DOCUMENT RESUME

ED 065 897	24	EA 004 261	

AUTHOR	Baas, Alan M.
TITLE	Systems Building Techniques. Analysis and Bibliography Series, No. 15.
INSTITUTION	Oregon Univ., Eugene. ERIC Clearinghouse on Educational Management.
SPONS AGENCY	National Center for Educational Research and Development (DHEW/OE), Washington, D.C.
BUREAU NO	BR-8-0353
PUB DATE	Jul 72
CONTRACT	OEC-0-8-080353-3514
NOTE	21p.
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	Bibliographies; *Component Building Systems; Construction Costs; Construction Needs; Construction Programs; Cost Effectiveness; *Educational Facilities; Flexible Facilities; *Literature Reviews; Planning (Facilities); Prefabrication; School Construction; *Structural Building Systems; *Systems Approach

ABSTRACT

This review presents an analysis of the literature concerning the growth of systems building programs in education and reports on the conclusions of numerous architects and educators that the systems-built school may well be the only cost-effective answer available to today's educational facilities needs. The terms "building systems" and "systems building" are defined and clarified, and the dependency of the systems approach on interfacing with other subsystems is discussed. The literature is divided into and discussed under the headings: systems approach; building systems and modular design; university residential building systems; academic building systems; European systems; information resources; journal coverage; and evaluation, refinement, and application. Publications dealing with school construction programs in California, Florida, and Toronto are reviewed briefly and separately for each area. A 57-item bibliography of relevant literature concludes the presentation. (Author)

Systems Building Techniques

Alan M. Baas

ERIC CLEARINGHOUSE ON EDUCATIONAL MANAGEMENT
UNIVERSITY OF OREGON
EUGENE, OREGON 97403

July 1972
Analysis and Bibliography Series, No. 15
Clearinghouse Accession Number: EA 004 261

ERIC and ERIC/CEM

The Educational Resources Information Center (ERIC) is a national information system operated by the United States Office of Education. ERIC serves the educational community by disseminating educational research results and other resource information that can be used in developing more effective educational programs.

The ERIC Clearinghouse on Educational Management, one of twenty such units in the system, was established at the University of Oregon in 1966. The Clearinghouse and its nineteen companion units process research reports and journal articles for announcement in ERIC's index and abstract bulletins.

Research reports are announced in *Research in Education (RIE)*, available in many libraries and by subscription for $21 a year from the United States Government Printing Office, Washington, D.C. 20402. Most of the documents listed in *RIE* can be purchased through the ERIC Document Reproduction Service, operated by Leasco Information Products, Inc.

Journal articles are announced in *Current Index to Journals in Education*. *CIJE* is also available in many libraries and can be ordered for $39 a year from CCM Information Corporation, 909 Third Avenue, New York, New York 10022. Annual and semiannual cumulations can be ordered separately.

Besides processing documents and journal articles, the Clearinghouse has another major function—information analysis and synthesis. The Clearinghouse prepares bibliographies, literature reviews, state-of-the-knowledge papers, and other interpretive research studies on topics in its educational area.

FOREWORD

Systems building techniques can provide schools that cost less and are more sensitive to changing needs than conventionally built facilities. But the systems approach is not a magic wand that can resolve overnight the financial and other problems confronting education. To obtain maximum benefits from the systems-built school, administrators and school personnel must be willing to rethink many of their traditional attitudes about how people live in buildings.

Applications of systems building techniques in other industries during the past several decades have proved the merits of the systems approach. But it was not until 1962, with California's School Construction Systems Development (SCSD) program, that the cooperative efforts of educators, architects, and contractors succeeded in applying systems techniques to school facilities construction.

This analysis and bibliography surveys the growth of systems building programs in education and reports on the experiences and conclusions of numerous architects and educators. The opinion expressed in all the literature reviewed is the same: systems building may well be the only cost-effective solution available for the design and construction of contemporary school facilities.

The author, Alan M. Baas, is employed by the Clearinghouse as a research assistant.

PHILIP K. PIELE
Director

Despite the significant progress that has been made in the school systems field . . . one important development has not taken place: the majority of school administrators and board members have given little, if any, serious consideration to whether the systems approach is right for them. This is a serious omission, in view of the crisis proportions that school building problems have assumed in many districts today: fantastic increases in school costs, due to inflation and rising interest rates; serious problems in getting work done on time; and tremendous requirements for school building flexibility.

School Management (September 1969), p. 66

SYSTEMS BUILDING TECHNIQUES

Systems building must represent the cooperative efforts of educators, designers, industry, and legislative bodies. Its concepts are not difficult to grasp, but experiences in the field indicate that its ramifications demand substantial reevaluation of conventional attitudes and methodologies during design and construction phases of the planning process. In addition, the administrator who is resolved to continue capitalizing on the benefits of a systems-designed structure must be willing to effect lasting changes in the relationship between the school community and its physical environment.

Systems building does not immediately guarantee cheaper buildings, but it can result in lower construction costs and, if properly managed, a continued savings in maintenance and renovation costs. The use of the systems concept implies the need for an astute awareness of the school as a dynamic system once it is in operation. Thus, decisions regarding the arrangement of flexible spaces and the distribution of students and personnel must logically relate to the building's fundamental design if innovative change is also to be cost-effective.

There is still a tendency to use the terms *systems building* and *building systems* interchangeably. Strictly speaking, the former term refers to the organized process of decision-making whereby a building is designed and constructed. This process is derived from systems analysis and makes use of the best possible coordination techniques, including computer selection of building elements and programs such as CPM (critical path method) and PERT (program evaluation review technique) for the scheduling of the various phases of construction.

The systems approach can coordinate conventional building processes and materials or it can expedite the production and use of *building systems.*

Building systems refers to those physical elements that can be put together to form the completed structure. An effective building system permits a wide range of alternative design solutions and is today understood to include those management and development functions relating to the production and use of the physical elements.

Systems building rationalizes the decision-making process in building design and construction. Building systems afford cost-effective and timely solutions to design problems. In theory, building systems do not require the systems approach for their implementation, but practice has shown that the two effectively complement each other. The school building projects reviewed in this paper all use the systems approach to coordinate building systems.

THE SYSTEMS APPROACH

Ehrenkrantz (1970) sees in the systems approach an opportunity for minimizing the "deceptions of narrow-minded thinking." As one of the leading innovators in systems building techniques, his analysis of the present state of that art provides a substantive perspective for anyone contemplating new construction. He asserts that a properly managed systems approach permits a completeness of problem definition unlike anything possible in the past. His remarks detail the distinctions between "open" and "closed" building systems and establish a context for future improvements in systems techniques.

The systems approach for incorporating design and construction information receives attention in a paper by Broadbent (1970). In addition to basic building technology data, the architect requires information about the cultural and physical contexts of the proposed structure, the objectives of the client, and the requirements of the users. Applying general systems theory to architectural design, Broadbent suggests that this data be correlated within a single "environmental design process." Against this background, he relates the systems concept to various points of view within the history of ideas, providing the reader with references to the fields of psychology, sociology, linguistics, cybernetics, urban planning, and philosophy.

Dietz (1967) answers fundamental questions on the use of computers in the building design process and provides basic information concerning the applications of systems analysis techniques to building problems. He discusses methods for analyzing and classifying design information and includes a detailed glossary of relevant terms.

Boice (1967) identifies the systems approach as integrating the process of the building coming into being. In such an approach, factory production and onsite construction processes are identified in the initial stages of building design and related to the problems of spacing and fitting of components. He maintains that to insure minimum cost, high quality, and flexibility, the systems approach must be based on production volume, reasonable notice time to industry for tailor-made components, and clearly defined functional goals.

According to Griffin (1971), the development of the systems approach in school construction was stimulated by educational changes requiring new sets of spaces for which the specifications could be met only by changes in building technology and

SYSTEMS BUILDING TERMS

building system: "An assembly of building subsystems and components, and the rules for putting them together in a building. Normally these components are mass-produced and used for specific generic projects in a construction program." (Griffin 1971)

interface: "The common boundary between two building subsystems, components, or parts including both the physical contact which may or may not form a joint and the overlap of performance characteristics." (Building Systems Information Clearinghouse 1971a)

module: "In architecture, module usually refers to a three-dimensional unit with specific dimensions. In systems building, module is used more specifically to designate three-dimensional repetitive design and production units such as classrooms or paired dwellings with common stairs." (Rothenstein 1970)

modular coordination: "The establishment of both building dimensions and building material sizes as multiples of a common base module to facilitate the assembly of materials according to plan with a minimum of modification at the site." (Koppes and Green 1967)

performance specifications: Conventional specifications describe products and their uses in detail. Rather than detailing the product, performance specifications identify what a given component is required to do. Industry therefore can capitalize and expand on its own research and development to provide the required performance. (University of California 1966)

systems building: "The application of the systems approach to construction, normally resulting in the organization of programming, planning, design, financing, manufacturing, construction, and evaluation of buildings under single, or highly coordinated, management into an efficient total process." (Building Systems Information Clearinghouse 1971a) construction management. Griffin sees the systems approach as both a revolution in management techniques and an improvement in building technology. To acquaint educators with its advantages, he examines four major systems building projects: California's SCSD and URBS, Montreal's SEF, and Florida's SSP.

Based on an examination of current trends in building volume, economic and population growth, and cultural and technological change, Schmid and Testa (1969) build a strong argument for wide-scale adoption of the systems building approach. Schmid's preliminary remarks set the context and establish the parameters for systems methodologies. Testa presents numerous photographic illustrations together with basic construction data for successful systems building projects. The book reviews the state of the art both in this country and abroad.

A concise summary of the present state of systems building is provided in a study on school construction economics published by the Washington State Office of Public Instruction (1971). The section dealing with systems building succinctly identifies its major benefits and describes substantial projects currently in existence. Recommendations for legislative response to systems building in education emphasize the importance of innovative thinking by school boards and state education departments.

BUILDING SYSTEMS AND MODULAR DESIGN

The success of an individual building system largely depends on how well it can interface with other subsystems. A heating-ventilation-cooling system may be highly efficient in its operation, but if its physical elements are not modularly coordinated to coincide with the necessary "slots" in the structural-roof system, it cannot be employed in a systems-designed facility. An important task in the management of a systems building project is insuring compatibility among subsystems.

In a state-of-the-art report to the architectural and educational professions, Koppes and Green (1967) agree that the logic and validity of modular design are well established and widely accepted. Present design and technological trends, particularly the systems approach, indicate continuing support for modular design and suggest its increased implementation as practical problems are resolved. Its significance is reflected in the development of modular drafting techniques with an accompanying system of computer symbols. Making reference to British and American systems building projects, the authors point out the immediate advantages of modular construction in school facilities.

"Systems building is an idea whose time has come. Now that industry has proven its capacity to produce superior quality units in the factory, and assemble them quickly on the site at a dollar saving, who can afford to go a longer, costlier route?" — *School Management (September 1969), p. 69.*

The dependency of the systems approach on prefabricated components and modular subsystems in both design and construction processes receives attention in a case study by Boice ([1970]). Construction times are shortened and costs often lowered because the flexibility of prefabricated subsystems allows construction on the building shell to proceed while interior design is still in the planning stage.

The use of performance specifications provides additional control over construction costs and saves additional time by using products that have already been tested and used successfully. Boice reports on the experience of an architectural engineering firm that uses systems analysis as one approach to the design and construction of school facilities.

King and Weinstock (1970) describe several schools constructed under a building systems program. Common features include long spans for a minimum of supporting columns; systems for heating, cooling, and ventilating; movable walls; and nonglare lighting systems with easily rearranged elements. They note how interior furnishings and equipment can be systematically coordinated both to harmonize with the building design and to offer freedom of space and movement.

The history, advantages, and disadvantages of component building systems are surveyed in a speech by Halsall (1969). His discussion includes educational facilities in the United States, Canada. and England that have made use of this approach, and an explanation of the cost and effectiveness of such systems as SEF, SCSD, CLASP, and SSP.

MAJOR SYSTEMS BUILDING PROJECTS

ABS	Academic Building Systems (states of California and Indiana)
CLASP	Consortium of Local Authorities Special Programme (England)
RAS	Recherches en Amenagements Scolaires (Montreal Catholic School System)
SCSD	School Construction Systems Development (California)
SEF	Study of Educational Facilities (Metropolitan Toronto School Board)
SSP	Schoolhouse Systems Project (Florida)

CALIFORNIA'S SCHOOL CONSTRUCTION SYSTEMS DEVELOPMENT PROJECT

The School Construction Systems Development (SCSD) Project was conceived in 1961 to represent a group of California school districts whose construction needs amounted to over twenty million dollars. It was decided that the districts represented sufficient buying power to interest manufacturers in researching and developing subsystems of compatible modular components that could then be applied in the design and construction of individual schools.

This project was the first major exploratory effort in systems building for education. A feasibility study done at the time indicated that the likelihood of a national market developing would provide an incentive for industry. The bidding procedure outlined performance specifications but did not make any restrictions on the design of individual parts or on their materials.

Boice and others (1965) provide a detailed report on the SCSD project. The project attempted to develop an integrated system of standard school building components that was adaptable, economically feasible, and time-saving. Component subsystems include:

- structural system and roof
- ceiling system (integrating lighting, heating,
- and electrical distribution)
- air conditioning
- demountable partitions

In addition, cabinet work and storage lockers were subjected to modular coordination.

Performance specifications, developed by the Educational Facilities Laboratories (EFL), were designed to assist in the implementation of educational developments by giving educators flexibility in the planning and use of school buildings. Primarily, such flexibility requires economically movable partitions and long spans to provide large areas of space. Lighting and ventilating systems are designed to match flexible space arrangements as they change in response to curriculum needs.

"In systems building, with its special mobility, we finally have an architecture that recognizes the most important ingredient — people" — Robbie, AIA Journal (November 1969), p. 66.

The system employs a structural technique that uses the inherent structural properties of a steel roof deck; it does not include exterior walls. The authors point out that while the total concept provided for an infinite variety of buildings, the individual components were not always compatible.

A set of educational specifications drafted by the First California Commission on School Construction Systems (1963) gives information on bidding procedures, a description of the construction program, procedures for submitting a proposal, data and conditions related to the development phase of the project, component contracts, and general conditions and procedures. Performance specifications are outlined for the four subsystems.

An interim report by the Educational Facilities Laboratories (1965) presents a brief history and explication of the SCSD. The report includes detailed structural and performance specifications for the four subsystems and is illustrated by schematics and photographs.

Benet (1967) reports on an EFL study demonstrating the efficiency, flexibility, and spatial planning of SCSD high schools. He concludes that systems-designed schools can creatively meet the needs of today's changing educational environment.

FLORIDA'S SCHOOLHOUSE SYSTEMS PROJECT

In 1966 the Florida State Department of Education organized the Schoolhouse Systems Project (SSP), thereby relieving individual school districts of the tasks of legally organizing themselves for bidding, contracting, and purchasing procedures. As school districts were organized into legal groups, specifications were written and bids sought. This process was repeated each time a group was formed, thereby providing a continuing interaction among manufacturers, designers, and construction industries to stabilize prices and increase industry incentive.

The SSP adopted the basic performance specifications developed by the SCSD project, substituting hurricane wind provision requirements for the earthquake resistance specifications of the California project. Later programs adapted newer, more sophisticated criteria for various subsystems as technology made them available.

SSP's first-phase report, published by the Florida State Department of Education (1967), considers the development of integrated building systems with regard to stimulation of research and development, performance specifications and competitive bidding, and roles of contractors, labor, architects, and engineers. The document evaluates the quality, design freedom, costs, and construction time of SCSD-type schools in four states. Recommendations are made concerning the use of existing components for single schools and for a volume buying program. Further suggestions discuss time schedule of the research and development program, legal authority, staff, and financing.

TORONTO'S STUDY OF EDUCATIONAL FACILITIES

Toronto's Study of Educational Facilities (SEF) is the most comprehensive systems building program in existence. A broader range of subsystems permits more competitive bidding, and an "open system" of specifications allows for the same components to be produced by different manufacturers and used interchangeably.

"School administrators who discuss their curriculum plans in detail with architects are rare. However, the greatest impact of the systems approach could be to force you to evaluate the educational program you will want to conduct in your schools; to decide on specific directions; and to articulate specific space needs" — School Management *(August 1969), p. 29.*

The open system is considered an improvement over the "closed system" employed by the SCSD project, where components are designed to integrate exclusively with one another. With the open system, the buyer has the freedom to select from a number of possible choices; in the closed system, the buyer must purchase the components specified.

Two speeches by Robbie, former SEF technical director, describe the Toronto building system and explain its general theories.

In the first, Robbie (1969a) discusses the project's organization and presents the rationale for selecting an open systems approach to the school board's building needs. He also gives information regarding SEF's ten subsystems and principal nonsystem items. A subsystem is defined as an identifiable, complete, physically integrated, dimensionally coordinated, installed series of parts that function as a unit without prescribed performance limits.

Specific requirements are given for an overall project time schedule, program budget, bidding procedures, and quality control procedures. In addition, codes and standards, bids and bid evaluation, and individual project construction receive attention.

Robbie's second speech (1969b) repeats the basic description of SEF and presents his views on the general principles of systems building as they might affect architecture and the economy.

Additional documents published by the Metropolitan Toronto School Board provide working guidelines for academic specifications and user requirements in that city's SEF schools. The first (1968) relates local Toronto conditions to the K-6 schools. The second (1969) focuses on the early adolescent and the cultural matrix in which the student and school system coexist, giving information concerning the development of intermediate schools.

Both documents consider in detail the steps necessary for formulating educational objectives and surveying school plant needs. Tables, technical data, and illustrations for all areas of the school supplement the text.

A recent document by the Metropolitan Toronto School Board (1972) provides a detailed evaluation of that city's systems building program. A comparison of SEF schools with non-SEF schools and open plan facilities with traditional facilities indicates

"Make no mistake about it: The systems building explosion is on its way and there's no way to stop it" — Balchen, AIA Journal (November 1969), p. 67.

widespread positive response to systems built schools. One of the theoretical ideals of the systems approach to school construction is the provision of cost-effective flexible spaces to accommodate innovative educational trends. Results of questionnaires concerning various physical characteristics of each school indicate modular components (essential to SEF schools) are well suited to flexibility requirements of open plan schools. This substantive report also provides an annotated bibliography of open plan facilities documents.

UNIVERSITY RESIDENTIAL BUILDING SYSTEMS

The University Residential Building Systems (URBS) project, undertaken by the University of California, was intended to provide forty-five hundred dormitory units in its first phase. After suffering some setbacks, such as a reduction in the number of units to two thousand and an accompanying loss of interest on industry's part, the project has proved that systems building techniques can be applied to specialized construction requirements such as those for housing, motels, nursing homes, and so forth. Griffin (1971) provides a concise overview of the URBS project.

The Phase I Report (University of California 1966) of URBS describes the university's performance specifications and the performance grading techniques whereby different building components are evaluated.

Performance specifications are derived from an analysis of student needs and the programming and design requirements of the overall project. Grading evaluation is in terms of initial cost, satisfaction of user needs, and expected maintenance and operation cost for each building component. Detailed studies of existing buildings provide performance data and compare projected maintenance and capital costs.

The Phase II Report (University of California 1968) identifies objectives of the URBS project as "the achievement of significant gains in environmental qualities concurrent with reductions in the costs for construction, maintenance and alteration of student housing facilities" and the building's adaptability "to changes in the physical environment and in the use of space over a period of many years as programs and requirements change." Evaluation of bids for URBS components presented in this document indicates that these expectations have been achieved.

The bidding procedure requires a preliminary design, a final design, and a final priced proposal. This process separates questions arising from technical and aesthetic matters from those relating to cost. In addition to background information on priced proposals and bidder attrition, the document provides illustrations of URBS requirements and manufacturer proposals.

The third document in the project (University of California 1969a) gives basic information and guidelines on the use of URBS components for architects and engineers. The systems approach requires that components and materials be coordinated at their design stage so that user requirements, production, site installation, maintenance, appearance, and cost can be considered simultaneously.

Another document relating to the URBS project (University of California 1969b) gives substantive user requirements for dormitory facilities.

"I believe it is clear that we lack in our architectural methods at present any reliable or consistent means of evaluating the performance of finished buildings in terms of their ability to satisfy human needs" — Eberhard, AIA Journal (July 1968), p. 36.

ACADEMIC BUILDING SYSTEMS

The Academic Building Systems program (ABS) represents a joint effort of Indiana University and the University of California to develop a building components system that can be applied to academic building requirements in either state. It represents a further development of techniques explored first in SCSD and later in the URBS project. Since the project is still in its development phase, documentation is minimal.

The University of California and Indiana University have published a series of reports presenting the results of a systems analysis of the problem of providing science and engineering buildings at the university level. The study was conducted within the ABS program.

The first ([1971a]) includes a user survey and background studies of academic methods used in ascertaining future uses of existing buildings. The second (1971b) relates construction costs to performance and includes studies of alteration costs and different space types. The third (1971c) is a technical manual for using the ABS approach in programming, designing, and constructing such facilities. Included is a detailed treatment of the five ABS subsystems.

EUROPEAN SYSTEMS

England's Consortium of Local Authorities Special Programme (CLASP) was instituted in 1957 to make use of the economies available through large-group purchases of prefabricated building components. In ten years, 703 buildings were constructed and the group was expanded to include several universities and local public bodies. Its membership is open to any authority in that country wishing to participate and it has provided the model for many European experiments in consortium purchasing.

The CLASP approach in higher education facilities is discussed in a document published by the Department of Education and Science in England (1970). This bulletin describes the various stages involved and discusses the differences between building system design and single building design. In addition, it reports the results of investigations into user needs and general performance specifications for heavy-duty buildings and summarizes the project's technical results.

The consortium approach in England also receives attention from Orlowski (1969) in his comparative study of the economies and flexibility afforded by use of prefabrication and modular components in Europe. After summarizing the history and general advantages of England's CLASP, he identifies its primary disadvantages:

- the performance of the system has been raised over the last few years to cope with a wider range of buildings, e.g. Universities, and the extra cost of this within the system has made it difficult for Architects to produce small primary schools within cost limits using the same pieces. One system cannot expect to be economical for all types of building;
- the system in some respects is too well developed and integrated with the result that there is little cost flexibility. An Architect wishing to make savings on his particular job will have very little scope for substituting cheaper, non-system components as this would cut across agreements on quantities between the Consortium and the suppliers of standard components. (pp. 38-39)

Other English consortium groups with basically the same characteristics as CLASP receive equal attention in this document. In addition, Orlowski discusses the current state of the field in West Germany, Switzerland, and Germany, where his research was drawn from school visits and meetings with leading authorities.

Stages of Systems Development

Problem analysis, data gathering, and statement of objectives. This stage involves a cluster of activities where the unique characteristics of the proposed construction are examined and a "system" is created to account for: (1) the present state of design and construction technology, (2) all the parts of the particular problem and whatever relationships might exist among them, (3) relative variables and constraints affecting the objective, (4) both present and future user requirements.

Development of performance specifications on the basis of the "system picture" obtained during the first stage.

Generation and evaluation of alternative solutions.

Selection of the solution best capable of meeting performance criteria and the variables that were identified in the first stage. In a sophisticated program, computers assist in the decision-making process and a cost-benefit analysis governs the final choice of solutions and the products that will go into the construction of the facility.

Earlier documents dealing with component building systems in England and published by the Department of Education and Science are of interest. The first (1964) outlines a common-dimensional controlling discipline for structural systems, ceiling heights, floor and roof depths, changes of level, and the spacing of structural supports. The discipline is intended to establish a dimensional framework for components, but not to establish actual dimensions for individual components.

"There is now sufficient knowledge, experience, and technology to enable any district on the continent to build a single school through the systems approach" – Griffin (1971).

The second document (1968) discusses the coordination of building components as a move toward establishing a national pool of dimensionally related components. To achieve this goal, the publication identifies those characteristics that must be standardized for multiuser implementation and suggests conventions of component assembly.

INFORMATION RESOURCES

The Building Systems Information Clearinghouse (BSIC) has published three documents that are of interest to administrators contemplating component construction.

The first, by Boice (1969), provides preliminary data about all relevant systems building products that could be used in a "post-SCSD" school—that is, products developed in accord with the principle of dimensional coordination and the fundamental performance characteristics of the SCSD project. The document surveys the problems of compatibility among subsystem components, identifying those components that are compatible with one another. In addition, it lists manufacturers' representatives for those who wish information beyond the limits of the catalog.

The second BSIC publication (1969) provides a list of 113 schools from twenty-three states that have been either designed or constructed with the building systems approach. The extent of each school's involvement in the systems approach is described in terms of four major subsystems: structure, lighting-ceiling, heating-ventilating-cooling, and demountable partitions.

The third document published by BSIC (1971a) attempts to provide a state-of-the-art study of building systems with an emphasis on their educational applications. The publication provides a comprehensive introduction to the field, including a glossary and a survey of information resources. Further discussion includes a generalized model of a building systems project and descriptions of the functions of programming, design, and multistage bidding.

An annotated bibliography published by the Stanford University School Planning Laboratory ([1969]) collects publications and reports dealing with five major courses of structural building research: School Construction System Development (SCSD), University Residential Building Systems (URBS), Florida Schoolhouse Systems Project (SSP), Study of Educational Facilities (SEF), and the Montreal Catholic School System project, Recherches en Amenagements Scolaires (RAS).

WHAT THE JOURNALS SAY

Several major treatments of systems building can be found in the journals. The August and September 1969 issues of *School Management* ("Parts One and Two of a Special Report")provide a comprehensive survey of the state of the field. The articles examine systems applications in various contexts, noting the advantages and disadvantages of major projects in the United States and Canada. The contents strongly recommend that administrators contemplating systems building become familiar with its concepts and ramifications and that governmental cooperation be sought to expedite volume purchasing.

Building Research devotes its April-June 1970 issue to capsule analyses by leaders in the field of systems building. Included are a state-of-the-art report, the SEF user requirements, a discussion of necessary preliminary conditions, and a critique highlighting the disadvantages of SCSD. The last subject is of particular value in that the bulk of the literature on SCSD has been devoted to its advantages. The author of the critique, Charles Gibson, the chief of the California Bureau of School Planning, gives valuable counterpoints to be considered by administrators and designers contemplating systems buildings. These include the physical shortcomings of component systems, industry's resistance to change, and unimaginative responses by both planners and users.

The September-October 1966 issue of *Building Research* examines comprehensive building systems and gives a valuable historical perspective on the field of systems building. One article traces the development of the field to several interacting causes: industry's search for markets, client's desires for shorter hours and lower costs, and growing complexities in building technology resulting in the architect's dependency on industry for research and development. The problems and techniques of the building systems concept are explored and its impact on industry is examined. Other articles examine the subject from the manufacturer's point of view, discuss the development of mechanical systems, and analyze the obstacles to popular acceptance of the concept. Numerous journal articles focus on particular aspects of the systems approach and describe individual case studies of systems built schools. The bibliography contains a representative sampling of such articles together with brief annotations.

EVALUATION, REFINEMENT, AND APPLICATION

The SCSD project in 1961 marked the beginning of a decade of rapid growth in systems building techniques. These were implemented in a number of major programs, many of which continue today and in themselves are vast enough to represent a wide range of concept development. There have also grown up in the past two years a variety of "second stage" projects—refinements of techniques originally spearheaded in SCSD and substantially developed during the last decade. Among these are Boston's BOSTCO and Detroit's CSP.

Vital progress has been made in educating manufacturers, building trades, and architects in the systems concept and its ramifications. Recognition is growing in local and state governments of the economies afforded by the approach, particularly in the light of the rapid growth of components manufacturing. As these trends continue, the second decade should see the lifting of many of the restraints currently impeding such systems processes as volume buying and trade union coordination. But, as *School Management* ("Part Two of a Special Report" 1969) has pointed out, effective systems building programs require that legislators and educational administrators thoroughly grasp the implications of the approach. This is brought out clearly in the Massachusetts study of school construction costs, which recommends strong legislative action to

RECOMMENDED LEGISLATIVE ACTION

In addition to the article in *School Management* quoted at the beginning of this paper, a number of other documents have stressed the need for action at the executive and legislative levels of local and state governments to cut across legal and political barriers to systems building techniques. Recommendations contained in a publication by the Washington State Office of Public Instruction (1971) provide a good summary of subjects needing legislative investigation:

- **Consortium organization and operation, including authorizations, management, and policies**
- **Standardized space allocation studies**
- **Standardized construction cost analysis and reporting methods**
- **Performance specifications**
- **Unified format for the summation of design program requirements**
- **Standardized components and their combination into feasible building systems**
- **Implementation of the English "quantity surveyor" technique**
- **Standard pricing and production policies**
- **Bulk buying procedures and policies**
- **Design studies showing the possible range of building types that can be created with a "kit of parts" building system containing a limited number of parts**
- **Generation of a suggested program of action to implement a school building system, together with schedules and budgets**

"Since the key to getting the right building lies with the schoolman, it seems inevitable that educators will play a key management role in the coordination of systems projects, as part of a new and closely knit ed specs team" — School Management (September 1969), p. 72.

expedite systems construction programs. Another study concerned with the same systems approach for the 1970s is Texas A & M University's evaluation of higher education facilities construction.

A *BSIC/EFL Newsletter* (Building Systems Information Clearinghouse 1971b) discusses two cases of the "refinement and application stage" of systems building. First, the Boston Standard Component System (BOSTCO) demonstrates that procedures and materials developed by large-scale building programs such as SEF can be adapted to fit different situations. In addition, the newsletter reports on Boston's success with dovetailing a systems building program with existing governmental processes—a task crucial to the success of such programs. The second case study involves Detroit's Construction Systems Program (CSP), a citywide school building commitment similar to that of BOSTCO.

To illustrate the results of ten years of EFL involvement in school building systems programs, the newsletter displays a chart of significant data concerning eight programs to which EFL gave financial assistance. And to round out its issue, the same newsletter presents a progress report on a major systems building project, Montreal's RAS.

A study commissioned by the Massachusetts Advisory Council on Education (Campbell, Aldrich, and Nulty [1971]) finds systems building to be the most cost-effective solution to that state's school construction needs. After a lengthy and detailed appraisal of school building cost factors, the researchers urged the state legislature to create a corporation to serve as a management tool for centralizing planning, building, and financing at the state level. Drawing from examinations of various major systems programs, the authors emphasize that systems building requires a "total process" wherein planning, design, contracting, and construction management interact constantly. In this way there would be regular opportunities for evaluating work in progress against related variables such as final objectives, user requirements, technological improvement, and changes in labor-management relations. A second document (Campbell, Aldrich, and Nulty 1971) summarizes the study's conclusions and recommendations to the Massachusetts legislature.

A report by Texas A & M University (1971a) details a year-long study of possible benefits in cost, time, and facility utilization of a systems building approach for Texas college and university construction. The first part of the report deals with trends and needs in higher education and the related architectural implications. A subsequent discussion of alternative building delivery processes is followed by a consideration of the utilization of present and future facilities.

A summary report (1971b) presents extracts from the work report itemizing requirements trends, examples of successful building systems projects, study findings concerning systems building processes, and recommendations for the state of Texas. Its recommendations suggest (1) the acceleration of scheduling techniques, such as overlapping the design and construction processes and prebidding the building subsystems; (2) a statewide centrally coordinated program to aggregate similar building needs and initiate purchase agreements with industry; and (3) the development of a computer scheduling service for academic space utilization.

CONCLUSION

The systems approach enables educators to treat the schoolhouse, together with students, school personnel, and educational methods, as components of a single complex system. Systems building programs for school construction have shown that it is possible to analyze a behavioral process such as education and determine the performance required of the physical facilities to house that process. With flexibility as a built-in characteristic, the educational environment can now be as sensitive to change as are the people it shelters.

At the present stage of systems building, it is now possible to construct single facilities using systems techniques. Enough manufacturers have entered the field of component production to eliminate the need for volume purchasing. However, much work remains to be done by legislators and educators to facilitate legal and political aspects of systems building programs. The future holds great promise; the machinery has been refined and all that remains is the active commitment of schoolmen to a new way of thinking about building.

BIBLIOGRAPHY

Balchen, Bess. "Coming On Strong: Systems Building." *AIA Journal*, (November 1969), 67-68.

An evaluation of systems building drawn from the proceedings of the 1969 AIA Committee on School and College Architecture. Notes systems building allows for changes in planning strategy as social problems arise in course of program.

Benet, James, and others. *SCSD: The Project and the Schools. A Report from Educational Facilities Laboratories.* New York: Educational Facilities Laboratories, Inc., 1967. 90 pages. ED 035 180 MF $0.65 HC $3.29. (Also available from Educational Facilities Laboratories, Inc., 477 Madison Avenue, New York, New York 10022, $2.00.)

"Better Buildings, Faster, for Less." *American School & University*, (May 1972), 8-26.

Reviews current systems building practices with capsule reports on Florida's SSP, Boston's BOSTCO, and Detroit's CSP. Surveys twenty-five years of Britisn systems building experiences and summarizes basic data on Montreal's RAS and California's SCSD and URBS. Also relates systems techniques to single school construction.

Boice, John R. "A Systems Approach to School Construction." Speech presented at the National Vocational-Technical Facility Planning Conference. Reno: Department of School Administration, University of Nevada, 1967. 13 pages. ED 025 113 MF $0.65 HC $3.29.

Boice, John R., ed. *Building Systems Information Clearinghouse Special Report Number One: Manufacturers Compatibility Study*. Stanford, California: Building Systems Information Clearinghouse, 1969. 24 pages. ED 036 094 MF $0.65 HC $3.29. (Also available from BSIC/EFL, 3000 Sand Hill Road, Menlo Park, California 94025.)

———. *K/M Associates: A Case Study in Systems Building*. Stanford, California: California School Planning Laboratory, Stanford University, [1970]. 27 pages. ED 046 075 MF $0.65 HC $3.29. (Also available from BSIC/EFL, 3000 Sand Hill Road, Menlo Park, California 94025, free.,

Boice, John R.; Ehrenkrantz, Ezra; and MacConnell, James. "School Construction Systems Development Project." In *Proceedings of the Forty-First Annual Meeting, National Council on Schoolhouse Construction, Houston, Texas, October 5-8, 1964*. 1965. 7 pages. ED 014 852 MF $0.65 HC $3.29.

Broadbent, Geoffrey. "Systems and Environmental Design." Paper presented at Environmental Design Research Association Conference, Pittsburgh, October 1970. 12 pages. ED 044 796 MF $0.65 HC $3.29.

Building Research, 3, 5 (September-October 1966).

Entire issue devoted to comprehensive building systems.

Building Research, 7, 2 (April-June 1970).

Entire issue devoted to analyses of systems building techniques and applications.

Building Systems Information Clearinghouse. *Building Systems Information Clearinghouse Special Report Number Two. Listing of Schools and Other Buildings Constructed with a Building System. Listed by States*. Stanford, California: 1969. 14 pages. ED 036 093 MF $0.65 HC $3.29.

———. *Building Systems Planning Manual. Building Systems Information Clearinghouse Special Report Number Three*. Stanford, California: 1971. 51 pages. ED 055 357 MF $0.65

HC $3.29. (Also available from BSIC/EFL, 3000 Sand Hill Road, Menlo Park, California 94025, $1.00.)

———. "Building Systems in the City." *BSIC/EFL Newsletter,* 3, 4 (December 1971). 24 pages. ED 060 527 MF $0.65 HC $3.29. (Also available from BSIC/EFL, 3000 Sand Hill Road, Menlo Park, California 94025, free.)

Building Systems Information Clearinghouse. Newsletter. 1, 1 (Spring 1969). 35 pages. ED 031 049 MF $0.65 HC $3.29.

Entire issue surveys all systems projects funded by Educational Facilities Laboratories since 1962, including Toronto's SEF. Montreal's RAS. Florida's SSP, Pittsburgh's GHS, and California's SCSD and URBS. Provides detailed summaries of program data and surveys relevant variations among the projects.

Campbell, Aldrich and Nulty. *A Systems Approach for Massachusetts Schools. A Study of School Building Costs for the Massachusetts Advisory Council on Education. Final Report.* Boston: [1971]. 304 pages. ED 060 531 MF $0.65 HC $13.16.

———. *A Systems Approach for Massachusetts Schools. A Study of School Building Costs for the Massachusetts Advisory Council on Education. Summary Report.* Boston: 1971. 22 pages. ED 060 530 MF $0.65 HC $3.29.

Chase, William W. "Systems and the Single School." *Construction Products Technology,* (September 1970), 41-46.

Reports that systems construction, through greater preplanning, provides improved school facilities while holding the line on construction costs. Includes examples.

Department of Education and Science. *Controlling Dimensions for Educational Building. Building Bulletin.* London, England: 1964. 27 pages. ED 035 243 Document not available from EDRS.

———. *The Coordination of Components for Educational Building.* London, England: 1968. 42 pages. ED 035 245 Document not available from EDRS. (Available from Pendragon House, Inc., 899 Broadway Avenue, Redwood City, California 94063, $1.60 paper plus $0.15 mailing.)

———. *CLASP/JDP: The Development of a Building System for Higher Education.* London, England: 1970. 95 pages. ED 057 448 Document not available from EDRS.

Dietz, Albert G. H., and others. "Systems Analysis and Building Design. Revised October 1967." Paper presented at the Architect-Researchers' Conference of the American Institute of Architects, St. Louis, October 1966. 1967. 36 pages. ED 037 952 Document not available from EDRS. (Available from Department of Architecture, Massachusetts Institute of Technology, Cambridge, Massachusetts.)

Eberhard, John P. "A Humanist Case for the Systems Approach." *AIA Journal,* (July 1968), 34-38.

Educational Facilities Laboratories, Inc. *SCSD: An Interim Report.* New York: 1965. 36 pages. ED 031 035 MF $0.65 HC $3.29.

Ehrenkrantz, Ezra D. "The System to Systems." *AIA Journal,* (May 1970), 56-59. Reprinted in *CEFP Journal,* (December 1970), 4-7.

One of the leading systems building innovators establishes perspectives and definitions of "systems approach" and "building system."

First California Commission on School Construction Systems. *Contract Documents and Performance Specifications.* Palo Alto, California: 1963. 269 pages. ED 018 958 MF $0.65 HC $9.87.

Fischer, Robert E. "Building Process in the 1970's: The Trouble with Systems." *Architectural Record,* (October 1970), 148-153.

A detailed critique of SEF project. Discusses the approach's negative aspects, concluding that restrictions can be overcome provided there is better "interfacing of client, architect and engineer, and management contractor."

Florida State Department of Education. *Florida Schoolhouse Systems Project. First Phase Report.* Tallahassee: 1967. 26 pages. ED 032 723 MF $0.65 HC $3.29.

Griffin, C. W., Jr. *Systems: An Approach to School Construction.* New York: Educational Facilities Laboratories, Inc., 1971. 90 pages. ED 050 475 MF $0.65 HC $3.29. (Also available from Educational Facilities Laboratories, Inc., 477 Madison Avenue, New York, New York 10022, $2.00.)

Halsall, R. "Systems Approach to Building. A Brief Report on the Canadian Scene in November 1969 with Particular Reference to School and College Construction." Speech presented at College of Applied Arts and Technology Design Workshop, Ottawa, Canada, November, 1969. 9 pages. ED 036 090 MF $0.65 HC $3.29.

Johnson, Frank W. "A Systems Approach to Facility Planning." *CEFP Journal,* (March-April 1971), 10-11.

Presents the systems approach as a workable methodology for managing the variable tasks of educational facilities planning.

King, Jonathan, and Weinstock, Ruth. "Schools in the 70's: The Case of the Relevant Schoolhouse. NASSP Dialogue." Paper presented at the annual convention of the National Association of Secondary School Principals, Washington, February, 1970. 15 pages. ED 046 086 MF $0.65 HC $3.29.

Koppes, Wayne F., and Green, Alan C. *Modular Coordination and School Design: A State-of-the-Art Report to the Architectural and Educational Professors. Final Report.* Troy, New York: School of Architecture, Rensselaer Polytechnic Institute, 1967. 102 pages. ED 016 369 MF $0.65 HC $6.58.

Metropolitan Toronto School Board. *Educational Specifications and User Requirements for Elementary (K-6) Schools. SEF Report E1.* Toronto, Ontario: Study of Educational Facilities, 1968. 208 pages. ED 035 188 Document not available from EDRS. (Available from The Ryerson Press, 299 Queen Street West, Toronto 2B, Ontario, Canada, $10.00.)

———. *Educational Specifications and User Requirements for Intermediate Schools. SEF Report E2.* Toronto, Ontario: Study of Educational Facilities, 1969. 247 pages. ED 030 295 Document not available from EDRS. (Available from The Ryerson Press, 299 Queen Street West, Toronto 2B, Ontario, Canada, $10.00.)

———. *SEF-Academic Evaluation: An Interim Report.* Toronto, Ontario: Study of Educational Facilities, 1972. 211 pages. EA 004 184 (ED number not yet assigned) MF $0.65 HC $9.87.

"A New English Translation: 'Systems Buildings' for Boardmen and Administrators." *American School Board Journal,* (January 1971), 22-29.

Examines various systems approaches used in the design and construction of flexible school facilities and systems buildings in use by school boards in Rochester, New York, and Hillsboro, Oregon.

Orlowski, S. T. *Research Study of Modular Design of School Buildings in Europe. April 30, 1968-May 20, 1968. Revised 1969.* Toronto: School Planning and Building Research Section, Ontario Department of Education, 1969. 69 pages. ED 035 219 MF $0.65 HC $3.29.

"Part One of a Special Report on School Building Systems: The Trend to School Building Systems: What's in It for You." *School Management,* (August 1969), 25-54.

"Part Two of a Special Report on School Building Systems: Why Systems Can't Miss." *School Management,* (September 1969), 66-73.

"Performance Design." *Progressive Architecture,* (August 1967), 104-151.

Extensive survey of systems building in urban and industrial applications. Provides comprehensive perspective for the administrator seeking to evaluate cultural impact of systems designs and societal ramifications for school facilities planning. Levels criticism at technological lag caused by unresponsive building industries.

Robbie, Roderick G. "The Application of the Systems Approach to School Building in Toronto." Address to the Regional Conferences on a Systems Approach to Buildings, sponsored by the Department of Industry, Trade and Commerce, Ottawa, Canada, 1969. 60 pages. ED 033 564 MF $0.65 HC $3.29.

——— "System Building and Architecture." Address to the Committee on School and College Architecture of the American Institute of Architects, Houston, August, 1969. 28 pages. ED 033 547 MF $0.65 HC $3.29.

——— "The Flexible Future of Architecture." *AIA Journal,* (November 1969), 63-66.

Former technical director of SEF presents arguments for stimulating "wide-spread human creative development" through new architectural techniques afforded by building systems. Suggests the individual's ability to redesign his environment is enhanced by the flexible nature of systems-built structures. Cites SCSD and SEF experiences.

———. "The Turning Point?" *RIBA Journal,* (June 1970), 254-261.

Provides further data regarding Toronto's building system schools and its implications for the future.

Rothenstein, Guy. "Systems Definitions." *Progressive Architecture,* (September 1970), 100-101.

Provides good capsule definitions of basic systems building terminology and sets context within which they are used.

Schmid, Thomas, and Testa, Carlo. *Systems Building: An International Survey of Methods.* New York: Frederick A. Praeger, Publishers, 1969.

Stanford University. *Bibliography of Selected SCSD, URBS, SSP, SEF, and RAS Publications.* Stanford, California: School Planning Laboratory, [1969]. 12 pages. ED 031 052 MF $0.65 HC $3.29.

Texas A & M University. *Higher Education Facilities: Systems Building Analysis. Documentary Work Report.* College Station, Texas: College of Architecture and Environmental Design, 1971. 109 pages. ED 060 536 MF $0.65 HC $6.58.

———. *Higher Education Facilities: Systems Building Analysis. Summary Report.* College Station, Texas: College of Architecture and Environmental Design, 1971. 15 pages. ED 060 526 MF $0.65 HC $3.29.

University of California. *University Residential Building Systems (URBS). Phase I Report, Revised December 1966.* Berkeley: Department of Physical Planning and Construction, 1966. 60 pages. ED 031 914 MF $0.65 HC $3.29.

———. *University Residential Building System. Phase II Report (Including Evaluation of Bids).* Berkeley: Department of Physical Planning and Construction, 1968. 79 pages. ED 031 915 MF $0.65 HC $3.29.

———. *University Residential Building System. URBS Components Preliminary Design Manual.* Berkeley: Department of Physical Planning and Construction, 1969. 39 pages. ED 035 216 MF $0.65 HC $3.29.

———. *User Requirements, April 1969.* Berkeley: Department of Physical Planning and Construction, 1969. 134 pages. ED 035 217 MF $0.65 HC $6.58.

University of California, and Indiana University. *Environmental Study: Science and Engineering Buildings, ABS Publication No. 1.* Berkeley and Bloomington: 1971. 123 pages. ED 055 369 MF $0.65 HC $6.58. (Also available from University of California, Office of Vice President/Planning, 641 University Avenue, Berkeley, California 94720, one copy free to educational institutions and government agencies, others $4.00.)

———. *Cost/Performance Study: Six Science and Engineering Buildings. ABS Publication No. 2.* Berkeley and Bloomington: 1971. 170 pages. ED 055 371 MF $0.65 HC $6.58. (Also available from University of California, Office of Vice President/Planning, 641 University Avenue, Berkeley, California 94720, one copy free to educational institutions and government agencies, others $6.00.)

———. *Information Manual: Procedures, Planning Concepts, Sub-systems. ABS Publication No. 3.* Berkeley and Bloomington: 1971. 274 pages. ED 055 370 MF $0.65 HC $9.87. (Also available from University of California, Office of Vice President/Planning, 641 University Avenue, Berkeley, California 94720, one copy free to educational institutions and government agencies, others $10.00.)

Washington State Office of Public Instruction. *A Study on Economies in School Construction.* Olympia, Washington: 1971. 40 pages. ED 057 446 MF $0.65 HC $3.29.

How to Locate and Order ERIC Documents

Many of the documents cited in this paper were processed by the ERIC system and have been announced in *Research in Education (RIE)*, the monthly ERIC index and abstract catalog. Each ERIC document is indicated by an "ED" number at the end of the citation. The "ED" number is the document's index number and can be used to locate the particular issue of *RIE* in which the document's abstract appears.

Most ERIC documents can be ordered from the ERIC Document Reproduction Service. If a document is available from EDRS, its order number and prices are given. To order documents from EDRS, indicate:

- the ED numbers of the desired documents (titles need not be furnished)
- the type of reproduction desired–hard copy (HC) or microfiche (MF)
- the number of copies being ordered

Payment must accompany orders under $10.00. Postage, at book rate or library rate, is included in the price of the document. If first class mailing is desired or if shipment is outside the continental United States, the difference between book rate or library rate and first class or foreign postage will be billed at cost. All orders must be in writing.

Address requests to: ERIC Document Reproduction Service
P. O. Drawer O
Bethesda, Maryland 20014

Previous Publications in This Series

1. **Educational and Social Demands on the Schools**
   ED 043 110; MF $0.65, HC $3.29
2. **Alternative Organizational Forms**
   ED 043 111; MF $0.65, HC $3.29
3. **New Sets of Jobs for School Personnel**
   ED 043 112; MF $0.65, HC $3.29
4. **Management Information Systems**
   ED 043 113; MF $0.65, HC $3.29
5. **Models for Planning**
   ED 043 114; MF $0.65, HC $3.29
6. **Models for Rational Decision Making**
   ED 043 115; MF $0.65, HC $3.29
7. **Procedures for Managing Innovations**
   ED 043 116; MF $0.65, HC $3.29
8. **Linking Schools to State Education Departments**
   ED 043 117; MF $0.65, HC $3.29
9. **Linking Schools and State Education Departments to Research and Development Agencies**
   ED 043 118; MF $0.65, HC $3.29
10. **New Programs for Training School Administrators**
    ED 043 119; MF $0.65, HC $3.29
11. **Introduction Plans (Marketing Plans)**
    ED 043 120; MF $0.65, HC $3.29
12. **Taxation in Public Education**
    ED 049 516; MF $0.65, HC $3.29. While the supply lasts, free single copies can be obtained by writing to the Clearinghouse.
13. **Accountability and Performance Contracting**
    ED 055 336; MF $0.65, HC $3.29. While the supply lasts, free single copies can be obtained by writing to the Clearinghouse.
14. **Student Involvement**
    ED 060 510; MF $0.65, HC $3.29. While the supply lasts, free single copies can be obtained by writing to the Clearinghouse.

Copies can be ordered from the ERIC Document Reproduction Service—see above