms in general in Section III, Chapter 7, are at least equally necessary when applied to systems building programs. It should be noted that the costs and risks involved in challenging the Field Inspector's rulings are sufficiently serious that his interpretations are rarely questioned, even when they contradict those of the Supervisor of Plans or incur additional costs. The policy of the Department of Public Safety should require that Field Inspectors abide by the interpretations of the Supervisor of Plans in enforcing school building codes at the construction site.

A systems program involving the development of new components requires performance-oriented codes in order to allow manufacturers the necessary design latitude. With performance codes, new products can be tested for compliance within the normal administrative framework; with specification codes, new products or materials must be approved by means of a variance. This procedure involves inferring, accurately and completely, the performance intent of the specification code, after which the new product is tested against these derived criteria. This is an unwieldy process, and may involve an unacceptable amount of guesswork in order to determine the code's performance "meaning."

Systems components are readily adaptable to a performance-code-plus-catalog approach such as is discussed in Section III, Chapter 7. Components are basically few in number, standardized and have relatively simple joinery. Under a performance-oriented approval system, many of the design conditions which conventionally must be explained in detail by means of drawings and specifications could be indicated by reference to standard approved details, with resultant savings both in design and review time.

A major redrafting of the codes such as would be necessary to convert from a specification code to one based on performance, however, would be accompanied by disadvantages as well as benefits, the most significant one being the amount of time and money required for such a project.

The influence of building codes on systems schools extends beyond the end of the construction period. An important characteristic of systems buildings is their extreme flexibility and adaptability to change. It is possible for a small work crew to make a major rearrangement of the interior space of a school in a very short time, even over a weekend. Less extensive changes can be made at almost any time. This issue is potentially somewhat complex, since the installation of demountable partitions, the relocation of plug-in

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electrical fixtures, the changing of air outlet locations and other work associated with modifying the configuration of systems buildings is less a matter of demolition and construction as traditionally described and more a matter of rearranging some movable equipment within the building envelope.

The terms of the final approval by the Department of Public Safety state explicitly that approval and the license to operate a schoolhouse are conditional upon the interior of the building not being "materially altered" and none of the exits or means of escape from fire being "rendered unavailable" or "materially changed." This clearly means that for many, if not most, interior rearrangements of systems buildings, the approval of the Department of Public Safety will be necessary for the building's operating license to remain in force. In order to establish the point at which re-inspection and approval become necessary and to handle informal rearrangements of the interiors of systems schools in a swift and orderly manner, it will be necessary to develop simplified procedures which fulfill the letter and spirit of the law with a minimum of red tape.

Building permits are issued locally and are required in many jurisdictions for any work which would alter the configuration of a building. Because localities vary in their requirements, it is not possible to describe all the circumstances under which a permit would be required for interior rearrangements of a systems school. In order to provide for the uniform handling of this matter in all parts of the Commonwealth, it appears desirable to specify on a statewide basis the types of interior rearrangements which need only Department of Public Safety approval and those for which both state approval and a local building permit will be necessary.

Specific Changes

There are a number of provisions of the Building Regulations for Schoolhouses which could be changed to good advantage. Some of these changes would simply update provisions which have become obsolete and others would remove considerations which are more properly the concern of other agencies. For example, the Department of Education would be more qualified to set environmental standards such as the window area required for classrooms. In some cases, cost savings are likely to result from such changes. In the examples below, likely ranges of possible savings are indicated to give an idea of the dollar value of these modifications.

The code states that classrooms for grades K through 7 must receive daylight through glass areas equivalent to 6 percent of the floor area of the classrooms. For grades 8 through 12, however, the code allows half of the classrooms to be developed as interior rooms with no exterior light requirements.

Contemporary educational philosophy has increasingly emphasized independent study, which, in turn, has greatly enlarged the role of the instructional materials center or library as a central element in student activities. This concept is reflected physically in wider school buildings which allow the library to occupy a central position surrounded by clusters of classrooms.

Many years ago schoolhouse design relied on large window exposures for natural ventilation and illumination. In recent years, with codes requiring much higher levels of illumination, heating and ventilation, and with the development of a technology capable of satisfying these requirements, windows and glass have become a liability. It is impossible to protect inexpensively

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1. Minimum case

Assume: Total cost

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children sitting near large glass areas from glare and thermal transmission. Most architects, therefore, have begun to limit glass areas, allowing an occasional view to the exterior for psychological reasons only.

The effect of the code on high school design appears to have resulted in a reasonable amount of glass although many architects question even this minimum. In the case of elementary and middle schools, however, the required glass areas are considered by most architects to be excessive. The requirements necessitate extra thermal and glare control as well as expensive light wells, clear stories and unneeded exterior glass.

Because the health and well-being of students is adequately protected by the illumination and ventilation levels stated in the code, it would seem reasonable to suggest that the subject of window area comes under educational environmental standards, which are more properly the province of the Department of Education than of the building code.

The following cases illustrate possible cost savings:

Assuming the removal of references to window area from the code, the effects on the cost of a $2.8 million elementary or middle school might reasonably result in a reduction of 50% in the glass area now required by law. Two cases bracket the range:

1. Minimum case

   Assume: Total cost $2,800,000.

   Wall area 24,000 sq. ft.; Cost of brick-and-block wall $10/sq. ft.

   Window area 2,500 sq. ft.; Cost of window $15/sq. ft.

Saving resulting from replacing window with wall =
$15 - $10 = $5.

Window area is reduced 50% or 1,250 sq. ft.

Saving = 4,250 sq. ft. x $5/sq. ft. = $6,250

Percent saving = $6,250/$2,800,000 = 0.22%

Heating loads might be reduced thus:

Assuming "U" factor for entire envelope to be .30 BTU/hour/sq. ft./degree

Assuming envelope to be 132,000 sq. ft.

Heat transfer = 132,000 x .30 = 39,750 BTU/hr./degree

U factor for glass = 1.13, for wall = .3, difference = .83

Reduce window area as above: 1.250 x .83 = 1,038 BTU/hr./degree

Percent improvement 1,038/39,750 = 2.6%

II. Maximum case

The code presently specifies glass "in outside walls." In order to provide outside walls for interior spaces in an otherwise loft-planned school, one architect introduced four small courtyards, or lightwells, into his building. Assuming these wells to be 15 ft. square, 25% glass, 75% brick-and-block wall, and 19 feet high, the following figures apply:

Courtyards:

Walls:	4 x 15' long x 10' high = 600 sq. ft. x 4 courts = 2,400 sq. ft.	
Solid:	2,400 sq. ft. x .75 x $10 =	$18,000
Glass:	2,400 sq. ft. x .25 x $15 =	$ 9,000
Total:		$27,000

Note that this figure is exclusive of wall footings, extra heating, etc.

Effect on cost

Without courts: assumed $
Courts $

Total $

Percent saving from eliminating court

RANGE: $\frac{1}{4}$ of 1 percent to 1 percent c

Engineers generally agree that the recent code ventilation requirements in classrooms to a rea neers consider, however, that the reduction in extended to places of public assembly such as a cafeterias. This would entail reducing the pre per square foot to the same per pupil CFM requi which would result in an approximate reduction foot. The anticipated savings are illustrated

Assume a one-story building containin area.

Further assume a reduction of $\frac{1}{2}$ CFM p

25,000 sq. ft. = public assembly are

.08/sq. ft. per year = average fuel

40% = percentage of fuel bill attri air required for ventilation

$5,700 = total yearly fuel bill (#5

40% x .08 = .032

.032 x $\frac{1}{2}$ = .01

25,000 x .01 = $250 fuel

4.4% fuel

* Cubic feet per minute.

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ed 50% or 1,250 sq. ft.

t. x \$5/sq. ft. = \$6,250

250/\$2,800,000 = 0.22%

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000 x .30 = 39,750 BTU/hr./degree

1.13, for wall = .3, difference = .83

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1,038/39,750 = 2.6%

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Effect on cost

Without courts:	assumed	\$2,800,000
Courts		\$ 27,000
Total		\$2,827,000

Percent saving from eliminating courts: 27/2,827 = 0.95%

RANGE: $\frac{1}{4}$ of 1 percent to 1 percent of cost of building.

Engineers generally agree that the recent code changes have reduced the ventilation requirements in classrooms to a reasonable level. Many engineers consider, however, that the reduction in ventilation should be extended to places of public assembly such as auditoriums, gymnasiums and cafeterias. This would entail reducing the present requirement of $1\frac{1}{2}$ CFM* per square foot to the same per pupil CFM requirements as for classrooms, which would result in an approximate reduction of about $\frac{1}{2}$ CFM per square foot. The anticipated savings are illustrated in the example below:

> Assume a one-story building containing 100,000 sq. ft. of floor area.
>
> Further assume a reduction of $\frac{1}{2}$ CFM per square foot of floor area.
>
> 25,000 sq. ft. = public assembly area
>
> .08/sq. ft. per year = average fuel costs/sq. ft. per year
>
> 40% = percentage of fuel bill attributed to heating outside air required for ventilation
>
> \$5,700 = total yearly fuel bill (#5 oil)
>
> 40% x .08 = .032
>
> .032 x $\frac{1}{2}$ = .01
>
> 25,000 x .01 = \$250 fuel bill saving per year or
>
> 4.4% fuel bill saving per year

* Cubic feet per minute.

The implementation of open planning, which is a new concept associated with team teaching and systems building, has been handicapped by the fact that the codes were written for conventional building types. No new codes or research have been directed to open planning, with the result that the 100'-egress-distance rule, which means a 200' width restriction, applies to all school buildings in Massachusetts including those employing open planning.

Centrally planned instructional media centers usually require a building wider than 200', which has forced architects to resort to expensive inner courts and other devices in an attempt to circumvent the 200' rule. Specific research into code changes responding to the need for open planning would no doubt relieve these design restrictions.

Another example of the arbitrariness of code restrictions as they pertain to open planning concepts is the rule that no walls or dividers can exceed 5'0" in height. This height restriction is imposed for the purpose of allowing teachers visual access to all parts of the building for the detection of smoke. This is a severe design handicap because many walls and dividers containing lockers, storage space or blackboards have to exceed 5'0" in height. Some research directed toward the use of smoke detectors would relieve this problem.

Although systems building can generally be accommodated within the framework of existing codes, certain technological developments will require changes in the codes. The most obvious of these innovations is the adoption of flexible cord, plug-in connections and remote-control switching for lighting power and controls in ceiling systems. The resulting elimination

of conduit reduces erection time, increa

This innovation was employed successfull systems projects with substantial saving savings of up to $ .50 per square foot o of the electrical portion of building co this technique on systems projects in th this magnitude would require, however, a of approximately 1,000,000 square feet, feel is necessary to cover research and tion costs. A change of this magnitude the National Board of Fire Underwriters Electrical Code. Because of the many ve anticipated that these changes will be m resistance and expense.

Regardless of the difficulty anticipated it is especially interesting to proponen is an example of the technological chang ment. It is anticipated that future sav tion will accelerate as the building ind and development in response to a continu systems movement throughout the United S

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This innovation was employed successfully in the Montreal and Toronto systems projects with substantial savings. Manufacturers estimate that savings of up to $ .50 per square foot of building area, or 15% to 20% of the electrical portion of building costs, could be realized by using this technique on systems projects in the United States. An innovation of this magnitude would require, however, an accumulated project square footage of approximately 1,000,000 square feet, which is the size manufacturers feel is necessary to cover research and development and change-over production costs. A change of this magnitude would also require the sanction of the National Board of Fire Underwriters and incorporation into the National Electrical Code. Because of the many vested interests involved, it is not anticipated that these changes will be made without encountering considerable resistance and expense.

Regardless of the difficulty anticipated in a change of these proportions, it is especially interesting to proponents of systems building because it is an example of the technological changes fostered by the systems movement. It is anticipated that future savings in school building construction will accelerate as the building industry embarks on large-scale research and development in response to a continuing performance-oriented building systems movement throughout the United States.

IMPLICATIONS OF SYSTEMS SCHOOLS CONSTRUCTION TRADE UNIONS

CHAPTER V - 3

Introduction

This chapter will review the factors involved in the introduction of industrialized methods into school construction in Massachusetts and attempt to assess the impact on current trade union practices.

Traditionally in the construction industry, as any technological change in construction methods has emerged, it has been met with apprehension and occasionally hostility by the trade unions. Invariably some accommodation is worked out and eventually the benefits of technology are realized. Because of such accommodation the construction industry cannot be honestly accused of widespread suppression of technological advancements. If the industry is not a model of efficiency, the fault lies in the area of organization and administration rather than in the area of technology.

The Battelle Report

The most ambitious and authoritative study of the industrialization of construction carried out to date has been the 1967 study by the Battelle Memorial Institute under the sponsorship of the Building and Construction Trades Department, AFL-CIO. The report is entitled "The State of the Art of Prefabrication in the Construction Industry." Among its many conclusions the Battelle Report projected the following "Effects on the Affiliates" (trade unions) in terms of all types of construction on a national basis:

1. The anticipated advance
   the next decade appear
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2. The Operating Engineers
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3. The Operating Engineers
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on on a national basis:

1. The anticipated advances in prefabrication and technology during the next decade appear to offer "opportunities" to half of the affiliates and "threats" to the other half.

2. The Operating Engineers and the Electrical Workers will have the greatest opportunities for growth while the Painters, Decorators, and Paper Hangers will have the least.

3. The Operating Engineers will encounter the greatest need for increased skills by 1975 due to prefabrication and other advances in technology.

4. The majority of the affiliates will experience movement in their work locations but none will move from factory to job site because of prefabrication.

5. The United Association (Plumbers and Pipefitters), Carpenters, and Electrical Workers will be the affiliates affected the most by relocation of work from job site to factory due to prefabrication.

The Effect of Systems Methods Relative to School Construction in Massachusetts

In Massachusetts the potential effects of industrialization of construction will be far more pronounced in other sectors of construction (such as housing) than on school construction. One reason is that school construction normally represents only 5% to 10% of the building construction in this state.* Also, industrialization will have less than sweeping impact because the scope of its implementation will comprise only a part of the "elements" of school buildings. Building "elements" are defined as the various subsystems such as foundation, structure, and exterior walls which, when integrated, comprise an entire building. There are approximately sixteen generally recognized elements in school buildings. The conversion from conventional construction techniques to industrialized methods is contemplated for only five of these sixteen elements in any school construction program visualized for the foreseeable future; however, these five elements may represent over 40% of the construction cost. Conventional construction

* U.S. Department of Commerce and Massachusetts Department of Labor and Industries figures project total Massachusetts building construction for 1971 at approximately $2 billion. SCHOOL MANAGEMENT Magazine projects Massachusetts new completions for 1971 at $175.9 million or 8.8% of the total.

methods requiring traditional numbers of on-site construction workers will continue to be used for the remaining building elements.

The Impact on Specific Trades

In attempting to identify the specific unions affected it has been assumed that any initial program of systems construction contemplated would limit systems applications to the following elements of school buildings:

STRUCTURAL
HEATING - VENTILATING - AIR CONDITIONING (HVAC)
CEILING
INTERIOR PARTITIONS
ELECTRIC - ELECTRONIC

In the systems approach, the Lighting portion of the conventional Electrical Element is grouped with Ceiling Element to create a distinct new element known as Lighting-Ceiling. This reflects the process in which lighting fixtures and acoustic ceiling sections are installed simultaneously in an integrated manner.

The trade unions which could be involved in the construction, erection, and placement of these building elements under present day conventional construction methods are:

United Brotherhood of Carpenters and Joiners of America (Carpenters)

Bricklayers, Masons, and Plasterers International Union (Brick Masons)

International Union of Operating Engineers (Operating Engineers)

International Brotherhood of Electrical Workers (Electrical Workers)

International Association of Bridges, Structural, and Ornamental Ironworkers (Ironworkers)

International Hod Carriers, Building and Common Laborers Union (Laborers)

International Association of Marble, Stone, and Slate Polishers, Rubbers and Sawyers, Tile and Marble Setters Helpers, and Terrazzo Helpers (Tile Setters)

Wood, Wire, and Metal Lathers

Brotherhood of Painters, Deco
(Painters and Glaziers)

International Association of
Workers (Asbestos Workers)

Operative Plasterers and Ceme
(Plasterers)

United Association of Journey
Pipe Fitting Industry of th

Sheet Metal Workers Internati

The trade unions normally involved
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STRUCTURAL ELEMENT

Reinforced Concrete or Masonr

Ironworkers (Reinforcing stee
Operating Engineers (Lifting,
Carpenters (Forming, concrete
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Brick Masons (Masonry)
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Ironworkers (Placement of str
Operating Engineers (Lifting,
Carpenters (Forming, concrete
Hod Carriers and Laborers (Ca

HVAC ELEMENT

Plumbers (Low pressure piping
Pipefitters (High pressure pi
Sheet Metal Workers (Ductwork
Electrical Workers (Electrica
Operating Engineers (Lifting,

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Electrical Workers (Electrical Workers)

Bridges, Structural, and Ornamental

3uilding and Common Laborers Union (Laborers)

Marble, Stone, and Slate Polishers, Rubbers
le Setters Helpers, and Terrazzo Helpers

Wood, Wire, and Metal Lathers International Union (Lathers)

Brotherhood of Painters, Decorators and Paper Hangers of America (Painters and Glaziers)

International Association of Heat and Frost Insulators and Asbestos Workers (Asbestos Workers)

Operative Plasterers and Cement Mason's International Association (Plasterers)

United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada (Plumbers)

Sheet Metal Workers International Association (Sheet Metal Workers)

The trade unions normally involved in the construction, erection, and installation of the various building elements are generally as follows:*

STRUCTURAL ELEMENT

Reinforced Concrete or Masonry

Ironworkers (Reinforcing steel)
Operating Engineers (Lifting, hauling)
Carpenters (Forming, concrete pouring)
Cement Masons (Concrete finishing)
Brick Masons (Masonry)
Hod Carriers and Laborers (Carrying and General Labor)

Steel

Ironworkers (Placement of structural members and reinforcing steel)
Operating Engineers (Lifting, hauling)
Carpenters (Forming, concrete pouring)
Hod Carriers and Laborers (Carrying and general labor)

HVAC ELEMENT

Plumbers (Low pressure piping)
Pipefitters (High pressure piping)
Sheet Metal Workers (Ductwork)
Electrical Workers (Electrical hookup and controls)
Operating Engineers (Lifting, hauling)

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* Subject to certain regional variations based upon jurisdictions and excluding the International Brotherhood of Teamsters, Chauffeurs, Warehousemen and Helpers of America who are active in the construction process but not considered one of the building trade unions.

LIGHTING ELEMENT - (Normally a portion of the Electrical Element)

Electrical Workers (Installation and hookup)
Carpenters (May install hangers for mounting fixtures)

CEILING ELEMENT

Carpenters (Suspension system, acoustic tile)
Lathers (Lathing)
Asbestos Workers (Installation)
Plasterers (Plastering)

INTERIOR PARTITION ELEMENT

Brick Masons (Masonry Partitions)
Carpenters (Wood framing, drywall)
Lathers (Lathing)
Plasterers (Plastering)
Painters (Painting, decorating, paper hanging)
Glaziers (Glazing)
Ironworkers (Metal work)
Plumbers (Piping)

ELECTRICAL - ELECTRONIC ELEMENT

Electrical Workers (All work of an electric-electronic nature)

Just how the transition from conventional construction methods to industrialized methods in school construction will affect these elements is a matter of conjecture. If one considers only the current state of the art, some conclusions can be drawn. However, it can be expected that the "open" systems approach will be followed creating countless technological innovations and new solutions. The results of such innovations are very difficult to predict. The following broad generalizations concerning the effect of industrialized construction methods might be made:

1. In the case of steel structural systems a great deal of the material is currently prefabricated in the shop and merely erected on site. There should be very little change in this process except that larger components will be assembled off-site. Many concrete structural systems are currently precast off-site and delivered to the

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site for erection. This trend will continue, eliminating much of the masonry, forming, reinforcing, pouring and finishing on site.

2. Some HVAC systems will be roof-mounted package units eliminating equipment rooms and some of the ductwork. However, ductwork will still have to be installed on site as will high and low pressure piping systems and electrical hookup. Much of the insulation may be factory applied.
3. As stated above, the installation of the lighting will tend to be done in conjunction with the ceiling element. Much of fixture mounting will be the same but the hand-wiring of junction box connections may give way to plug-in connections. Ceiling systems will be much the same as at present with acoustic ceilings replacing plaster ceilings almost entirely.
4. Except for wet walls, interior partitions will tend to be prefabricated and to a great extent pre-glazed and pre-finished off-site. The trades involved in installation of interior partitions will be the most seriously affected by industrialized methods in school construction. However, this is very much the pattern that has been established in high-rise office buildings, and no particular difficulties have occured with the affected trades.
5. The overall effect on the electric-electronic element will be slight. Prefabricated distribution systems may eventually replace conventional distribution but that is still over the horizon. Pre-wired electrical "columnettes" and wall panels could replace much conventional interior wiring but this should be offset by the increasing demand for more electric communication and control systems.

Potential Relocation from Construction Site to Factory

Because the construction of schools in Massachusetts represents only 5% to 10% of total construction systems, school buildings will create very little job relocation in the Commonwealth. Although this relocation will be insignificant, some consideration should be given to the subject.

The traditional fear of labor has been, of course, that the function of craft labor will be eliminated by automated factory production. However, as indicated in this chapter, the Battelle Report suggests that most craft union functions, rather than being eliminated, will merely be relocated to a manufacturing plant and be automated to some extent to maximize the output of skilled labor. This implies a relocation rather than elimination of work.

Is such relocation really a threat to labor or is it perhaps an opportunity? Such redistribution of work could, of course, require a relocation of a worker and his family from one geographical area to another, but such physical relocation is not normally onerous to the construction worker who generally professes a preference for mobility. An interesting sidelight to this issue is the strong probability that Massachusetts, because of its traditional manufacturing capabilities, highly skilled labor force, and current overcapacity of manufacturing facilities, could become a major center for production of industrialized building components. Consequently, many job opportunities in the field could develop in this state.

Conversion to factory work could necessitate retraining. Certainly this is not a radical demand in modern industry which recognizes the need for almost constant retraining in nearly every field due to rapid technological

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change. The relocation of functions from job site to factory does offer the following tangible and recognizable benefits to labor:

1. Generally improved working conditions in a sheltered environment not subject to the elements;
2. A stabilization of employment due to the mitigation of climatic influences and through production planning inherent in factory processing;
3. The advantages of a long-term, single-employer relationship over the more casual nature of the multi-employer relationships operational in the industry at present;
4. The greater probability of gains in productivity in a factory environment due to refinement of repetitive processes and sophisticated production control methods. This increase in productivity may not offer an immediate increase in earnings to the worker but would provide a sound economic basis for longer-term wage increases and continuity of employment.

If these longer-term advantages do not capture the imagination of the typical construction worker, it is because his psychological motivation tends to differ from the motivation of workers in other industries. The construction worker enjoys moving from one job site to another rather than working permanently in one location. Evidence indicates that when the construction worker tires of such mobility, he leaves the industry and moves into maintenance work related to his trade, or perhaps he abandons the trade entirely.

In addition to appreciating the mobility of the industry, the construction worker appears to appreciate the time off "between jobs" or in the "off season." This degree of unemployment is an integral part of the industry and accepted by both the worker's family and society. As the BLS Bulletin "Compensation in the Construction Industry" states: "Less than a full year of work is prevalent even among the industry's major earners. In 1964, for example, fewer than one-third of all workers and only about one-half of the major earners worked in contract construction during all four quarters of the year."*

What has reinforced the appreciation and expectations of free time by the worker has been the traditional ability of the construction trade unions continually to secure average hourly earnings for its members far in excess of labor in general. The higher hourly earnings are not only a result of less than full employment, but also a cause of it. Much evidence indicates that the prevalence of high hourly earnings encourages the worker to stay in an industry that does not provide full employment but does provide annual earnings comparable to industry in general.

In his belief that wages are much less in factory labor, the construction worker has resisted the concept of removal of his work from the job site to the factory. As Table 1 below points out, this is true in the case of the hourly wage rates where there is a 32% differential. But Table 1 goes on to show that in the more important area of annual earnings there is a much smaller (8%) differential between the average annual earnings of construction workers and workers in durable goods manufacturing. As indicated, however, the durable goods worker works an average of 643 more hours per year than does the construction worker.

* Page 19, Extent of Annual Employment

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Tabulation of Comparat
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Classification of Employment	Average Hourly Wage Rate	Wage Rate Differential
Durable Goods Manufacturing	$3.56	68%
Contract Construction	$5.22	100%

* This figure includes earnings from

SOURCE: This tabulation was project wage rate data for 1970 (ob Review, March, 1971) to the classification as projected Bulletin No. 1656, Compensa

In considering hourly wage rates, str unions can continue to obtain wages f There is a mounting campaign focussed struction wages as evidenced by the r control board within the industry cre President. Furthermore, the experien in Europe over the last twenty-five y toward equalization of factory and fi standing the psychological preference appears to be dictating the inevitabl tions from the job site to the factor tion of this trend within the next few industrial divisions under which fact

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Table 1

Tabulation of Comparative Hourly Wage Rates and Annual Earnings, 1970

Classification of Employment	Average Hourly Wage Rate	Wage Rate Differential	Proj. Hours Worked Per Year	Proj. Avg. Annual Earnings	Annual Earnings Differential
Durable Goods Manufacturing	$3.56	68%	2456	$8,743	92%
Contract Construction	$5.22	100%	1813	$9,464*	100%

* This figure includes earnings from contract construction only.

SOURCE: This tabulation was projected for 1970 by applying known hourly wage rate data for 1970 (obtained from the BLS Monthly Labor Review, March, 1971) to the numbers of hours worked in each classification as projected from Bureau of Labor Statistics Bulletin No. 1656, Compensation in the Construction Industry.

In considering hourly wage rates, strong doubt exists whether the trade unions can continue to obtain wages far in excess of industry as a whole. There is a mounting campaign focussed directly on the stabilization of construction wages as evidenced by the recent formation of a national wage price control board within the industry created under strong pressure by the President. Furthermore, the experience with industrialized construction in Europe over the last twenty-five years has clearly established the trend toward equalization of factory and field wages in construction. Notwithstanding the psychological preferences of the construction worker, economics appears to be dictating the inevitable transfer of many construction functions from the job site to the factory. All indications point to an acceleration of this trend within the next few years. At present a few craft unions have industrial divisions under which factory workers are organized. Normally the skill requirements are less in the factory and the wages are lower than job site wages. This variation in wage rates between factory and site is apparently an accepted principle within the union. The implication is that such two-tiered unions might develop in all trades.

Discussions with Representatives of the Trade Unions

In attempting to determine the response of labor unions in Massachusetts to the prospect of industrialized school construction, three labor union officials were interviewed to solicit their views on the subject. These interviews disclosed that while the unions are extremely wary of industrialized construction in general--particularly in the housing sector--they do not appear to be alarmed by this innovation in school construction. This lack of concern is probably due to their recognition that school construction currently represents such a small segment of total construction in Massachusetts and that only limited portions of school buildings will be industrialized.

All three of the union officials interviewed had been to Toronto to inspect the schools constructed there under the SEF program. Two of them indicated that they had not observed anything particularly radical in the methods used there and, from what they could learn, the usual complement of journeymen was utilized. Both indicated that while it is the prime responsibility of the union representatives to assure employment for their members, they realize that systems methods are part of a technological evolution that has gone on for decades and will continue. They both recounted the great changes in materials and methods of construction which they have witnessed during their lifetimes and indicated that in their opinions their unions would accommodate the industrialized concepts on a realistic basis.

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The "Opportunities" to Labor

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The other union leader stated that he did not expect significant reductions in labor force on school construction projects because of systems methods, but he does look for a significant reduction of construction time. He was skeptical that streamlining the school construction process would substantially increase school construction; he cited the propensity of Massachusetts citizens to carry on with traditional methods of doing things and their strong desire for stringent local control over all aspects of schools including the responsibility for construction.

The "Opportunities" to Labor

In addition to the potential advantages to labor which could accrue from the relocation of certain functions from the job site to the factory (improved working conditions, stabilization of employment, single employer relationship and productivity gains) the application of industrialized methods to school construction could introduce yet another factor which would tend to increase work on site. This factor is the ability of the contractor to close in the building very rapidly after placement of foundations. This early closure allows the interior trades to pursue their work regardless of the outside weather conditions and is a major factor in maximizing the work force and hastening completion.

Streamlining the entire process and reducing the cost through efficiencies could significantly increase the number of schools built annually over the next few years. While some trades might be getting a smaller share of school construction as others are getting a larger share, total school construction will probably be growing substantially. Therefore, with systems building, there is a strong possibility that most workers would register net gains in number of hours worked on school construction.

The construction worker also must be considered in his role as a parent, homeowner, and taxpayer. In this context he will gain manifold benefits along with the other citizens of Massachusetts. Improving the quality of education and increasing educational opportunity will benefit him as a parent and citizen. Reducing the cost of building schools and lowering the property tax burden will benefit him as a homeowner and taxpayer. It is very possible that on balance even the construction worker whose services are in less demand on school projects may derive non-employment gains as a citizen in excess of any losses in income from work on school construction jobs. With the backlog of demand for conventional construction over the next decade, all indices point to more than ample employment in all sectors of the construction industry.

Communications with Labor

Trade union members and their leaders have a continuing interest in systems building in general. With regard to its application to schools in Massachusetts, state school authorities contemplating systems construction should establish and maintain an open line of communications with the Building Trades Council. The purpose of such communication is to maintain a continuing insight into the attitudes and concerns of the unions and to insure that they are advised in advance of any plans which might deviate from orthodox practices. If objections do develop, time would be available to work out satisfactory solutions avoiding crises and delays.

Conclusions

Based upon the research and
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<u>Conclusions</u>

Based upon the research and analysis set forth above, the following conclusions are drawn:

1. The definite trend in school construction is toward industrialization and transfer of functions from the job site to the factory.
2. Although it is possibly not recognized by labor, this trend may provide more advantages to labor than disadvantages.
3. Despite the significant differential in average hourly wage rates between construction labor and labor in the manufacture of durable goods, the differential in average annual earnings is much smaller. Transfer from construction to durable good manufacturing by workers will have little overall effect on their annual income from employment, although they must expect to spend more hours annually working in the industry.
4. The impact on labor from industrialization of school construction in Massachusetts will be slight and far less significant than in other sectors of construction.
5. There is every reason to believe that the attitude of the building trades will be mature and progressive on this issue. This report does not predict any serious labor problems stemming from the implementation of industrialized methods in school construction in Massachusetts.
6. School authorities contemplating systems building should establish and maintain clear lines of communication with the Building Trades Council prior to commencement of construction in order to anticipate and avoid labor difficulties.

IMPLICATIONS OF GEOGRAPHIC FACTORS FOR SYSTEMS

CHAPTER V - 4

In proposing a statewide systems building program for Massachusetts schools, care must be taken to account for the various physical environments which occur in different parts of the Commonwealth since in some instances the nature of the hardware system can be affected by these conditions. Section III-10 of this report briefly outlines their nature; this chapter is concerned with their implications for systems hardware.

Climate

In general, the conditions imposed on systems buildings by climatic factors will not differ substantially from those imposed on conventional construction. As is evident from the various climates in which systems schools have been designed and built, including southern California (SCSD), Florida (SSP), Canada (SEF), and Massachusetts itself (see Chapter IV-6), systems hardware imposes no special constraints on the manner in which a building may respond to climate. The critical factor, then, is not the seasonal variation from hot to cold, but whether climatic conditions are sufficiently homogenous in all parts of the Commonwealth for any given season to allow the use of a single set of design criteria in all parts of the state without incurring any cost penalties due to local conditions being significantly different from those which serve as the basis for design. While there is a slight variation in the Massachusetts climate, tending toward somewhat colder winters in the western part of the state, the small size of the Commonwealth

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prevents these variations from becoming significant. Therefore there does not appear to be any reason for using more than one set of climatic conditions as a basis for performance specifications for systems hardware; there is no need to introduce any climatic factors into the design process which are either peculiar to one particular section of the Commonwealth or which are not already significant in the design and specification of conventional construction.

Topography and Subsurface Conditions

There is great variation in topography and subsurface conditions all over Massachusetts, which is evident at every scale from the state as a whole down to an individual plot of land. Its effect on systems hardware, however, should be minimal. Subsurface conditions have no effect on systems hardware at all because the building foundations are always outside of the hardware system. The structural hardware system begins at the interface plane formed by the meeting of the foundation top and the base of the vertical support element. The foundation is then able to act as the interfacing element between the very precisely engineered and highly predictable elements of the hardware system and the earth, which is basically unengineered, imprecise and unpredictable. Conventional construction is well adapted to this sort of interface work; much of the art of building in the conventional manner is in the handling of elements which stand as interfaces between dissimilar, unrelated or nonstandard objects. With the location of the interface between systems hardware and non-system elements set at the top of the foundations, differences in subsurface conditions are dealt with in exactly the same manner in a systems building as in a conventionally constructed one.

Sloping topography presents no serious or unusual problem to systems hardware. The ability to accommodate various types of "split levels" and a variety of slopes and grade level changes is normally specified as one of the performance characteristics required of the hardware. This capacity carries no cost penalty, so therefore there is no need to distinguish between the requirements for hardware designed for flat sites and that intended for use on slopes.

Demography and Degree of Urbanization

There does, however, appear to be a variation in the requirements for systems hardware based on demographic factors. As has been noted in Section III-10, the degree of urbanization of a site has a far greater influence on the design of schools in different parts of Massachusetts than any other so-called natural factor. The cost and difficulty of acquiring and developing a site, the configuration of a building, the number of stories, and the resistance to fire required of it are all closely related to whether a school is to be located in a basically rural or urban area.

Site acquisition and development are matters which lie wholly outside of systems hardware and need not be a concern here. Building configuration and fire resistance, however, are very serious concerns. With all other things equal, the more urbanized and built-up the location for a new school is, the less land is likely to be available and, in turn, the more expensive

it is likely to be. This act
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it is likely to be. This acts to reduce the amount of ground which the building is allowed to cover, making it increasingly likely that the new building will be built on two or more stories. Accompanying the increase in building height is the need for a greater degree of resistance to fire, both for the safety of the building and its occupants and for the protection of adjacent properties. These requirements involve additional expenditures over the basic amount paid for a structure of one-story capacity with minimum fire-resistive qualities.

If an attempt is made to use statewide a single performance specification oriented either to low (one- and two-story) buildings or to higher ones (two stories or more), the consequences of these demographic factors will cause problems. An unnecessarily heavy structure or a degree of fire resistance greater than that which is actually needed will penalize the economic effectiveness of a set of systems hardware in some situations, as in the case of a multistory Type 1 (fireproof construction) hardware system in the typical rural environment. Conversely, a structure which lacks sufficient load-bearing capacity to go several stories high or has inadequate fire resistance to meet local fire zoning requirements will be unusable where these qualities are important, as they would be in a densely built-up urban environment.

It therefore appears that some means will be required to provide for hardware systems, in particular the structural subsystem, which can respond to either situation. There are basically two ways of doing this. On the one hand is the possibility of using two distinct sets of hardware. The first set would include a lightweight structure and would have limited fire-resistant qualities, usable in buildings one or two stories high. The second set would be used for buildings at least two stories high and would require both a heavier structure and a greater degree of fire resistance, both with their attendant higher costs. On the other hand, it is theoretically possible to design a modular "add-on" system in which the basic lightweight, unfireproofed structural elements could be selectively replaced by elements with greater load-carrying and fire-resistive capabilities. The first example would be easier to specify and design but would result in two separate structural subsystems. As long as both subsystems were fully compatible with all the other elements of the systems hardware, this would not be expected to present any problems. The second example would require significantly more work to specify and design but would result in a single structural subsystem, rather than the conceptually less elegant paired system of the first case. Whether or not this elegance would justify its development costs is not a matter which can be definitively determined here, although we suspect that it would not.

Conclusions

In summary, climate, topography and subsurface conditions can be expected to exert little or no influence on systems hardware which would result in a set of design criteria too wide to be optimally satisfied by a single set of performance statements. The degree of urbanization of a school site, however, is a condition which influences the hardware system in such a way that more than one set of performance requirements must be satisfied by the hardware system, probably by means of two paired sets of structural subsystems.

COST IMPLICATIONS OF SYSTEMS CONSTRUCTION AND VC

CHAPTER V - 5

One of the major objectives of this study was to develop a reliable estimate of the cost of constructing schools in Massachusetts today using present systems building methods. The cost estimate is presented and explained in this chapter. Comparison of the estimated cost of systems built schools with the known costs of conventionally built schools provides an insight into the possible cost savings which might be derived from the conversion of conventional construction methods to systems methods in Massachusetts.

Procedures

The methodology used to develop an estimate of the cost of a systems built school begins with the model of costs of conventionally constructed schools described in Chapter III-5. This model allocates construction costs among 13 separate functional building elements corresponding to building subsystems. The total of all the functional element costs equals the cost of the total school building.

Using this conventional cost model as a base, a determination was made as to which of the 13 functional elements would offer the most potential for conversion to systems methods of construction in terms of functional feasibility and potential cost savings. A study of completed systems school projects in other states and provinces of Canada indicates that the building elements whose conversion to building subsystems would offer the most advantages are:

1. Structural subsystem
2. Exterior wall subsystem
3. Interior partitioning subsystem
4. Lighting subsystem*
5. Suspended ceiling subsystem*
6. Heating, ventilating and air co
7. Electric - electronic subsystem

Construction costs for these selecte systems cost model.

Since Massachusetts has had little e by systems building methods, it was construction by obtaining cost estim installers listed in the appendix to upon performance specifications orig tion Systems Development (SCSD) prog form to Massachusetts requirements. scope was based upon a hypothetical square feet with the following parti

1. Structural Frame and Deck Subsy
   The vertical and horizontal str the building, multiple floor de received were based upon a stan bay spacing of 60'x60' complete sary fireproofing.

*In systems construction, the lighti the suspended ceiling element are c namely, the lighting - ceiling subs

OF SYSTEMS CONSTRUCTION AND VOLUME PURCHASING

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offer the most advantages are:

3. Interior partitioning subsystem
4. Lighting subsystem*
5. Suspended ceiling subsystem*
6. Heating, ventilating and air conditioning subsystem
7. Electric - electronic subsystem

Construction costs for these selected subsystems are substituted in the systems cost model.

Since Massachusetts has had little experience to date in constructing schools by systems building methods, it was necessary to determine the costs of such construction by obtaining cost estimates from the systems manufacturers and installers listed in the appendix to this chapter. The costs were based upon performance specifications originally developed for the School Construction Systems Development (SCSD) program in California, and modified to conform to Massachusetts requirements. For estimating purposes, the project scope was based upon a hypothetical single school project consisting of 136,000 square feet with the following particular specifications:

1. <u>Structural Frame and Deck Subsystem (1B):</u>

   The vertical and horizontal structural frame support elements within the building, multiple floor decks (if any), and roof decks. Quotations received were based upon a standard module grid of 5'x5' with a maximum bay spacing of 60'x60' complete with roof decks and including all necessary fireproofing.

*In systems construction, the lighting portion of the electrical element and the suspended ceiling element are combined to form a new building element, namely, the lighting - ceiling subsystem.

2. Exterior Wall Subsystem (2):

The total building enclosure including fenestration, insulation, entry and egress ways. Quotations were based upon a scope of 66,000 square feet of wall surface.

3. Interior Partitioning Subsystem (3):

All interior walls and partitions including fixed, demountable and operable partitions with doors, frames and hardware. Quotations were obtained on the basis of 35,000 square feet of interior walls, including 10% typical masonry walls accommodating water supply and waste lines, 15% fixed partitions, 65% demountable partitions, and 10% operable partitions together with doors, frames and hardware.

4. Lighting - Ceiling Subsystem (4B):

Quotations included the ceiling grid support system, acoustical finish material, and integrated lighting fixture with accommodation of HVAC supply and return.

5. Heating, Ventilating, and Air Conditioning Subsystem (8):

Quotations received include air conditioning throughout.

6. Electric - Electronic Subsystem (9):

All switchgear, distribution systems and power, lighting and communications equipment except lighting which is included in the lighting - ceiling subsystem. Quotations were received on the basis of one drop pole or console per classroom.

The data on installed costs of building elements constructed by systems methods were obtained from leading manufacturers currently active in the field of school construction. These quotations (which are included within

the Appendix) generally repres
appearance and other qualitati
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For comparison purposes a sche
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Cost Survey is also included.

Accepting the total constructi
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Additional Potential Cost Savi

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It is estimated that these fac
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the Appendix) generally represent a range of costs based upon performance, appearance and other qualitative factors. The analysis of these cost ranges and physical inspection of the components by cost engineers resulted in the development of three separate cost projections as the minimum, probable, and maximum cost schedules. These schedules are presented below. For comparison purposes a schedule of costs of the composite school based upon the findings set forth in Chapter III-5, School Construction Cost Survey is also included.

Accepting the total construction cost of $33.92 set forth in Exhibit 2 as the "probable" cost utilizing systems construction methods, an immediate saving of $1.33 or 3.7% over conventional construction cost is estimated.

Additional Potential Cost Savings Through the Use of Systems Components

The projected 3.7% cost savings represents a potential saving based only on manufacturers' quotations obtained under static conditions. This estimate does not contemplate such significant variables as:

1. Increased competitiveness of manufacturers and installation contractors as their experiences with the products increase.
2. The cost advantages derived from further research and development of systems components and methods spurred by increasing demand.
3. Increased knowledge and facility in the use of systems components by architects.

It is estimated that these factors offer the potential of an additional 6% to 9% savings over a five year period with a potential 12% saving in ten years based upon sound orgainzation and management practices by the contracting authorities. This type of management capability can best be developed

Exhibit 1

Projection of Estimated School Costs
Based Upon the Use of
Minimum Quality Systems Components

Building Element Proposed for Substitution of Conventional Construction by Systems Components	Cost of* Systems Component ($/Sq.Ft.)	Cost of Remaining Portions of Installation not Subject to Systems Components ($/Sq Ft)	Total Installed Cost ($/Sq Ft)	Estimated Cost of Composite School Built by Conventional Methods ($/Sq Ft)
Structural Frame and Desk (1B)	1.80	.75	2.55	5.64
Exterior Walls (2)	2.00	.25	2.25	3.77
Interior Partitions (3)	2.65	.35	3.00	3.81
Lighting-Ceiling (4B)	1.28	.10	1.38	.71**
H.V.A.C. (8)	3.00	.15	3.15	3.94
Electric-Electronic (less lighting) (9)	.50	2.68	3.18	3.68***
	11.23	4.28	15.51	21.55
Remaining 10 Building Elements Built by Conventional Methods			13.25	13.70
TOTAL CONSTRUCTION COST			28.76	35.25

* Based on manufacturers' quotations for mid-1971
** Excludes lighting
*** Includes lighting

Pro[illegible]

Pr[illegible]

Building Element Proposed for Substitution of Conventional Construction by Systems Components	Cost o[illegible] System[illegible] Compon[illegible] ($/Sq [illegible]
Structural Frame and Deck (1B)	3.1[illegible]
Exterior Walls (2)	3.4[illegible]
Interior Partitions (3)	3.1[illegible]
Lighting-Ceiling (4B)	2.4[illegible]
H.V.A.C. (8)	3.5[illegible]
Electric-Electronic (less Lighting) (9)	.7[illegible]
	16.3[illegible]
Remaining 10 Building Elements Built by Conventional Methods	
TOTAL CONSTRUCTION COST	

* Based on manufacturers' qu[illegible]
** Excludes lighting
*** Includes lighting

School Costs
Use of
s Components

ing - tems Sq Ft)	Total Installed Cost ($/Sq Ft)	Estimated Cost of Composite School Built by Conventional Methods ($/Sq Ft)
	2.55	5.64
	2.25	3.77
	3.00	3.81
	1.38	.71**
	3.15	3.94
	3.18	3.68***
	15.51	21.55
	13.25	13.70
	28.76	35.25

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Exhibit 2

Projection of Estimated School Costs
Based upon the Use of
Probable Quality Systems Components

Building Element Proposed for Substitution of Conventional Construction by Systems Components	Cost of * Systems Component ($/Sq Ft)	Cost of Remaining Portions of Installation not Subject to Systems Components ($/Sq Ft)	Total Installed Cost ($/Sq Ft)	Estimated Cost of Composite School Built by Conventional Methods ($/Sq Ft)
Structural Frame and Deck (1B)	3.15	.75	3.90	5.64
Exterior Walls (2)	3.40	.25	3.65	3.77
Interior Partitions (3)	3.10	.35	3.45	3.81
Lighting-Ceiling (4B)	2.49	.10	2.59	.71**
H.V.A.C. (8)	3.50	.15	3.65	3.94
Electric-Electronic (less Lighting) (9)	.75	2.68	3.43	3.68***
	16.39	4.28	20.67	21.55
Remaining 10 Building Elements Built by Conventional Methods			13.25	13.70
TOTAL CONSTRUCTION COST			33.92	35.25

* Based on manufacturers' quotations for mid-1971
** Excludes lighting
*** Includes lighting

Exhibit 3

Projection of Estimated School Costs
Based upon the Use of
Maximum Quality Systems Components

Building Element Proposed for Substitution of Conventional Construction by Systems Components	Cost of* Systems Component ($/Sq Ft)	Cost of Remaining Portions of Installation not Subject to Systems Components ($/Sq Ft)	Total Installed Cost ($/Sq Ft)	Estimated Cost of Composite School Built by Conventional Methods ($/Sq Ft)
Structural Frame and Desk (1B)	4.50	.75	5.25	5.64
Exterior Walls (2)	4.80	.25	5.05	3.77
Interior Partitions (3)	3.55	.35	3.90	3.81
Lighting-Ceiling (4B)	3.50	.10	3.60	.71**
H.V.A.C. (8)	4.00	.15	4.15	3.94
Electronic-Electronic (Less Lighting) (9)	1.00	2.68	3.68	3.68***
	21.35	4.28	25.63	21.55
Remaining 10 Building Elements Built by Conventional Methods			13.25	13.70
TOTAL CONSTRUCTION COST			38.88	35.25

* Based on manufacturers' quotations for mid-1971
** Excludes lighting
*** Includes lighting

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Volume Purchasing

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at a level of ten or mo

The projected savings a
manufacturer to:

1. Anticipate a level
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2. Implement long run
   tooling changes and
3. Purchase materials
4. Allocate the market
   expenses over a max
5. Forecast and progra
   provide a backlog o

School Costs
se of
Components

n- on o nents	Total Installed Cost ($/Sq Ft)	Estimated Cost of Composite School Built by Conventional Methods ($/Sq Ft)
	5.25	5.64
	5.05	3.77
	3.90	3.81
	3.60	.71**
	4.15	3.94
	3.68	3.68***
	25.63	21.55
	13.25	13.70
	38.88	35.25

I

through experience and therefore would be difficult to develop under the present mode of school construction on a single school basis.

Volume Purchasing

The potential for additional savings is offered through the purchasing of systems components in mass volume. A general rule is that the component manufacturer should have complete responsibility for installation on site as well as the fabrication. In practice, installation is usually accomplished by a local contractor under agreement with the manufacturer with the warranty obligation the responsibility of the manufacturer - as the manufacturer normally has the greater financial strength.

The magnitude of volume required to achieve maximum savings is estimated at a level of ten or more projects within a one-year period.

The projected savings are possible because volume purchasing allows the manufacturer to:

1. Anticipate a level of profit sufficient to motivate a strong incentive to compete.
2. Implement long run production of a standard design item minimizing tooling changes and set up charges.
3. Purchase materials on a mass volume basis earning maximum discounts.
4. Allocate the marketing, administration, transportation, and overhead expenses over a maximum number of units minimizing unit cost.
5. Forecast and program a major portion of production for the year and provide a backlog of work to effectively utilize slack production time.

6. Develop maximum efficiency in installation through repetitive installations of a similar nature by the same work crews.
7. Affect time savings throughout the entire manufacturing/installation process.

The level of potential savings which might be achieved through volume purchasing is estimated at 6%.

The potential savings described within this chapter through the use of systems components and volume purchasing are exclusive of and in addition to potential savings through other means such as the implementation of project management, changes in code requirements, reduction of space requirements, etc. The potential cost effects of these other means of savings are described in other chapters within this report.

RECAPITULATION OF POTENTIAL COST SAVINGS

CHAPTER V - 6

Having examined a number of possible individual changes in the school planning and construction process, it is now useful to analyze the cumulative effect of these changes in terms of cost savings. By setting them into a common framework, we can see the relative importance of each. This recapitulation conclusively demonstrates that there is no single "one-shot" saving. It also demonstrates that when we speak of savings it is important to be specific about exactly which saving we mean. The overall saving is the cumulative effect of many little savings, and it can only be achieved by a disciplined coordinated effort by the client and his consultant team.

The ultimate frame of reference of savings is the cost per pupil. Many discussions of savings focus on the cost per square foot of construction. This is of course a perfectly valid measure of building cost but it is only fully meaningful when combined with some measure of how much space is being built. No money is saved by reducing cost per square foot by 25% if the area per pupil is 33% greater than is needed. Cost per pupil figures as such are not listed in this summary, but they are an important measure of how much the school costs the taxpayer. The material which follows consists first of a listing of all savings identified in the preceding chapters; second, a chart which illustrates the relationship of these savings, and third, the detailed worksheets showing how the figures in the recapitulation chart were derived. Reference to Chapter III-4, "How Costs are Defined and Measured" may be helpful.

Exhibit I

Listing of Savings Identified in Previous

General Contract Savings

a) Cost per Square Foot
   1. Market Aggregation/Bulk Purchasing
   2. Systems Components & Installation
   3. Project Management

b) Floor Area Savings
   1. Reduction of Programmed Space Reqs.
   2. More Efficient Planning of Space

Project Cost Savings

a) General Contract (calculated from above figures
b) Equipment
c) Architect's Fees

Debt Service Savings through lower interes

Extra Administrative Cost required to achi above savings

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ese savings, and third,
in the recapitulation chart
Costs are Defined and

Exhibit I

Listing of Savings Identified in Previous Chapters

General Contract Savings	% of General Contract Cost	
a) Cost per Square Foot	Initially	Future
1. Market Aggregation/Bulk Purchasing	3-6%	6%
2. Systems Components & Installation	4-9%	12%
3. Project Management	8-10%	12%
b) Floor Area Savings		
1. Reduction of Programmed Space Reqs.	8-10%	8-10%
2. More Efficient Planning of Space	8-10%	8-10%

Project Cost Savings	% of Project Cost
a) General Contract (calculated from above figures	29-36%
b) Equipment	1%
c) Architect's Fees	2%

Debt Service Savings through lower interest rates	% of Debt Service
	3%

Extra Administrative Cost required to achieve above savings — 2-3% of Project Cost

Exhibit 2

SUMMARY OF POTENTIAL SAVINGS ON THE INITIAL COST OF A MEDIAN PRICE SCHOOL

Cost Per Square Foot Savings

1. Systems Construction
   Systems Components & Installation
   Performance Specifications
   Prequalifications of Bidders
   Project Management
   Phased Construction
   — 12-19%

2. Less: Deduction for Additional Administrative Costs — (2-3)%

Net Saving 9-16% of cost per square foot

Volume Purchasing — 3-6%

12-21% of cost per square foot

Floor Area Savings

1. Reduce Program Space Requirements — 8-10%
2. More efficient Planning (Improve Net to Gross Ratio) — 8-10%

15-19% of Area per Pupil

29-36% Saving on General Contract (23-29% of Project Cost)

Further Savings on Project Cost

1. Equipment — 1%
2. Architect's Fees — 2%

26-32% Project Cost (Savings on Debt Service would be same percent

Reduction of Cost of Debt Service (Reduce interest rate on bonds) — 3-4%

28-36% of Debt Service

Derivation of Savings

Savings in the General Contract

There are two ways of saving money on the general contract. One we shall call situational -- i.e., it depends on the characteristics of any particular situation: (1) the skill of the architect; (2) the availability of sites which will permit economical construction; and (3) the willingness of the town to accept more economical materials, lower standards of workmanship, and reductions of teaching space and equipment. A certain amount of careful economizing on any job is prudent; it becomes a false economy when it begins to affect the teaching operation or the sound functioning of the building. Because this kind of saving will vary from situation to situation, depending on who is involved, its control is beyond the scope of this study or of any potential building program for the Commonwealth of Massachusetts.

The other kind of saving is systemic -- i.e., the kind which can be affected by changes in the system or procedure by which schools are planned and built, and which therefore is relevant to this study.

In summing up these savings on the general contract, the savings fall into two groups: cost per square foot savings and floor area savings. It is useful to analyze these separately in order to recognize the implications of each. It is particularly useful since people tend to view savings in construction cost per square foot as having more significance than floor area savings. This helps to show they are equally important.

a) Cost Per Square Foot Savings

The preceding chapters have attemp
subjects separately in order to cl
in each. Yet the subjects are so
ficult and perhaps misleading to t
them. The justification for this
to do so, each concept could and h
It is stressed however that they a
of which may exceed the sum of the
part of the systems construction p

1. Systems components and Installa
Independent of and additional to t
savings on the purchase and instal
been estimated to be 10-18% of the
these components would initially c
this would be the equivalent of a
These figures are based on data re
and are borne out by cost experien
years, as a larger proportion of t
this saving could be expected to i
(Chapter V-5).

2. Management

It has been estimated that the pro
part of the systems construction p
8-10% in the square foot cost of c

eneral contract. One we shall
characteristics of any
architect; (2) the
nomical construction; and (3)
economical materials, lower standards
space and equipment. A certain
prudent; it becomes a false
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kind of saving will vary from
involved, its control is beyond
building program for the

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to this study.

contract, the savings fall into
d floor area savings. It is
to recognize the implications
eople tend to view savings in
more significance than floor
equally important.

a) <u>Cost Per Square Foot Savings</u>

The preceding chapters have attempted to treat the following three subjects separately in order to clearly illustrate principles involved in each. Yet the subjects are so closely interrelated that it is difficult and perhaps misleading to try to attach separate cost factors to them. The justification for this is that although it is far from ideal to do so, each concept could and has on occasion been utilized separately. It is stressed however that they are ideally part of a package, the benefits of which may exceed the sum of the parts. Together they form an important part of the systems construction process.

1. Systems components and Installation

Independent of and additional to the savings from bulk purchasing, the savings on the purchase and installation of coordinated components have been estimated to be 10-18% of the cost of the systems components. Since these components would initially comprise 40-50% of the total contract cost, this would be the equivalent of a 4-9% saving on the general contract cost. These figures are based on data received from systems products manufacturers and are borne out by cost experience of the Florida school programs. In later years, as a larger proportion of the building becomes systems construction, this saving could be expected to increase to 12% of the General Contract (Chapter V-5).

2. Management

It has been estimated that the project management procedures utilized as part of the systems construction process will initially produce a saving of 8-10% in the square foot cost of construction depending on how it is administered. This saving should rise to 12% in later years. (Chapter V-5) These procedures include phased or fast-tracked construction, pre-qualification of bidders, performance specifications, and continuous cost control among others.

The combined effect of these would be:

1. Systems components and installation	4-9% initially (12% ultimately)
2. Project management procedures	8-10% initially (12% ultimately)
3. Volume purchasing	3-6% initially (6% ultimately)
Combined effect*:	14-23% initially, 27% ultimately

If these savings could be achieved immediately, the statewide average cost per square foot would be reduced from $35.25 to about $27.00.

It does not necessarily mean that those schools currently being built for $28/square foot could be further reduced all the way down to $22/square foot, since such schools may already be utilizing some of these potential savings. However, by the same logic, those schools costing over $40 per square foot might be reduced by <u>more</u> than 14-23%.

b) <u>Floor area Savings</u>

Quite separate from the savings on square foot costs are savings achievable simply through a reduction in the amount of space to be built. This is accomplished in two ways (Chapter III-12).

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* Note the method of calculation to determine a percent of a percent; the complements of the savings are multiplied together:

Lesser Saving = 100% - (96% x 97% x 92%) = 100% - 86% = 14% saving

Greater Saving = 100% - (91% x 94% x 90%) = 100% - 77% = 23% saving

1. Reduction of Programmed Space Re
The combination of a reduction of spa
better utilization of such facilities
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1. Reduction of Programmed Space
2. More Efficient Use of Space

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c) <u>Savings on Escalation of Construc</u>

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of that delay could save 7-14% of wha
savings on escalation are not include

o 12% in later years. (Chapter V-5)
tracked construction, pre-
ecifications, and continuous cost

4-9% initially (12% ultimately)
8-10% initially (12% ultimately)
3-6% initially (6% ultimately)
14-23% initially, 27% ultimately

iately, the statewide average cost
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schools currently being built for
all the way down to $22/square
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se schools costing over $40 per square
%.

e foot costs are savings achievable
of space to be built. This is
).

termine a percent of a percent;
ultiplied together:
92%) = 100% - 86% = 14% saving
90%) = 100% - 77% = 23% saving

1. Reduction of Programmed Space Requirements

The combination of a reduction of space submissions to the Commonwealth and better utilization of such facilities as dining spaces and auditoriums has been estimated to allow reduction of the new area per pupil by 8-10%, which should result in construction cost savings of a comparable amount.

2. More Efficient Planning of Space

It is estimated that more efficient planning of space could save up to 30% of the area and cost of some school plans. This saving would be achieved only on the less efficient school plans; on many other schools no further saving could be achieved. These savings could produce an average saving of 8-10% per pupil.

The combined effect of these savings is:

1. Reduction of Programmed Space Requirements 8-10%
2. More Efficient Use of Space 8-10%

or a saving of 15-19 percent savings over what is current practice in Massachusetts. The savings on cost per square foot and on floor area, have a potential for saving 27-38 percent per pupil on the general contract.

c) Savings on Escalation of Construction Costs

Considerable evidence has been accumulated to show that many Massachusetts schools have indeed been delayed - some as long as from 5 to 10 years. If the "normal" delay is one to two years, and the annual rate of escalation is taken to be about 7% (see Chapter III-3), then this delay adds 7-14% to the cost of those schools. It would therefore be fair to say that elimination of that delay could save 7-14% of what the cost would otherwise be. These savings on escalation are not included in the estimate of total potential savings; the point here is to recognize, however, that delay definitely adds to the contract price, and that elimination of that delay will avoid its increase.

Savings on the Project Cost

In addition to the general contract, the total project cost includes land acquisition, site development, equipment, architect's fees and other capital expenses. The question of land prices is considered to be a local issue which often transcends cost considerations. Analysis of these factors might reveal potential cost savings, but was considered to be outside the scope of this study.

Equipment not included in the general contract could be subject to many of the same savings as the building. This includes purchasing through market aggregation programs, performance specifications, better utilization of equipment, and possibly a reduction in equipment. Without going into further analysis, it is estimated that initial expenditures for equipment could be reduced by perhaps 15%. Since equipment is about 7% of the total project cost, this would create a saving of 1%.

One way of determining architect's fees is as a percentage of the general contract, so that a contract saving is automatically reflected in the fee as well. The fee scale actually is designed so that as the size of the contract increases, the percentage rate reduces, but the difference is minor. For instance, the AIA scale fee for a $5 million school is 6½%, while the fee for a $6 million school is 5-3/4%. For all practical purposes, therefore, the fee is proportional to the contract cost, and a 30-40% saving in the contract means a similar saving in the fee. Since these fees average about 5% of the project cost, net savings would run around 2 percent. Another

possible saving sometimes suggested
Each new issue of bonds incurs dire
legal fees, and cost of printing of
$2000 to $10,000 or more for each n
more in a year. If the bonding cou
large packages, further money would

Since the current issuing costs are
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which it is desirable to achieve.

The project cost is the sum of the
the total saving is simply the sum

	Normal (% of th Project
General Contract (inc. for escalation savings)	82
Equipment	7
Architect's Fees	5
Land and Site Development, and other costs	6

Savings through Reduction of Cost of

It is believed that a reduction of up
if a single agency with the full fait

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ll practical purposes, therefore,
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Since these fees average about
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possible saving sometimes suggested is on the cost of issuing the bonds. Each new issue of bonds incurs direct expenses for the bank certification, legal fees, and cost of printing of the bonds. These costs may vary from $2000 to $10,000 or more for each new issue, of which there may be 50 or more in a year. If the bonding could be done collectively by the state in large packages, further money would be saved.

Since the current issuing costs are about 0.1% of the total project cost (e.g., $10,000 on a $10 million investment), the possible saving is below the order of magnitude that would show up in this cost summary, despite which it is desirable to achieve.

The project cost is the sum of the preceding components of cost, so that the total saving is simply the sum of the savings of the individual parts.

	Normal Cost (% of the Total Project Cost)	% Saving	Saving as a % of the Total Project Cost
General Contract (inc. for escalation savings)	82%	29-36%	23-29%
Equipment	7%	15%	1.0%
Architect's Fees	5%	29-36%	2%
Land and Site Development, and other costs	6%	Not calculated	--
		Total:	25-32% of Project Cost

<u>Savings through Reduction of Cost of Debt Service</u>

It is believed that a reduction of up to ½% in the interest rate is possible if a single agency with the full faith and credit of the state has to do all borrowing for school construction. If the normal rate which towns must pay is about 6.2 percent per annum, this is a reduction of about 8 percent in the rate of interest. Since the interest charges for 20 year bonds in recent years have been about 35% of the total debt service, this saving reduces the cumulative cost of debt service by about 3 percent. (For 10-year bonds, the same reduction in rate would produce a saving of about half that.)

Combining this with the savings on project cost, the total would be about 28-36% savings of debt service.

Savings through Greater Utilization of Existing Space

The bulk of this report is devoted to improving the process of obtaining new schools. Other savings could result from those changes which would increase the utilization of instructional and supporting space, thereby reducing the future need for new space. Two ways have been identified:

a) Renovation and remodeling of existing space (including the conversion of non-educational space into schools), and

b) Increased utilization of new buildings through innovations in scheduling.

a) Savings through Renovation and Remodeling of Space

As stated in Chapter III-6, presently available data are not sufficient to establish what savings if any may be made by remodeling existing facilities. It is known that in order to achieve a good quality teaching environment it is usually less expensive to remodel an existing school than to replace it. Most buildings, however, eventually reach a point at which it is no

longer feasible to do this, and their pupi
reduced. No specific saving can be listed
that savings may be possible, when new sc
which can reduce the working time for remo

b) Savings through New Trends in Scheduli

It has been pointed out in Chapter II-4 th
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open campus, work study programs, the year
scheduling. However, the approximate natu
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conditioning for year round schools), and
educational decisions are such that we can
about savings with any precision. Further
these issues.

Savings on Lifetime Costs

Lifetime cost is more significant than any
usually too many uncertainties to allow th
the outset of a project, so it is usually

There are three components of lifetime cos

1. Initial Cost (Debt Service)
2. Running or Operating Cost
3. Alteration Cost

The quantitative relationship among these

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longer feasible to do this, and their pupil capacities are frequently reduced. No specific saving can be listed, but it is reasonable to believe that savings may be possible, when new schools are constructed in ways which can reduce the working time for remodeling and renovation.

b) Savings through New Trends in Scheduling

It has been pointed out in Chapter II-4 that savings from adoption of some of the new trends in scheduling could result in an increase in the utilization of adequately designed school buildings. These trends include, the open campus, work study programs, the year round school and extended scheduling. However, the approximate nature of the savings, the uncertainties about the additional costs which these alternatives may incur (such as air-conditioning for year round schools), and the nature of the political and educational decisions are such that we cannot begin to draw conclusions about savings with any precision. Further study will be needed to refine these issues.

Savings on Lifetime Costs

Lifetime cost is more significant than any initial cost, but there are usually too many uncertainties to allow this figure to be estimated at the outset of a project, so it is usually ignored.

There are three components of lifetime cost:

1. Initial Cost (Debt Service)
2. Running or Operating Cost
3. Alteration Cost

The quantitative relationship among these is not known, although the M.A.C.E.

Business Task Force study did show that the annual running costs usually exceed the annual debt service costs of new buildings. Estimates of the cost of alterations range from 25-100% of the original building cost, and cases are known where alterations have cost more than twice the school's original cost. This begins to suggest the general magnitude of each part of the cost.

Savings on initial costs could, as demonstrated above, approach 30-40% if all the proposed savings are taken. Other studies have also demonstrated that the flexibility resulting from the use of systems components can cut alteration costs by 50% (Chapters III-9 and III-10).

Lifetime operating costs are not presently known, but the Business Task Force study and other reports have documented great wastage in this area. It should not be possible that high operating costs may cancel out all the hard-earned savings on both initial cost and alteration costs. Unfortunately, even the toughest products and designs can be wasted or ruined by poor maintenance practices and often are. Therefore, in addition to being designed for low and easy maintenance, and being constructed of quality materials, enlightened maintenance practices can do much to extend the useful life of a new school.

This suggests the importance of:

a) the use of low-maintenance products and durable construction, even if the initial cost may be less of a saving.
b) increased attention to the intelligent training and use of custodial manpower.

COMPARATIVE ANALYSIS OF POSSIBLE COURSES OF ACTION

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ANALYSIS OF POSSIBLE ACTION

vi

INTRODUCTION

CHAPTER VI - 1

The fundamental responsibility for public education in Massachusetts rests by constitutional provision with the state government. In actuality, however, the provision of public education has been carried out at the local level. While the state has, particularly in recent decades, assumed a greater share of the financial burden for providing education, the local communities have borne most of these costs. They have done so from the inelastic local property tax base.

The resultant burden upon local property taxpayers has sharply increased since the Second World War, reflecting the population growth, the flight to the suburbs, the development of major metropolitan areas and changing educational philosophies and methodologies with the accompanying demand for new and innovative facilities.

The strain which this has placed upon local government is readily seen from an examination of school building costs in Massachusetts. Generally, school building costs in Massachusetts are higher than those in most other states. The competitive demands upon the local tax dollar for increased governmental services of all kinds has resulted in an increasing reluctance on the part of local communities to construct needed additional school facilities. Unquestionably this adversely affects the quality and equality of Massachusetts public education. Notwithstanding these pressures, the "Report of the Massachusetts Business Task Force for School Management," a study of the Massachusetts Advisory Council on Education published in September 1970 stated that "School Construction is big business in Massachusetts. In fact it is the largest single construction speciality in the state."*

* MACE "Report of the Massachusetts Business Task Force for School Management, p. 37.

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The Commonwealth, once a pioneer through its enactment in 1948 of the School Building Assistance Act which provided state aid for the construction of schools, now lags far behind the current need despite adjustments and increases in the kind and amount of aid which the state has provided since that enactment.

Massachusetts public education has rested upon a highly decentralized and diffused governmental structure which reflects the complex relationships between state and local governments. This is particularly true in the cost of school building construction. In sum, the role of the Commonwealth has been a passive one relying heavily upon local initiative, resources and leadership.

Partly as the result of the structure of the relationships and of the pressures upon local taxpayers, decisions to build needed schools have all too frequently been put off by weary taxpayers. Eventually, at least in most communities, the needed facilities are built. The enormous time delays, however, have resulted in greatly increased costs, largely as the result of inflation.

During the course of this study, we have endeavored to develop various approaches and recommendations designed to reduce school building costs in the Commonwealth, while at the same time maintaining at least the present quality of modern school facilities.

As with the development of any significant set of recommendations bearing upon fundamental public policy, final decisions are supremely matters of judgment. A wide spectrum of alternatives exists on many of the questions treated in this report, and the choice of one alternative over the other may well lead some observers to different conclusions from those set forth here. We believe, however, that differences in detail with respect to one or another policy should not be overemphasized in view of the widely held agreement as to goals.

We identify these goals as the provision of the highest quality of school construction in the shortest possible time and in the most economical way to ensure the provision of equal educational opportunity for generations of Massachusetts school children.

Toward these goals, each of our recommendations rests upon our conclusion that the Commonwealth has a direct legal obligation to provide equal educational opportunity for every child of school age in the Commonwealth. This principle encompasses not only the currently volatile public policy areas which the General Court has addressed through the enactment of the Massachusetts racial imbalance law and through other measures. Affected are not only children living in urban ghettos, but children who by happenstance dwell in cities and towns whose fiscal resources, so dependent upon the local property tax, dictate the dollars available for expenditure in public education and inevitably therefore disparately govern and control the quality of education received by our children. The recent decision of the California Supreme Court affirms that the education of the state's children is a statewide concern, not to be left to the vagaries of local affluence. In order for it to achieve its objective, we believe that the Commonwealth must reshape its policies and practices and assume, with the local municipalities, an activist role.

Further, in formulating our recommendations, we have taken the view that the tax dollar -- whether gathered by the state or the local government -- is derived from essentially the same taxpayer. We have been mindful of the fact that Massachusetts has one of the highest local property taxes in the nation and that local governments have been largely reliant upon that tax for their general revenues.

We have concluded, therefore, that any significant change in the process of construction of public schools must include a shift of the responsibility for financing that construction from the local property tax to general state revenues. It is to be emphasized that this shift is not intended to reduce meaningful participation by the municipalities in the planning and operation process of their schools.

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Concomitant with the assumption of increased state leadership and financial responsibility, we perceive the need for redefining the relationship which has existed between state and local governments in the financing and construction of public schools. This redefinition is reflected in the alternative courses of action set forth in this section.

Our studies have led us to conclude that there are two possible beneficial courses of action, which, in varying degress, would tend to reduce the cost of public school construction in the Commonwealth; to speed up the planning and construction process while maintaining existing levels of quality and increasing the degree of flexibility for future adaptability. The purpose of this section is to outline those two possible courses of action and to share with the reader a comparative analysis of them.

A possible course of action is first described which could bring about needed changes working basically within the present legal and administrative framework. It involves a series of specific adjustments, often unrelated to each other, each addressed to one aspect of the present method by which schools are designed, constructed and financed. We perceive them to be discrete actions, some requiring legislative change or adjustments and others achievable under present law through administrative action; some simple to achieve and others complex. However worthwhile and desirable we believe these various changes which have been described in Chapter 2 of this section to be, we conclude that the children and the taxpayers of Massachusetts would not be well served if those within the executive and legislative branches of the government were to be content to implement some or all of these recommendations. The potential achievement of high quality facilities, improved educational opportunities, and desperately needed savings of public funds offered by the recommended course of action set forth in Chapter 3 of this section could not be realized by the implementation of the recommendations contained in Chapter VI-2.

Massachusetts taxpayers, educators and concerned parents will recognize that the recommendations following in Chapter VI-2 within the Massachusetts political context are susceptible of being blunted, weakened and thwarted by their diffuse nature. Vested bureaucratic interests, however legitimately they may be perceived by some, hold a dangerous potential for preventing the achievement of these goals. Perhaps most importantly, the implementation of the recommendations contained in Chapter VI-2 would fail to bring about the shift in public policy mandating the assumption of state responsibilities for the achievement in partnership with the local communities of the goals set forth and the realization of the effective political and administrative leadership so evidently required.

The second and recommended course of action is the establishment of a Massachusetts School Construction Corporation set forth in Chapter VI-3 of this section. In the form presented, the corporation as a public instrumentality would be able to achieve each of the specific recommendations described. Its virtue would be its ability to provide a comprehensive solution to the school construction and financing problem; to be innovative and flexible in all phases of its responsibility; and at the same time, to provide the essential cooperation with the municipalities in meeting their needs.

Finally, in order to distinguish more clearly between the relative merits of these two courses of action, Chapter VI-4 compares the costs, cost savings, and time factors of alternatives presented.

A POSSIBLE COURSE OF ACTION: CHANGES WITHIN THE EXISTING FRAMEWORK

CHAPTER VI - 2

Changes made within the Existing Framework

This report recognizes that solutions to problems in the Massachusetts school construction process do not start from a clean slate. There is an existing framework which may be modified to a greater or lesser extent by specific legislative and administrative actions, each one of which could be addressed to solving a specific problem identified by this report and the aggregate of which would inevitably have a beneficial effect upon the resulting product.

The proposals for change to be made basically within the existing legal and administrative framework would provide for moderate increases in state responsibility and financial support for the construction of public schools. These changes are intended to accomplish the following results: (1) retention of the jurisdiction of the Board of Education through a strengthening of the School Building Assistance Bureau; (2) improvement of public safety and building regulations codes; (3) modification of bidding laws to accommodate special requirements of systems building; (4) increase in state aid; (5) assistance to local communities in determining school needs. Even with the implementation of one or even all of these changes, however, the basic relationship between state and local government in the school construction and financing process would remain largely as it is today.

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The specific recommendations for changes within the existing framework are proposed in full recognition of the limitations of the piecemeal approach to so significant a problem. Each of the changes to be outlined assumes that the Commonwealth would proceed to meet the school building need demonstrated in other parts of this report through existing agencies whose functions, administration and organization might be adapted for that purpose. It further assumes that that need would be met in substantial part through the authorization and utilization of systems building.

1. Department of Education A brief review of the history of the School Building Assistance Act is instructive as to the present limitations of the administrative agency. Founded in 1948, the agency has a minimal staff. It has been unable to recruit adequate numbers of professionals trained and experienced in school planning. The Commonwealth salary schedule has hampered the functioning of this agency by not permitting it to offer salaries competitive with universities, private consulting firms, or even for public school systems able to attract experienced planners. The present salary schedule, for example, cannot go beyond Job Group 18 (salary range of $11,400 to $14,000). Whereas public higher educational institutions have received a high degree of fiscal autonomy, making it possible to offer salaries to attract outstanding personnel, other state agencies such as the Department of Education have not been given that needed flexibility.

Throughout the course of this study we have heard from local and state officials of the need for substantially strengthening the staffing pattern and increasing the salary levels of persons working within the Department of Education. Criticisms of the functioning of the School Building Assistance Bureau may in substantial part be explained when one contemplates the workload of the agency and the personnel available to it to accomplish the tasks.

The present predicament of this agency will only be increased by the enactment of legislation in 1971 requiring the Department to render its approval or disapproval of applications for state aid within ninety days. Substantial increase in staffing will be required if this legislative objective is to be realized.

Unless the long-sought reforms of the state civil service system are adopted generally and are applicable to this agency, we would favor the exemption of at least the professional positions in the Department from the present outmoded civil service system.

The introduction of the use of systems construction will require the recruiting of highly skilled, professionally trained persons, competent to do the work. Salaries offered for such positions must be competitive. If the Department were to perform such needed roles as the inventorying of existing school spaces required, the evaluation of the condition of existing instructional spaces and the planning for future enrollment increases, additional staffing would be essential. We wish to emphasize that these new tasks must be performed while the agency undertakes to discharge its continuing burden of reviews and approvals.

A summary of our recommendations for improvements which should be achieved within the existing framework of the Department of Education is as follows:

(1) Increase in staff and budgetary flexibility for the Department.

(2) Simplification of the man
an undue burden upon many comm
state assistance.

(3) Establishment of an ongoi
costs, using statistical and d
now or in the future in the De

(4) Provision of greatly incr
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(5) Using increased staff and
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(2) Simplification of the many administrative steps which constitute an undue burden upon many communities in making their application for state assistance.

(3) Establishment of an ongoing program of research on spaces and costs, using statistical and data processing capabilities available now or in the future in the Department of Education.

(4) Provision of greatly increased procedural assistance through public information services to municipalities and school districts.

(5) Using increased staff and modernized facilities, undertaking and updating a complete inventory of public school building needs and facilities which will then serve as the basis of continuous comprehensive planning.

The implementation of each of these proposals would facilitate the construction of public schools through the improvement of the functioning of the Department. Special requirements of systems building, however, cannot be met simply by improving the administration of this agency. So long as there is to be an agency to assist the cities and towns in the delivery of school buildings, it should be made adequate to its responsibilities.

2. <u>The Board of Education and the Department of Public Safety</u>

Critical comment has been received during this study upon the failure of the Board of Education to comply with the provisions of Chapter 15 of the General Laws, specifically the provision contained in Section 1G requiring the establishment of minimal standards both for educational space requirements and for construction code standards for public school buildings. We recognize that the manner in which the provisions relating to the responsibilities of the Department of Public Safety are set forth in the statutes are such that a situation may have been created by which the Board of Education is not its own master in this vital field of establishment of standards. We also recognize that the Board of Education may have been reluctant to become involved in jurisdictional disputes between itself and another state department. Nonetheless, an impasse between two major departments has resulted at the expense of both the achievement of educational objectives and the waste of public tax dollars. Executive leadership is required to make certain that the Board of Education fulfills the obligations provided in Chapter 15, Section 1G, of the General Laws.

The problem of fragmentation of jurisdiction and authority under existing circumstances has been described in Chapter V-2 of this report. In view of the fact that there are in Massachusetts at least thirteen different state departments, agencies, boards or divisions issuing regulations concerning construction in general, producing a total of at least eighty-five different sets of regulations of general applicability, and involving at least six agencies specifically in the school building process, the report concludes that the source of wonder is that it has been possible for school buildings to have been constructed at all within the existing limitations.

If the present framework is to be continued, we further recommend the adoption of legislation modifying the provisions of Chapter 15, Section 1G of the General Laws to require the Board of Education to promulgate and establish its minimum standards as binding regulations on or before June 30, 1972. This promulgation should be in accordance with the provisions of the state Administrative Procedure Act (Chapter 30A of the General Laws) first as

proposed regulations so that all affected pers
of the Department of Public Safety, may be hea
prior to their going into effect. We propose
lating to the Department of Public Safety to p
disapproves of the minimum standards proposed
dispute would be finally resolved after a spec
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the impasse presently promoted by existing law
Board of Education's responsibility for final

There is also a lack, noted in this report, of
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those who promulgated a code and those whose r
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proposed regulations so that all affected persons, including representatives of the Department of Public Safety, may be heard concerning the regulations prior to their going into effect. We propose amendments to the laws relating to the Department of Public Safety to provide that if that department disapproves of the minimum standards proposed by the Board of Education, the dispute would be finally resolved after a special public hearing by a newly-established Board of School Building Standards. This procedure would end the impasse presently promoted by existing laws, and, for once, establish the Board of Education's responsibility for finally promulgating minimum standards.

There is also a lack, noted in this report, of any effective appellate procedure from the varying interpretation of codes and from attempts at enforcement procedures, particularly where differences of interpretation exist between those who promulgated a code and those whose responsibility it is to apply it to individual situations. In order to simplify existing practices and to ensure the protection of the public in a manner in which is fair and yet does not interrupt sound and economical construction, the following changes in the interpretation and application of codes are recommended as necessary.

There should be established within the Department of Public Safety a new and independent Board of School Building Standards, to be appointed by the Governor, consisting of a registered engineer, a registered architect, an educator, a member of the Bar of the Commonwealth, and a representative of labor. In addition to its role described above as final arbiter of code disputes between the Board of Education and the Department of Public Safety, this independent publicly-oriented board would have exclusive appellate jurisdiction over the decisions of the Commissioner of Public Safety and personnel of the Department of Public Safety pertaining to school building construction and the enforcement and interpretation of the applicable codes and regulations. In addition, the Board would make recommendations to the Commissioner of Public Safety, the Board of Education, and to the Governor and the General Court annually of needed changes in existing practices, codes, regulations and legislation in order to ensure that the pre-eminence of the school building code is not adversely affected by subsequent enactments or by actions of other agencies. The presently-legislated termination date of the existing Board of Schoolhouse Structural Standards (November 13, 1973) should be harmonized with this proposal once enacted.

This report recognizes that the pendency in the General Court during the course of this study of proposals for a statewide building code is inevitably related to the proposals made here, and it is to be anticipated that final legislative action concerning school building construction would be consistent with the status of other statewide codes.

3. <u>Public Bidding</u>. The ways in which the current public bidding laws inhibit the utilization of Systems Building procedures have been described in Chapter V-1. Specific technical amendments to the present laws relating to public construction, notably the filed sub-bid law (General Laws Chapter 149, Sections 44A-44L), may ease the present incompatibility of those laws with systems building. Specifically, this report would recommend the following: (1) Authorization of specific categories of filed sub-bids such as "integrated ceiling systems," "integrated wall systems" and others which would include trades otherwise specified in other filed sub-bids. It should be noted, however, that authorizing the bidding of integrated systems and thereby eliminating some of the work to be performed under specific trades, does not solve certain practical on-site problems which result from the situation when different sub-contractors may be working on different parts of the project. Ideally, the filed sub-bid law would authorize the use of systems bidding in any technologically feasible area.

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(2) Another amendment to the bidding procedures which might assist in harmonizing the systems approach with present law would be the clarification of the ambiguity under present statutes concerning serialized bidding upon one project, sometimes described as "fast-tracking." It has become the practice without clear or specific authorization of the statute, that an owner may issue a series of general contracts with specific filed sub-bids for different parts of the work to be done serially, or at least starting at the different times during the course of construction. Thus, foundation work is often let as a general contract with one or more filed sub-bids and normally is completed before the second of the series of general contractors commences upon the site. It should be noted that the serializing of general bids on one site is more complex when, as with systems building, it is likely that various general contractors will be working on the site at the same time. There again exists the practical problem of different subcontractors working for different general contractors on the same project at the same time, although proper construction management, when available, can ease the situation to some extent.

(3) A third amendment to the present laws which might assist bidding and contracting under a systems building approach is the specific authorization of performance specifications in lieu of detailed specifications. A problem with this proposal is, however, that there is no hard line dividing performance and detailed specifications, particularly in the gray area in which many specifications are inevitably written. A pure performance specification cannot be bid under the present law, and a pure detailed specification is often inconsistent with the goals of systems bidding. A general statement in the law with respect to performance specifications may, however, be

helpful in eliminating some of the problems which those who have attempted systems bidding under present statutes have encountered.

4. Market Aggregation The importance and desirability of market aggregation has been described in Chapter IV-4. In order to obtain the benefits of bulk purchasing and to facilitate the organized introduction of the systems approach to school construction, it is desirable to develop a coordinated program involving an aggregated market of school projects. There are two distinct ways in which market aggregation may be accomplished within the existing legal and administrative framework:

(1) Voluntary Consortium. Several school districts may bind themselves together in a consortium as was done for the original SCSD program in California. There, for instance, thirteen districts organized to build twenty-two schools.

(2) State-Sponsored Program. A state agency, such as the Department of Education, may provide a continuing organization to administer the market aggregation program. This was done in the successful SSP program in Florida, which has now been building schools for several years. Participation by school districts is voluntary.

Some modest acknowledgment of the possibility of those procedures in Massachusetts has been suggested by the enactment in 1971 of legislation authorizing collective purchasing by the Commonwealth and one or more municipalities and districts (Chapter 53 of the Act of 1971).

The voluntary consortium has three disadvantages in comparison to a statewide program:

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(a) The time required to organize this program, dependent upon separate fiscal authorization, may delay the towns to a point beyond that at which they would have started if they had been working individually. (A state program can already have the administrative mechanism. Preliminary product investigations can be done before a school building project comes on line.)

(b) Because of this delay factor, a degree of attrition may occur among the towns which have volunteered to participate, creating difficulties in terms of making volume guarantees to suppliers. Attrition may occur because school building committees are unable to cooperate, or because bond issues are not approved by the voters.

(c) It is unlikely that the size of the market aggregation with voluntary membership would be as great as a state agency could provide. There are a number of measures which could be taken within the existing legal and administrative framework which could greatly assist localities in aggregating a significant purchasing market. These fall into three categories:

(1) Extra services by the State. Any market aggregation program requires some central administration; some or all of this could be provided pursuant to centralized purchasing rules by the Department of Education (or any other existing agency properly staffed). This is the role which the Department of Education played in Florida's successful SSP program. Some of these functions include:

(a) Product investigation, specification and selection;

(b) Coordination of separate school districts into a voluntary aggregation program; provision of some contractual mechanism to insure participation after initial commitment has been made;

(c) Bulk bidding and purchase of products.

(2) Increased construction subsidies above present levels to benefit communities participating in an aggregation program. Adjustment of subsidy levels has long been one of the most accepted and workable methods of encouraging or discouraging participation in programs which the government believes will work for the public good.

In Massachusetts, where school construction has been partially subsidized by the state since 1948, this has been used both on programs which are considered morally and ethically desirable (elimination of racial imbalance) and on programs which are simply considered preferable on economic grounds (regionalization). In each case the state subsidy administered through the provisions of the School Building Assistance Act is raised from 40% up to 65% of the construction cost. It could, therefore, be used to encourage market aggregation by paying a higher than normal subsidy to school districts participating in an aggregation program.

(3) Financial guarantees to suppliers. A problem in many forms of voluntary consortium is that individual members may opt out, either because they have a change of heart, or because their building project is simply not going to be carried out. Once negotiations with suppliers are underway, the reduction in the size of an order can have an adverse effect on prices and contractual terms. If the consortium or negotiating body were backed up by a state guarantee of a minimum order, this obstacle could be surmounted. If an individual district dropped out of the program, the state could undertake to find

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5. Financing School Buildings

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another district to take the first one's place rather than to pay under such a guarantee.

5. Financing School Buildings

A possible change which might be made in the existing framework relating to the financing of school building construction would be the granting, through legislative action, by the Commonwealth of an unconditional guarantee of both principal and interest of each municipality's and district's school bond issues. This grant would require a two-thirds vote of both branches of the General Court under present constitutional provisions. This change would probably save one quarter of 1% interest cost on the average for all issuers. However, this change would not eliminate all of the cost and time spent in preparing and marketing each issue by the municipality.

Even the adoption of this change would not aggregate the school bond market as would result if all school bonds were issued by one entity with the full faith and credit of the Commonwealth securing the bonds. Much of the present hit or miss financing would inevitably be carried forward, even with the Commonwealth's guarantee.*

If justification were needed for such a proposal to commit the Commonwealth to 100% state guarantee on school construction, it may be found in a revealing statistic upon which this study has relied. Massachusetts ranks forty-seventh in state aid to school districts by providing only 20% of the total operating expenditures. Hawaii provides 87%; forty-six states provide more

* There would be no reason why state grants for schools could not be increased to 100%; thus effectively eliminating need for a municipal bond issue and the local referendum.

than the 20%.*

As an alternative to 100% state guarantee, this report suggests a legislative revision of the present two-thirds requirement for authorization of local borrowing for the construction of public schools. The funding of school building costs by municipalities poses a serious problem to voters presented with bond issues. Massachusetts law (Chapter 44(7)) requires a two-thirds vote to authorize town indebtedness for school construction. This means, in effect, that a negative vote is worth twice as much as a positive vote, thereby making the authorization of a bond issue for school construction extremely difficult. In the past few years, some have looked to the United States Supreme Court to apply the doctrine of "one man, one vote" by eliminating by judicial fiat the requirement of a two-thirds vote in this area. The Supreme Court, has, however, spoken and has recently held that such a requirement did not contravene the provisions of the United States Constitution.

The way is, therefore, left open for the General Court to change the requirement of the two-thirds vote and establish a majoritarian concept here as in so many important areas in public affairs. The study concludes that the establishment of majoritarian rule for the authorizing of school building indebtedness would be in the public interest and would inure to the benefit of the taxpayers so long as the safeguards contained in the provisions establishing the Emergency Finance Board (General Laws Chapter 44, Section 10), were continued. The failure of communities to meet a stringent two-thirds vote requirement, often over a long period of time, has ultimately increased the cost actually paid by the taxpayers for the needed facility. In the

* Charlotte Ryan, The State Dollar and the Schools, Massachusetts Advisory Council on Education, 1970, p.4.

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6. Roles and Responsibilities of Municipalities. The failure of many of the cities and towns to have adequately surveyed existing school facilities and to have prepared a comprehensive needs projection for an appropriate period has substantially increased the ultimate cost paid for school construction during recent decades. Too often needs have not been adequately perceived nor has there been the kind of creative leadership in school land use planning that would facilitate renewal or development and economic growth of local communities through comprehensive well-planned community action. Legislation is desirable, therefore, requiring each city or town of the Commonwealth to establish on or before June 30, 1972, a standing School Committee consisting of five members, at least one of whom would be a member of the school committee designated by its chairman and at least one of whom would be appointed by the selectmen, mayor or manager. Members would serve for a term of three years; initial appointments would have staggered terms. The Superintendent of Schools would be a member of the committee ex officio.

The standing School Building Committee would survey existing school facilities, project school building needs and develop a comprehensive land use plan in accordance with the standards which may be established from time to time by the state Board of Education. The committee would be responsible for the provision and selection of sites by purchase or otherwise. It would be empowered to select and retain architects, approve plans and provide for the construction of school facilities as authorized by the community.

The establishment of standing school building committees would greatly facilitate the planning and construction of schools and would afford an opportunity for the participation of both educational and municipal administrators as well as citizens during the critical decision making process. It would further provide the continuity which has been lacking in most communities.

Thus, it is evident that there are many possible courses of action to effectuate beneficial changes working substantially within the existing administrative framework or through specific, substantive changes through the enactment of needed legislation. We have enumerated in this section a variety of proposals which we believe should be adopted in the event that the state government were to adopt the view that fundamental and comprehensive changes cannot or should not be adopted.

Such a decision would shortchange the Massachusetts taxpayer. It would favor established, entrenched bureaucratic interests. It would disregard the full potential which may be achieved through demonstrated technological advances and modern management techniques.

It is emphasized, however, that the adoption of all or any of these proposals would be preferable to the present condition. We conclude that measured by the potential benefits that could be achieved, both the Massachusetts taxpayer and our children would suffer nonetheless were the Commonwealth to settle for these limited alternatives.

THE RECOMMENDED COURSE OF ACTION: ESTABLISHME CONSTRUCTION CORPORATION

CHAPTER VI - 3

The second possible course of action which this report recommends is the establishment of the Massachusetts School Construction Corporation, providing for the direct assumption by the Commonwealth of the major responsibility for the design, construction and financing of public schools. The Commonwealth's role would be, to be sure, in cooperation with the municipalities, but it is fair to say that under the construction corporation, the state's role as a passive partner would end.

The existing uncoordinated, cumbersome and decentralized process for planning and building schools would be replaced by a centralized process which could exploit the modern techniques of management and construction which have been analyzed at length in the preceding portions of this report.

From the taxpayer's point of view, the burden of the cost of school construction would be shifted from the unpopular local property tax through the assumption of school buildings costs. The net effect of this would be not simply to shift the burden, but to reduce it as well, since the state would be in a position to build schools much more economically than municipalities are currently building them.

This recommendation is designed to achieve the construction of first quality public school facilities within a realistic period of time, at the least possible costs, utilizing modern methods of technology, construction, administration and management. Under this proposal governmental and funding relationships would be reshaped pragmatically so as to achieve the programatic objectives and to save tax dol

It is proposed that legislati School Construction Corporatio existing executive officers un recommendation is made here as the autonomous corporation sho the legislation establishing t during the next two years for further legislation as to the the considerations which shoul following:

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(2) The construction responsib of its placement within the Ex Construction.

(3) The educational subject ma consideration being given to i Educational Affairs. Regardle izational chart, however, its for the provision of school bu essential comprehensive recomm

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It is proposed that legislation be adopted establishing the Massachusetts School Construction Corporation as a state agency within one of the existing executive officers under the present cabinet system. No recommendation is made here as to the particular cabinet secretariat in which the autonomous corporation should be placed, and it is noted that under the legislation establishing the Governor's cabinet authority exists during the next two years for decisions through Executive Orders or by further legislation as to the ultimate placing of specific agencies. Among the considerations which should be weighed in this decision are the following:

(1) The planning function of the corporation would seem to appear to make it suited for inclusion within the Executive Office of Communities and Development.

(2) The construction responsibilities would indicate the appropriateness of its placement within the Executive Office of Transportation and Construction.

(3) The educational subject matter with which it deals results in some consideration being given to its placement within the Executive Office of Educational Affairs. Regardless of its eventual placement in an organizational chart, however, its establishment as a public instrumentality for the provision of school buildings throughout the Commonwealth is the essential comprehensive recommendation of this report.

The Massachusetts School Construction Corporation as recommended in this report is described as follows:

1. Structure of the Corporation
2. Purposes and Functions of the Corporation
3. Functions of the Municipalities
4. Functions of Other State Agencies
5. A Program for the Transitional Period

(1) Structure of the Corporation

The corporation would function under the Board of Directors composed of fifteen members appointed by the Governor for five-year terms. The members would be appointed from the following categories:

(a) Cities

i. one from a city over 500,000 in population

ii. one from a city between 100,000 and 500,000 in population

iii. one from a city less than 100,000 in population

none of whom would be from the same county

(b) Towns

i. one from a town within the metropolitan Boston area

ii. one from a town under 5,000 in population

iii. two from other towns

none of whom would be from the same county

(c) Professional members

i. a superintendent of schools

ii. an educator

iii. an architect

iv. a person experienced in industrial or construction management

v. a person experienced in municipal and state finance

(d) two members from the pu

none of whom would be from

(e) the chairman of the Boa

The members would serve without

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Other officers would be elected

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(d) two members from the public at large
none of whom would be from the same county

(e) the chairman of the Board of Education

The members would serve without compensation but with reimbursement of expenses. We propose that the chairman be designated from time to time from the members by the Governor, in order to maintain accountability in the office of the Governor for the standard of performance of the corporation. Other officers would be elected by the board in accordance with by-laws established by them.

In order to insure that the functions of this board would be carried out free from political interests, not more than eight members would be of the same political party.

The Board of Directors would enact and appoint requisite professional staff and personnel and would be responsible for the achievement of the objectives of the corporation. The corporation would not be subject to the provisions of the Civil Service laws. The tasks to be performed by this agency require the highest degree of flexibility and competence, and they necessitate the offering of competitive salaries commensurate with those paid for comparable skills in the private sector. The tasks to be performed by the corporation are in fact those performed by top level managers in private industry and the corporation must be free to assimilate the techniques and executive procedures and policies necessary to insure the carrying out of such responsibilities in an independent and businesslike manner. This would include incidentally the ability to reduce its staff when need allows. The corporation would be subject to audit by the State Auditor to insure appropriate accountability to the general public.

(2) <u>Purposes and Fuctions of the Corporation</u>

The purposes of the corporation would be to provide for the design, construction management, construction and state financing of school buildings. To carry out these purposes, it would perform the following functions:

(a) It would assist the local communities in developing

- (a) a comprehensive survey of existing school building facilities
- (b) projections of school building needs
- (c) a comprehensive school land use plan

It is contemplated that such a plan would be developed by each community for a five-year projected period which would form the basis of a statewide detailed survey providing current inventories of existing facilities and a projection of future needs. The broad advantages of this provision and its potential for economic growth and community development are ovbious. The costs of such planning would be funded by the corporation and the plan could be done either through the use of consultants or by educational and planning staffs within the local communities, if available.

(b) The corporation would cooperate with the Department of Education to establish the procedure and standards of review for the cities and towns to survey their existing facilities and needs and to establish the criteria for site selection.

(c) The corporation would cooperate with the Department of Education in the development of educational program specifications as required under the provisions of General Laws Chapter 15, Section 1G.

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(d) The corporation would establish and administer the procedure for the planning and construction of schools throughout the Commonwealth.

(e) The corporation would administer safety and building codes for school construction developed by the Department of Education and Commissioner of Public Safety as hereinafter set forth.

(f) The Corporation would provide design review of plans drawn up by architects selected by the municipalities.

(g) The corporation would administer under a new system of competitive bidding the construction of school facilities and the purchase of components for school construction.

(h) The corporation would administer a program of market aggregation rather than being a goal incidentally achievable from time to time by one or more of municipalities. Market aggregation as administered by the Massachusetts School Construction Corporation would have the advantage of a much larger volume and consequently have the potential of greater savings. Thus, if 80% of all schools were systems schools and 40% of the components were systems components, a market would be provided attractive enough for the largest of component manufacturers. In addition, some non-systems components, such as windows and plumbing fixtures, might be purchased in bulk for several schools at a time, thereby increasing further the market strength of the corporation. Ultimately systems components could constitute 75% of the entire building program.

(i) The corporation would have authority to employ the best technique of construction management in cultivating its construction program.

(j) The corporation would provide a continuing program of research and developments relating to construction techniques, building materials, planning, and cost data analysis. Those functions are currently beyond the financial limits and resources of individual local communities and in fact are not presently being carried out by any of the communities involved in building schools. The changes which have occurred in building technology and the resultant development of new materials and building techniques makes the provision of this service an essential part of any economical school construction process.

Under this proposal the corporation would provide the funds for the cost of planning, design and construction of all public schools. It would in cooperation with the Department of Education establish standards for public schools. Communities desiring to supplement a school building project beyond such standards, perhaps a community center or for some other municipal or educational purpose, would be required to bear the added costs but all other costs of planning, design and construction would be funded and carried out by the corporation.

In order to ensure equal educational opportunity, it is proposed that the corporation be empowered in instances when communities have failed to provide needed sites for schools, and in cases of urgent need, to recommend to the Governor whether it is in the public interest to have the Commonwealth exercise the eminent domain power. The exercise of that power would only be undertaken, under the proposal, with the approval of the Governor. In such cases, presumed to be rare, the cost of land thus incurred would be assessed back upon the local community.

This proposal requires that the state provide the initial appropriation for the agency startup costs and for preliminary project costs. Thereafter, money that is required for the operation of the corporation and the funding of projects would be derived from a percentage of construction cost savings. The amount of bonding authorization would be, under present constitutional requirements, recommended periodically by the Governor

and authorized by enactments pa
of the General Court. The peri
would be flexible in order to t

The financial powers to be gran
issue both temporary notes and
and credit of the Commonwealth
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After an initial bonding author
year period, we recommend that
School Building Assistance Act
the School Building Corporation
1976, or, upon authorization by
then pending projects are compl

(3) <u>Functions of the Municipali</u>

It is recommended as part of th
requiring each city and town to
consisting of five members, at
school committee designated by
of whom would be appointed by t
serve for a term of three years

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and authorized by enactments passed by two-thirds majorities of each branch of the General Court. The period for which notes and bonds may be issued would be flexible in order to take full advantage of market conditions.

The financial powers to be granted the new corporation would enable it to issue both temporary notes and permanent bonds backed 100% by the full faith and credit of the Commonwealth with respect to principal and interest. This method would relieve all municipalities from the responsibility of issuing school construction bonds, together with the costs and time involved in their issuance. By using this procedure the corporation could schedule permanent financing in accordance with projections of the economy and market and would have large enough issues to attract nationwide syndicates, thereby enabling the corporation to obtain the lowest possible rate of interest available at any given time. We believe this ability alone would probably save one half of 1% in interest costs.

After an initial bonding authorization sufficient to cover a three to five year period, we recommend that the existing functions provided for under the School Building Assistance Act which would continue for all projects not under the School Building Corporation, would be able to be terminated by June 30, 1976, or, upon authorization by the Governor, until such further time as all then pending projects are completed.

(3) Functions of the Municipalities

It is recommended as part of this course of action, that legislation be enacted requiring each city and town to establish a Standing School Building Committee consisting of five members, at least one of whom would be a member of the school committee designated by the chairman of such committee and at least one of whom would be appointed by the selectmen , mayor or manager. Members would serve for a term of three years: initial appointments would have staggered terms. Similar committees would be established for each regional school district.

Each such committee would have the following responsibilities:

(a) to survey existing school facilities, prepare a projection of school population and school building needs, and prepare a plan for the comprehensive development of school land use;

(b) to hold a public hearing on the plan;

(c) to provide a site by purchase or otherwise;

(d) to obtain an educational program and space requirements for a specific school project as each is to be undertaken;

(e) to select an architect; (See Appendix for AIA recommended process);

(f) to approve preliminary plans;

(g) with the School Committee, to accept the school building once constructed on behalf of the city of town (operation and maintenance of the building remains a function of the school committee).

Each building committee would be required to maintain records and file reports with the appropriate city officials and the corporation.

Under this proposal the local committees would therefore retain jurisdiction over site selection, educational program, space requirements (consistent with state established standards) and final selection of an architect and approval of preliminary plans. Thereafter the design, construction and funding of each school facility would be carried out by the corporation.

A chart of one possible set of Procedures for Constructing A School under such a corporation is attached as Exhibit 2.

(4) <u>Functions of Other State Agencies</u>

(a) Department of Education: The Board of Education would retain its present functions set forth in Chapter 15 of the General Laws relating to the

establishment of minimum standards for all
we propose the adoption as part of the sta
School Construction Corporation, other leg
of Chapter 15, Section 1G so as to require
minimum standards as binding regulations o
ance with the provisions of the Administra
legislation, the Department of Public Safe
the minimum standards published as propose
they relate to areas within their jurisdic
ment of Public Safety would be finally res
a newly established Board of School Buildi
School Building Assistance Act would, as d
30, 1972, or such further time as the Gove

(b) <u>Department of Public Safety</u>: In
and to insure the protection of the public
does not interrupt sound and economic buil
the following changes are necessary:

(i) The presently legislated t
of Schoolhouse Structural Standards (Noven
with this proposal once enacted.

(ii) The Department of Public S
to the appellate review of the Board of Sch

(c) Department of Public Health: Th
powers and duties relating to the approva
for site selections for public schools by

(5) <u>A Program for the Transitional Perio</u>

This report recognizes that there will be ablished for each regional school dis-

owing responsibilities:

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Board of Education would retain its

15 of the General Laws relating to the

establishment of minimum standards for all public school buildings. However, we propose the adoption as part of the statute creating the Massachusetts School Construction Corporation, other legislation modifying the provisions of Chapter 15, Section 1G so as to require the board to promulgate and establish minimum standards as binding regulations on or before June 30, 1972, in accordance with the provisions of the Administrative Procedure Act. As part of this legislation, the Department of Public Safety would be allowed to disapprove the minimum standards published as proposed regulations by the department as they relate to areas within their jurisdiction. Any dispute between the Department of Public Safety would be finally resolved by a special public hearing by a newly established Board of School Building Standards. Activity under the School Building Assistance Act would, as described above, continue until June 30, 1972, or such further time as the Governor might authorize.

(b) Department of Public Safety: In order to simplify existing practices and to insure the protection of the public in a manner which is fair and yet does not interrupt sound and economic building construction, we believe that the following changes are necessary:

(i) The presently legislated termination date of the existing Board of Schoolhouse Structural Standards (November 13, 1973) should be harmonized with this proposal once enacted.

(ii) The Department of Public Safety will enforce the code, subject to the appellate review of the Board of School Building Standards.

(c) Department of Public Health: The department would retain its present powers and duties relating to the approval of health and sanitary requirements for site selections for public schools by local communities.

(5) A Program for the Transitional Period

This report recognizes that there will be a transitional period, if the Massachusetts School Construction Corporation is established, during which the provisions of the School Building Assistance Act and the Corporation will both be operative and that such a period might give rise to a problem of a potentially substantial nature to which the Commonwealth must address itself. That problem would arise if some communities would intentionally fail to build needed schools under School Building Assistance Act procedures and the existing partial state funding, awaiting the opportunity to do so under the full funding of the corporation.

A variety of alternative proposals for the adjustment of this situation and the insuring of various means of providing incentives to local communities not to delay but rather to build needed schools during the transitional period, has been considered. We have concluded, however, that from the point of view of the taxpayer and from the point of view of the quality of schools which may result, the best solution to this problem is the adequate funding of the corporation at the outset, thus the shortening of the period during which potential difficulty might exist. As a practical matter, this would require the complete funding and staffing for the planning functions of the corporation and for the building of a number of pilot demonstration school projects which might be selected from among those applicants with the most pressing needs upon the creation of the corporation.

Alternatively, it is possible for the enabling legislation to include a provision extending the benefits of state funding retroactively to all new school projects underway at an early date subsequent to the release of this report, conceivably as early as January 1, 1972. If the General Court should in its wisdom prefer to adjust the existing reimbursement formula to provide increased state aid during the transitional period, such a solution, although it may not provide for the greatest return on the tax dollar, would be justified as leading toward the goal of a fully-operating state school construction program. If it is

Exhibit 2

RECOMMENDED PROCEDURES FOR CONSTRUCTING

MASSACHUSETTS SCHOOL CONSTRUCTION CORP

Constitution	1.	assigns "duty future periods schools." (Cha
General Court (Legislature)	2.	authorizes Sta minimum educat
	3.	requires every of schoolhouse (Chapter 71, S and provide fu fort of the pu
	4.	authorizes Mas (MSCC) to fund
MSCC	1.	notifies citie Committee
	2.	notifies commu a. develop a building b. project s c. develop a
SBC	3.	consults with surveys and ob
	4.	submits survey
MSCC	5.	approves compre
	6.	establishes pri reports of need
	7.	selects, within number of schoo
SBC	8.	obtains educati
	9.	selects and app
	10.	provides site.
MSCC	11.	approves site

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Exhibit 2

RECOMMENDED PROCEDURES FOR CONSTRUCTING A SCHOOL

MASSACHUSETTS SCHOOL CONSTRUCTION CORPORATION

Prologue

Constitution	1.	assigns "duty of legislatures and magistrates in all future periods of the Commonwealth to cherish...public schools." (Chapter V, Section II)
General Court (Legislature)	2.	authorizes State Board of Education to establish minimum educational standards. (Chapter 15, SECTION 1G)
	3.	requires every town to maintain "a sufficient number of schoolhouses...for the accommodation of all children" (Chapter 71, Section 1), "Keep them in good order... and provide fuel and all things necessary for the comfort of the pupils." (Chapter 71, Section 68)
	4.	authorizes Massachusetts School Construction Corporation (MSCC) to fund construction of school projects.

Procedures

MSCC	1.	notifies cities and towns to appoint School Building Committee
	2.	notifies communities to: a. develop a comprehensive plan of existing school building facilities; b. project school building needs; c. develop a school land-use plan.
SBC	3.	consults with Corporation, arranges for completion of surveys and obtains funding and contract approval.
	4.	submits surveys and plans to MSCC.
MSCC	5.	approves comprehensive plan, survey and school land-use.
	6.	establishes priorities for construction based upon reports of needs.
	7.	selects, within appropriation from General Court, the number of schools for construction.
SBC	8.	obtains educational program and specifications.
	9.	selects and approves architect.
	10.	provides site.
MSCC	11.	approves site.

	12.	establishes preliminary budget for construction projects.
Dept. of Education	13.	approves educational specifications.
Architect	14.	prepares detailed preliminary plans (space requirements, exterior appearance, and site development).
SBC	15.	approves preliminary plans.
Dept. of Education	16.	approves preliminary plans.
SBC	17.	submits preliminary plans to MSCC.
MSCC	18.	reviews preliminary plans.
SBC	19.	attends meeting with MSCC.
MSCC	20.	approves preliminary plans.
	21.	aggregates market of schools.
	22.	prepares performance specifications for product purchase.
	23.	bids performance specifications.
	24.	accepts bids.
	25.	approves bids from manufacturers.
Architect	26.	prepares working drawings and specifications.
	27.	submits working drawings to MSCC.
MSCC	28.	approves working drawings.
Dept. of Education	28a.	approves working drawings.
MSCC	29.	advertises for construction.
	30.	accepts bids
	31.	awards contracts for construction.
	32.	approves contractor's payments recommended by the architect.
	33.	conducts field inspection.
SBC/Architect	34.	orients staff to new school.
	35.	presents school facilities to School Committee.

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the second course of action, is in the bes
problem of the transitional period should
result. Indeed, any proposal which provid
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ultimately decided that the Massachusetts School Construction Corporation program, the second course of action, is in the best interests of the Commonwealth, the problem of the transitional period should not deter policy-makers from that result. Indeed, any proposal which provides the needed schools, provides them when they are needed and provides them economically is indeed *the* solution to the goals which the Commonwealth has set for itself to educate its children.

A COMPARISON OF TIME AND COST FACTORS FOR EACH OF ACTION

CHAPTER VI - 4

It is possible to evaluate those factors of the two courses of action previously outlined above which almost certainly will affect the final results, measured by time and costs. A comparison demonstrates conclusively that considerable savings can be made in time and money, and that the Corporation has both higher potential savings and a greater portential for success than does the piecemeal approach, working within the existing framework.

Savings on Initial Cost

The Recapitulation of Potential Cost Savings (Chapter V-6) listed the maximum potential savings through all sources.

The only course which could hope to realize all these would be the establishment of the Massachusetts School Construction Corporation as outlined. This is because although many of the individual changes necessary to cut costs could theoretically be made by a series of separate actions of the General Court, the Department of Education and some two other state agencies, in real terms, the political likelihood of all the proposed changes being made separately is virtually nil. Even were they all accomplished, the coordination necessary to achieve maximum time and dollar savings would still be lacking. The Corporation, by contrast, is a coordinated and unified program, which would in a single stroke start a mechanism by which all the necessary changes could be made. Only a packaged program would "put it all together."

The nature of the reforms is such that they are mutually supporting. It is a case where the whole is greater than the sum of the parts. The individual changes

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may be desirable, but their full benefit is only obtained when they are used as part of a complete school delivery process.

The use of systems components and installation, for instance, may save money by itself, but its time benefit will be more fully realized when coordinated by modern project management techniques. Likewise, while phased construction may produce benefits when used with traditional building components, they will be greatly enhanced by the use of systems components. Therefore the changes in the constructional process -- systems products and installation, contract management, performance specifications, and phased contracts, are not listed separately in the following comparison of costs. (Exhibit 1).

Because of this interrelation of factors, therefore, not only would the Corporation be able to achieve higher maximum potential savings, it would also have a far greater chance of achieving its maximum than would a piecemeal, decentralized approach. In viewing the potential cost benefits to Massachusetts, it may be realistic to expect the Corporation to achieve 30% savings very soon after its inception, whereas even the "probable" savings of 20% listed for the piecemeal approach would only be achieved if all the individual improvements are enacted, which is itself relatively improbable.

Neither of the two programs outlined could be carried out without incurring some operating expenses. In the case of the corporation they would appear as its operating budget. For the piecemeal approach, they would be mainly in project management fees plus the administrative costs of market aggregation, if any were carried out. Based on present professional project management service fees, this item is estimated to run 2-3% of construction costs for either course of action. However, this expense would be more than offset by the savings to be achieved through this process. This fact is graphically demonstrated in Exhibit 1, where the administrative costs have been deducted from the gross savings. The savings listed therefore are the <u>net</u> savings which result after deducting any expenses which would be charged against them.

Time Factors

This report has demonstrated that the present process for construction of schools takes too long, and that a great deal of time can be saved*. The typical school delivery process, from identification of the need to occupancy of the building, takes from three to ten years. The typical process for school construction when the bond issue is passed at the first opportunity is approximately four years. This time span includes agreement upon the need, setting up committees, acquisition of the site, deciding upon educational specifications, design and working drawings, and construction. The defeat of a bond proposal may add from one to five years to the delivery time of a needed school.

The importance of time varies from project to project. Because of the rapid escalation of building costs, earlier completion of a project ordinarily means a saving in project cost. By taking note of how and where time is spent or lost, it is possible to draw what should be realistic conclusions about the relative potential of the two courses of action outlined above. This evidence indicates that implementation of the possible changes within the existing framework would save from 6 to twelve months on the usual planning and construction process, and that establishment of the Massachusetts School Construction Corporation would save from one and a half to two years. Exhibit II presents a summary of these potential savings.

* Delay in school construction -- chapter II-2
Design and construction time -- chapter III-6
Time advantages of systems -- chapter IV-2
Time saving techniques -- chapter IV-4

Exhibit I
COMPARISON OF POTENTIAL COST SAVING ON SCHOO
OF ACTION

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Table 1:
<u>SAVINGS ON CONSTRUCTION COST PER SQUARE FOOT</u>

Net savings through the Systems Construction Process:	5%
Systems Components & Installation	
Performance Specifications	
Prequalification of Bidders	
Project Management	
Phased Construction	
<u>Less</u>: Deduction for Administration of Program	
Volume Purchasing	1
Net Savings	6%

Table 2:
<u>SAVINGS FROM REDUCTION OF FLOOR AREA</u>

Increased Planning Efficiency (reduction of gross:net ratio)	8%
Reduce Programmed Space Requirements	8
	15%

Table 3:
<u>COMBINED SAVINGS OF REDUCED COST PER SQUARE</u>

Cost per sq.ft. Savings (from Table 1)	6%
Floor Area Savings (from Table 2)	15
Combined Savings on General Contract	20%

(Note that figures in above calculations are adding the savings, because successive savi a percent.)

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Exhibit I
COMPARISON OF POTENTIAL COST SAVING ON SCHOOL CONSTRUCTION UNDER DIFFERENT COURSES OF ACTION

	Savings through Changes Within Existing Framework		Savings thru Mass. School Construction Corporation		
			Initially		6-10 yrs. in future
	Probable	Maximum	Probable	Maximum	
Table 1: SAVINGS ON CONSTRUCTION COST PER SQUARE FOOT					
Net savings through the Systems Construction Process: Systems Components & Installation; Performance Specifications; Prequalification of Bidders; Project Management; Phased Construction; Less: Deduction for Administration of Program	5%	9%	13%	16%	20%
Volume Purchasing	1	3	6	6	6
Net Savings	6%	12%	18%	21%	25%
Table 2: SAVINGS FROM REDUCTION OF FLOOR AREA					
Increased Planning Efficiency (reduction of gross:net ratio)	8%	10%	8%	10%	10%
Reduce Programmed Space Requirements	8	10	8	10	10
	15%	19%	15%	19%	19%
Table 3: COMBINED SAVINGS OF REDUCED COST PER SQUARE FOOT AND REDUCED FLOOR AREA					
Cost per sq.ft. Savings (from Table 1)	6%	12%	18%	21%	25%
Floor Area Savings (from Table 2)	15	19	15	19	19
Combined Savings on General Contract	20%	29%	30%	36%	40%

(Note that figures in above calculations are not what would be obtained from simply adding the savings, because successive savings must be calculated as a percent of a percent.)

POTENTIAL TIME SAVINGS ON TYPICAL SCHOOL BUILDING PROJECT

Steps in Procedure	Usual Time Under Existing Procedures	First Course (Possible) Time Saved by Adopting Changes Within Existing Framework	Second Course (Recc Time Saved by Adopt School Constructior
1. Needs Survey	6-12 months	Years may be saved by identification of need sufficiently in advance to ensure that school can be built by time it is needed. However, possibility of bond rejection means there is always an uncertainty, so that advantage of pre-planning may be lost.	Years may be saved ciently in advance by time it is neede
2. Setting up School Building Committee	0-3 months depending on whether permanent committee exists	Permanent school building committees (in those municipalities which do not already have them) can save months in pre-planning stage by building on previous experience.	Same as for First C
3. Site Selection & Acquisition	1-12 months or more	1. & 2. above can ensure that this time-consuming step is carried out sufficiently in advance to avoid delay. Elimination of delay can save 0-12 months.	1. & 2. above can e is carried out suff Elimination of dela will know it must c eligible for school with it with dispat
4. Preparation of Educational Specifications	1-12 months	Possible standards by the Dept. of Education would save a month at least, and in many cases could reduce many months of delay by eliminating need for lengthy discussion.	Same as for First C
5. Architect Selection	1-3 months	Permanent school building committee may be able to select architect more quickly than inexperienced committee.	Having standing lis their interest in c submitted their cre necessary effort fo
6. Preliminary Plans	2-4 months	Knowing systems planning grid and structural bays can save 0-1 month.	Same as for First C
7. Planning & Safety Approvals	0-3 months	Not all jobs are delayed, but many are. Reduction of number of approvals needed and being able to work to written standards can reduce unnecessary delays. Save 0-3 months.	Same as for First C
8. Detailed Design	2-6 months	Having dependable standard details can save 1 month.	Same as for First C
9. Working Drawings & Specifications	3-9 months	Systems design reduces number of working drawings and ensures that many details are worked out in advance. Save 1-3 months.	Same as for First C
10. Bidding	1 month	No possible time saving as long as phased construction is not permitted by bid procedures.	1. Systems componen months before ne 2. Phased contracts drawings are com
11. Bond Issue Referendum	1 month for referendum; rejected bond may delay school 1-5 years or more	No possible saving as long as construction hinges on bond referendum. Phased construction is not practical as long as uncertainty exists about whether project will proceed.	1. Elimination of r but also is nece realistic. 2. Elimination of p on going ahead.
12. Construction	18-30 months	Systems components and site management may save 4-8 months.	Same as for First Co
TOTAL	3-10 years or more	6-12 months reduction below usual time	$1\frac{1}{2}$-2 years reductior Elimination of dela 5-8 years or more of

Note: Totals may not equal sum of individual times because steps of procedure may sometimes overlap.

:HOOL BUILDING PROJECT

First Course (Possible) Time Saved by Adopting Changes Within Existing Framework	Second Course (Recommended) Time Saved by Adopting Mass. School Construction Corporation
Years may be saved by identification of need sufficiently in advance to ensure that school can be built by time it is needed. However, possibility of bond rejection means there is always an uncertainty, so that advantage of pre-planning may be lost.	Years may be saved by identification of need sufficiently in advance to ensure that school can be built by time it is needed.
Permanent school building committees (in those municipalities which do not already have them) can save months in pre-planning stage by building on previous experience.	Same as for First Course.
1. & 2. above can ensure that this time-consuming step is carried out sufficiently in advance to avoid delay. Elimination of delay can save 0-12 months.	1. & 2. above can ensure that this time-consuming step is carried out sufficiently in advance to avoid delay Elimination of delay can save 0-12 months. Since town will know it must complete this step in order to be eligible for school, it will have incentive to deal with it with dispatch.
Possible standards by the Dept. of Education would save a month at least, and in many cases could reduce many months of delay by eliminating need for lengthy discussion.	Same as for First Course
Permanent school building committee may be able to select architect more quickly than inexperienced committee.	Having standing list of architects who have stated their interest in designing schools and who also have submitted their credentials in detail could save unnecessary effort for committee, save 0-2 months.
Knowing systems planning grid and structural bays can save 0-1 month.	Same as for First Course.
Not all jobs are delayed, but many are. Reduction of number of approvals needed and being able to work to written standards can reduce unnecessary delays. Save 0-3 months.	Same as for First Course.
Having dependable standard details can save 1 month.	Same as for First Course.
Systems design reduces number of working drawings and ensures that many details are worked out in advance. Save 1-3 months.	Same as for First Course.
No possible time saving as long as phased construction is not permitted by bid procedures.	1. Systems components may be bid and contracted for months before needed - save 0-2 months. 2. Phased contracts allows construction to begin before drawings are complete - save 1-3 months.
No possible saving as long as construction hinges on bond referendum. Phased construction is not practical as long as uncertainty exists about whether project will proceed.	1. Elimination of referendum saves $1\frac{1}{2}$ months in itself, but also is necessary to make phased construction realistic. 2. Elimination of possible rejection eliminates delays on going ahead.
Systems components and site management may save 4-8 months.	Same as for First Course.
6-12 months reduction below usual time	$1\frac{1}{2}$-2 years reduction below usual time. Elimination of delays means reduction of 5-8 years or more on some jobs.

individual times because steps of procedure may sometimes overlap.

CONCLUSION

CHAPTER VI - 5

The conclusion of this report, recommending the creation of a single state-funded corporation for the construction of Massachusetts public schools, has significant parallels with other developments in the United States today. Students of public administration have often speculated on what appears to be the cyclical attraction of, and then revulsion from, the creation of legally powerful or encompassing agencies -- czar-like to their critics, efficient solutions to their proponents. Skeptics who have commented upon this phenomenon have probably never expressed the matter more succinctly than Alexander Pope in one of his noted aphorisms:

> "O'er forms of government
> Let fools contest
> That which is best administered
> is best."

It seems to the authors of this report, however, that the validity of each solution depends upon the hard present facts of the given context. The facts set forth in this report demonstrate the high costs of decentralization, inconsistent and partial funding, and damaging delays. Hence, the proposal for a Massachusetts School Construction Corporation is not based upon a theoretical or philosophical preference for bigness but is, rather, a reflection of a need to cure present ills which have as their source inadequate public policies, a lack of comprehensive planning and insufficient ability to act efficiently and promptly.

Proposals which have been made by other groups during the course of this study (notably in the field of public housing) are coincidental in time to this proposal for the Massachusetts School Construction Corporation. Without doubt, they have their origin in a backgrounc problems.

Within the field of education itself, federal issues of public policy not si must deal with budgetary problems at t more broadly for the entire electoratc the recent decision of the California 30, 1971) not merely as an interpretat States Constitution, (this interpretat the United States Supreme Court). The case, and of the reasoning in many oth funding of school costs, is the acknow pendent of whether it is mandated by t demands that the solution to the educa statewide commitment to equal educatic vagaries and delimited capacities of s eras.

It is perhaps a reflection of the impc many responses to the preliminary pror tion which participants in this study meetings, fears of state control have approached the strength of the opposi which have been and still are heard fi in that area are debated in the Congre however, have been universally expres economic necessity and continued loca

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they have their origin in a background of similar governmental and construction problems.

Within the field of education itself, the problems of funding have become federal issues of public policy not simply for the local agencies who annually must deal with budgetary problems at town meetings and in city councils, but more broadly for the entire electorate. This report sees the significance of the recent decision of the California Supreme Court in <u>Serano v. Priest</u> (August 30, 1971) not merely as an interpretation of the requirements of the United States Constitution, (this interpretation may or may not be finally adopted by the United States Supreme Court). The significance of the reasoning in that case, and of the reasoning in many other proposals for state assumption of funding of school costs, is the acknowledgement of a basic public policy, independent of whether it is mandated by the Constitution or is not. That policy demands that the solution to the education of a state's citizens must be a statewide commitment to equal educational opportunity and not be left to the vagaries and delimited capacities of smaller governmental units born of other eras.

It is perhaps a reflection of the importance of the <u>economics</u> involved that in many responses to the preliminary proposal for the formation of a public corporation which participants in this study have heard during the series of regional meetings, fears of state control have been only rarely cited and have never approached the strength of the opposition to federal interference in education which have been and still are heard from time to time when specific proposals in that area are debated in the Congress. Requests for additional state funds, however, have been universally expressed. We have concluded, therefore, that economic necessity and continued local involvement as well as the arguments for construction efficiency which lead to the proposal for the establishment of a state school construction corporation do far outweigh the counter-arguments.

It rests, of course, with the General Court and the Executive Department to make the final decision with respect to which course of action to follow. The judgment of this study to prefer and propose the Massachusetts School Construction Corporation comes, therefore, from the most practical of all reasons: it alone is likely to do the job. In our judgment, in the practical context of Massachusetts governmental affairs, the substantial number of piecemeal proposals which must be enacted together -- not simply picked and chosen from -- are not likely ever to be accomplished. If they are not enacted together, the separate enactment of one or two or even all of them will not effect the needed results. Hence the proposed Massachusetts School Construction Corporation, with a significant amount of local contribution through membership in the corporation and the role of local school building committees, and with the best of administration is the solution to the need to design, build and pay for schools for Massachusetts children in the decades ahead.

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Limited copies of the appendicies to this report may be borrowed from or reviewed at the State House Library, the Boston Public Library, university, state college and community college libraries throughout the Commonwealth, the offices of the Massachusetts Advisory Council on Education, regional offices of the Department of Education,and the offices of Campbell, Aldrich and Nulty.

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