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ABSTRACT

Academic Building Systems (ABS) is an architectural planning and design method which allows the construction owner to respond to the need for less expensive structures, economically adaptable to the changing conditions of the academic world, by providing the owner with the maximum controls over the variable cost factors in educational facility construction. In the ABS open system, more than one manufacturer can supply each of the components of the building system. This is felt to offer the best potential for reducing construction, maintenance, and remodeling costs and for improving the usefulness of academic facilities. The systems approach provides a high degree of coordination of the building components. It takes into consideration standard and repetitive features, life costs of complex buildings, adaptability of station utilization, tradeoffs of higher first costs versus lower life costs, and shorter construction time. The major innovation in the fixed elements is the space module, which is a repetitive unit used throughout the structure and which reduces construction costs by making possible the use of standard units of heating, ventilation, and air conditioning to service each module. (LBH)

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STUDIES IN MANAGEMENT

ACADEMIC BUILDING SYSTEMS

A Technique to Maximize Control of Construction Costs

By Donald H. Clark

Many factors have contributed to major academic construction cost increases in the past decade:

(a) *Inflation.* The greatest single cause of this increase has been and probably will be inflation. Continued inflation will mean very high future renovation and modernization costs.

(b) *Great demand.*

(c) *Complexity.* Increasingly complex buildings requiring [illegible] plumbing and electrical systems must meet ever increasing code demands.

(d) *Restrictive labor union policies.*

(e) *Design.* Elaborate expensive designs beyond those necessary to meet the program demands, are being dictated whether by the architect, the owner or the donor.

(f) *Excessive time length.* Time is spent unnecessarily on programming, financing, and preparing architectural drawings, all done consecutively.

(g) *Excessive change orders.*

(h) *Quality.* Custom items, not standard off-the-shelf inventory items are specified.

(i) *Trade-offs to change life costs.*

(j) *Project size.* Larger buildings and larger contracts tend to reduce the competitiveness of bidding and to lengthen construction time, adding to the contingency on a materially increased percentage for the third and fourth years.

(k) *Labor productivity.* On-site labor productivity is relatively low compared with factory production.

(l) *Lack of repetitive features.* Everything is different and, therefore, everything is a pioneering effort or an expensive prototype.

(m) *Profit.* After the competitive bidding, the contractor's knowledge is used primarily for his own profit.

(n) *Practical loss in design.* The contractor's team has no say on features of building during design. Thus their expertise cannot give maximum benefit to the owner.

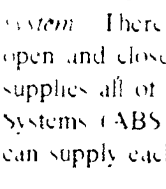
Factors of inflation, over-all demand, labor union policies and low on-site production are not controllable by the individual owner. *Academic Building Systems*, including *Contract Management*, is an attempt to give the owner the necessary tools to respond to the need for less expensive structures economically adaptable to the changing conditions of the academic world, by providing the owner with the maximum controls over the variable cost factors.

The History of *Academic Building Systems*

The joint California-Indiana Study in Interinstitutional and Interstate Cooperation analyzed ways to reduce construction costs while at the same time provide better academic facilities. This sounds like a big order, and it was. But it was one that the legislators of the two States felt must be attempted. As a result they approved a joint project by the University of California and Indiana University. The goal was to show that the change from conventional planning and design to the "system approach" offers the best potential for reducing construction, maintenance, and remodeling costs, and improving the usefulness of academic facilities. This approach is based on an *open system*. There are two major types of building systems: open and closed. In the closed system one manufacturer supplies all of the components; in the Academic Building Systems (ABS) open system more than one manufacturer can supply each of the components.

The idea for systems building achieved an important breakthrough in 1963. In that year, thirteen California school districts united in School Construction System Development (SCSD), the first large-scale effort in the United States to systemize construction for one-story buildings on a component basis.

The current California-Indiana study began in 1966 through the cooperation of Elmo Morgan, then University of California Vice President for Physical Planning and Construction, Harold Gores and Jonathan King of Educational Facilities Laboratories, and myself. $1,200,000 in



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funding for this research project came from the following sources: the United States Office of Education, $600,000; the States of California and Indiana, $200,000 each for a total of $400,000, and Educational Facilities Laboratories, $200,000. The principal research consultant was Building Systems Development, a San Francisco architectural firm whose principals also headed the California School Construction System Development.

Academic Building Systems is an architectural planning and design method directed toward attaining an adaptable building through "a high degree of coordination of the components that make up a building, plus concepts and procedures that have been tested in other situations."[1] It has been described as "excellent optimization" by the Assistant Director of Research at Facilities Engineering and Construction Agency (FECA).

The Facts of Life Cost

A major factor, too often overlooked, is the life cost of a structure. In a comprehensive study of science buildings, the rehabilitation cost of older structures often exceeds twice the original cost. No dollar evaluation has been set for the disruption costs of space surrounding the area being remodeled. The adaptability of the ABS buildings will materially reduce the time necessary to complete the change and the savings from minimized disruption in adjacent space also will be of great value.

Two of the major objectives of the Academic Building Systems Study are to reduce costs and to provide better academic facilities. The ABS results offer potentials which give the owner maximum ability to manage the controllable high cost areas for both first and life costs. At the same time, it builds in adaptability to provide the desired better academic environment for the future.

Design: Standard and Repetitive Features

The building system consists of conventional components which can reduce design time, can be mass produced to reduce construction time and costs, and can have specified performance standards related to the real needs of the user. From these components, a wide variety of buildings—in size, shape and appearance—can be created to answer specific requirements.

The building system approach has evolved more recently into the conceptualization of the total building process as a system. Thus, other phases of the construction process which ABS is studying include new methods of programming the needs of users in relation to budgeting constraints and ways of reducing the total time of developing a building, from initiation of planning to completion of construction.

Complex Building: Life Costs

As the study of construction continued, it became apparent that a major question concerning building designs that had disturbed administrators in the past demanded greater attention in the future. This question involves the fact that heating, ventilating, air conditioning, and electrical systems in buildings have become more and more complicated and are taking an increasingly higher percentage of the total construction budget. These problems become even greater in size when one couples the original high cost with the knowledge that during the structure's lifetime these subsystems will have to be replaced, some parts several times at the future inflated cost levels. This emphatically suggests the increasing importance of using a structural design that facilitates access to the expensive utilities and machinery, thus reducing future remodeling and repair costs. It became obvious early in the study that the old puzzles created by pipes and conduits buried in partitions, floors, or ceilings could not be continued because of inflexibility as well as prohibitively high costs of repair or replacement.

Adaptability: Station Utilization

The need for a different system thus was dictated by increasing costs—both for construction and for land—and by the fact that no system existed which would meet educational needs with the economics of the runaway inflation in the construction field. There also is the urgent need to build adaptability into the structures. In the past, remodeling costs often have far exceeded the building's original cost.

We also find that not nearly enough has been done to meet the challenge of the relatively poor station utilization caused, at least partially, by fixed structures. For example, if a laboratory is in use five hours a day, this means a room utilization of 5 hours × 5 days, or 25 hours out of 40 hours per week (62.5 percent room utilization). If the room has 30 student stations and has an average of 20 occupied, this is a 66 percent station utilization when the room is in use. The actual station utilization then becomes 66 percent × 62.5 percent or 41.25 percent.

In the past the size of the laboratory has been inflexible. If it were designed for 30 students, it was prohibitively expensive to enlarge it to accommodate 40 students, or reduce it to accommodate only 20. This inflexibility prevented the introduction of new and better teaching techniques for different sized classes and, in effect, placed a limit on faculty ingenuity and efficiency. The building could not be easily revised to accommodate a multi-purpose laboratory, or changed to individual study laboratories in order to meet any other future needs. ABS adaptability makes it possible to meet changing conditions efficiently.

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[1] Building Systems Development, Inc., *Feasibility Study Report --Academic Building Systems*, May 1967, page 7.

Therefore, new needs can be met and potentially greater station utilization can be realized economically

For existing buildings, the cost to both institutions and granting agencies for converting laboratory facilities to accommodate research projects has been astronomical. In some instances a single mobile faculty member has used two or three grants to complete his laboratory designed to meet his research requirements at each of the two or three institutions to which he has moved within a ten-year span In turn, the laboratory from which he has moved has again been remodeled for his successor. Investigation reveals that these rather minor remodeling projects have cost from $100,000 to $250,000 or more They are minor in the amount of space required, but major in terms of dollars In addition to delaying the scientific results, the faculty member's time has occasionally been lost for a longer period of time than either he the institution, or the granting agency desire through the slow remodeling process

If a laboratory or classroom building can be planned to eliminate much of the loss of inefficient station utilization as well as the need for excessive remodeling, the potential future savings can be great In addition, major immediate savings are visible. For instance, by building in semester-to-semester adaptability, it is estimated that the academic program can be met with 20 percent fewer lab stations In the Science Engineering Technology Building in Indianapolis (Indiana-Purdue Universities), 10 percent of the total cost of the originally proposed structure will be saved through space reduction agreed to by the faculty, who recognized that adaptability will meet their needs with less space[1]

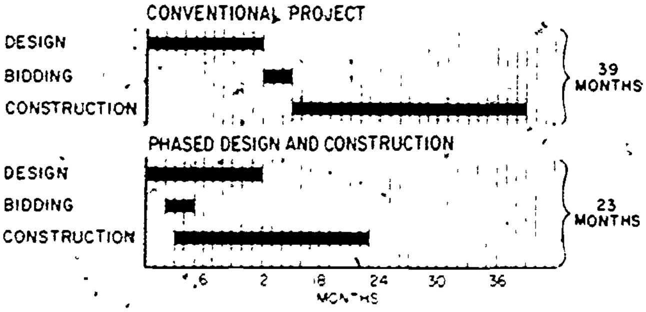
To assure the best academic environment, a major research project within the ABS program was recently conducted by Building Systems Development, Inc. This involved an evaluation of present facilities by the faculties of the University of California and the four state-supported universities in Indiana (Ball State, Indiana State, Purdue and Indiana), coupled with cost analysis of three major buildings in California and three in Indiana.

Trade-Offs: Higher First Costs vs. Lower Life Costs

User criticisms revealed that at times an apparent economy is actually very wasteful (e g., the use of less expensive partitions where their sound control was so ineffective as to interfere with proper room use). The technique of the building system design should assist in alleviating this type of problem since it permits the owner and the architect to make the best cost decisions for the lifetime of the building.

Shorter Time for the Project

One of the major ways that savings can result from the use of Academic Building Systems is by accelerated planning It is no longer necessary to have completed academic programs and completed architectural plans before bidding and construction begins The flexibility of the structure permits changes late in the construction period, with predictable cost In addition, the following diagram shows how ABS works with phase design and construction to save time



Lower Life Cost

Lower life cost permits planning, architectural drawings, and the actual construction work all to proceed simultaneously Adaptability before the structure is erected is just as valuable and dollar-saving as it is during the life of the completed structure Flexibility is especially valuable for structures on developing campuses. That the campus has changing needs through the next five or ten years is obvious to all. These needs are almost as strong on more established campuses, but much less obvious.

In the next ten years there will not be the same requirements for language classrooms, for laboratories, etc. Because of research, the needs of the future will be much different from the needs of the past. The language laboratory of today is markedly different from the French or Latin classroom of forty years ago. Surely, even greater future changes will occur. A structure that will facilitate these future changes will provide its owner with the maximum future advantage, as opposed to the liabilities of most of today's construction methods which resist change by making it expensive in both cost and time

The importance of adaptable elements in ABS cannot be overestimated. The future savings resulting from the ability to adapt to the existing demands inexpensively will prolong the structure's effective life and will tend to insure maximum utility for the future. The adaptable elements include:

1. Utility distribution laterals and drops to rooms.
2. Heating, ventilating, air conditioning (HVAC) zone duct work and controls
3. Ceiling panels, lighting, and HVAC diffusers.
4. Partitions.
5. Casework

It should be emphasized that the cost of altering an academic building over its assumed forty to fifty year life may be as much as double the contract cost of the original construction. Furthermore, the lack of funds usually dictates a much longer usage. Each remodeling project disrupts the operation of the facility to varying degrees. In addition, the more difficult and expensive it is to alter the existing structure, the less probable it is that needed alteration will take place, thus, forcing staff to work under increasingly inefficient conditions. The use of deep service space in ABS eliminates disruption costs and lost time in salaries equivalent to fifteen to thirty percent of the modification costs. Perhaps the greatest potential savings under ABS is in the low alteration costs (with little or no neighboring space disruption costs) where, by the concept of adaptable building elements, alterations can be effected with minimum time and user skill.[2]

Permanent elements of the ABS structure are: space module (10,000 sq ft ± 20%), structure, vertical utility distribution, HVAC main duct work, service towers, horizontal utility distribution mains, vertical occupant circulation, and exterior walls. The changing of these elements is extremely expensive so that their positions are fixed.

Repetitive Feature

The major innovation in the fixed elements is the space module, which is a repetitive unit used throughout the structure. It should assist in reducing construction costs by making possible the use of standard off-the-shelf units of heating, ventilation, and air conditioning (HVAC) to service each module, thus eliminating the costly custom-designed HVAC unit used in the large traditional buildings. It also facilitates having as much work as possible performed at the most economical level—in the factory—as contrasted to the more costly on-the-site work.

An additional value from ABS for administrators, architects, and engineers is the detail of costs by subsystems. This provides a major refinement over the sole use of cost per square foot, or cubic foot which has, all too often, been the only criteria used by owners.

The gross square feet subsystem costs were analyzed for these areas:

Structure
Heating, ventilating, air
 conditioning
Partitions
Lighting ceiling
Site work, below grade
 and basement

Plumbing
Electrical
Exterior skin
Elevators
Other
General contractor

There were several systems of high cost where the user requirements were not met, or where the user requirements were changed subsequent to the construction. This information is reported in detail in Volume 2 of the ABS publication, "Cost Performance Study."

The greatest value of this cost analysis is that the owner can stress performance in the most critical area and, if necessary, control costs in other less critical areas. Another advantage accruing to owners and architects is the users rating of the products which have been used in past construction. This technique of computing costs by subsystems gives the owners and architects better cost control during the architect's design time. If lower costs are necessary, the changes can be made with full knowledge of the costs by subsystems.

HEW Data Available

The Department of Health, Education and Welfare has committed itself to the systematic observance of cost, time, and quality in the design and construction of facilities, as follows: To ensure that, despite the current escalation of construction costs, quality levels will be maintained or improved at no sacrifice in the lifetime costs of the facility, to reduce design and construction time so that the facility is available for use at an earlier date, and to permit ease of physical modification as the functional and operational requirements change. Toward that commitment, these circulars are HEW position papers offering creative solutions in the areas of interpreting user requirements, planning, programming, design, construction, and use of facilities.

The Building Information Circular series covers the following subjects:

1. Comprehensive planning
2. Value analysis
3. Systems building
   (a) Academic Building System (ABS)—Higher Education
   (b) Systems Building in Elementary Secondary Schools—SSP Experience
4. Construction Management Phased Design and Construction

The use of the findings of the ABS Study incorporating "Construction Management Phased Design and Construction" offers the university or college an opportunity for a better academic environment over a longer period of time with lower first and life costs and with a considerable savings of time for the project.

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[2] Paraphrased and or quoted from *Academic Building Systems Design Manual* by BSD page 18

This study is available from either University of California, Office of Vice President Planning, 641 University Hall, Berkeley, California 94720 or Indiana University, Assistant Vice President-Treasurer's Office, 210 Bryan Hall, Bloomington, Indiana 47401. The first copy of the three volume publication is free to a university or governmental agency. Each additional copy to a university and each copy to an architectural firm is $20.