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ABSTRACT

This document reports a yearlong 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. Study findings are summarized and recommendations are made for improving the building delivery system. Appendixes contain background data for the information developed in the report and a selected bibliography. A related document is EA 004 061. (Parts of the appendixes may reproduce poorly.) (Author/MLF)

Higher Education Facilities Systems Building Analysis

Commentary Work Report

ED 060536

EA 004 095

TEXAS A&M UNIVERSITY
ARCHITECTURE RESEARCH CENTER
COLLEGE STATION TEXAS 77843

Dr. Bevington Reed
Commissioner
Coordinating Board
Texas College and University System
Capitol Station
Austin, Texas

Dear Dr. Reed:

This report summarizes our findings and recommendations concerning a systems building approach to the design, construction and utilization of Texas College and University facilities.

We wish to express our sincere appreciation for your staff's contribution to the direction and content of this report.

Very truly yours,

F.J. Trost
Principal Investigator

W. Cecil Steward
Administrative Director
Architecture Research Center

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June 17, 1971

FJT:jh

1 Introduction

In July 1970, the Coordinating Board Texas College and University System commissioned the Architecture Research Center of Texas A&M University's College of Architecture and Environmental Design to undertake a year-long study of the possible benefits in cost, time, and facility utilization of using a systems building approach for Texas' college and university construction. The study was supported by a comprehensive planning grant from the U.S. Office of Education. The purpose of this report is to present the results of the study and to make recommendations for improving the building delivery system for Texas' college and university facility construction.

Because one cannot reasonably talk about ways to satisfy future facility requirements without being aware of what those requirements may be, the first part of this report deals with what appear to be the present and future trends and needs in higher education and the related architectural implications. The discussion of alternative building delivery processes which follows will then have been properly prefaced and will in turn prepare the reader for a consideration of the utilization of present and future facilities. Finally the studies' findings will be summarized and conclusions drawn on which final recommendations will be based.

Contents

2 Higher Education

2.1 Trends

Today in virtually every aspect of American life, conventional ways of thinking and doing are being re-examined and challenged. Changes result which test cultural assumptions previously held above question. The over-riding theme of current cultural concern is turmoil, and change itself has become one of the most basic facts of modern existence.

Educators tell us of developing generations which regard change as normal and necessary rather than as annoying or damaging. They are aware of this trend in today's young not only because they interact frequently with them but also because they are partly responsible for it. Education more than any other social institution besides the home mediates the environment to the young. The development of new cultural responses appear most obvious in college students because they have been exposed to the rapidly changing social environment during their formative years and have reached the age when they are more capable and likely to effect new structures.

Higher education, the cultural medium for these students, is pressured from within and without to change. The changing social scene, the growing body of knowledge and technology, rising costs, and the increasing population force colleges and universities to reevaluate the quality and efficiency of their programs and facilities. This is to be expected. For in a time of great cultural flux, educational programs cannot long remain viable without changing to suit the society served. The fact is that higher education is and has been changing for some time. New procedures and technology constantly reshape the educational scene so that colleges must change as fast as they grow. Although the changes differ from institution to institution and may be neither evolutional nor sequential, several discernible patterns emerge.

Independent Study

One growing trend in higher education is that

of independent study or individualized programs. The basic feature of this trend is student control of time, subject matter, and extent and depth of study. Ideally, the student works on his own time, in his own direction with help from instructors when requested. A faculty advisor consults with him on a study program, on the anticipated depth and scope of the study, and about his expectations for the student's activities. The dialogue continues until the goals agreed upon are realized.

Individualized programming recognizes that people learn at different rates and attempts to accommodate the differences by allowing students to study not only what they want but also when and for how long. Flexible schedules are evolved which suit individual rather than institutional needs. And the needs considered include those of the instructors as well. Whereas conventional schedules deny autonomy to teachers and students alike, the newer concept views time control as a personal matter and scheduling as a flexible tool for optimizing time use for both groups.

Another concept vital to individualized programs is that of flexible grouping. Individual students studying at their own rates may well desire and be directed toward involvement in small groups where discussion can be freely shared. Students change. Their interests fluctuate and they differ in abilities and achievements. Flexible grouping can allow for these differences and capitalize on the stimulating interactions which occur in heterogeneous groups. Dynamic allocation of space for changing groups meeting at different times and for varying periods of time becomes an important consideration and one not customarily faced in conventional programs.

Continuing Education

Another growing trend in higher education is the recognition of continuing education as a means of alleviating the problems of technological

obsolescence, the use of leisure time, and old age. Individuals involved in such programs can learn new technical skills and keep up with additions in general knowledge as well.

Extended Campus

One of the newest trends in higher education relates college and university services directly to host communities. The "extended campus" concept means that instead of working people in the community rushing home after a full day's work to hurriedly eat, dress, and travel to a night class at a nearby institution, the college or university sends professors out to the people to instruct them during the noon break or after work at their places of business.

The college benefits by being able to operate with less overhead for instructional space and equipment. Borrowed or donated space for classrooms comes in the form of conference rooms, cafeterias, offices, and other work areas. Idle equipment is made available for demonstration purposes as whole factories become temporary laboratories.

The students save time by not having to travel to the institution. They save money from the reduced rates colleges can offer and the support their company's offer. And they learn more efficiently since they are less fatigued during class and have evenings free for study. The extended campus trend brings higher education to more people at less cost and promotes better relations between college and community.

Interdisciplinary Studies

The trend toward interdisciplinary studies continues to grow as scholars and students realize the educational value of heterogeneous team effort and the fundamental similarities in subject matter and technique among the various disciplines.

Multi-Media Presentations

The increasing use of a variety of media to present information to students finds its impetus in the search for more efficient means of teaching, technological advancements, and the demands of rising enrollments. Multi-media presentations of information used appropriately can increase the opportunities and likelihood of learning. The use of such techniques can bring education to more people, improve the utilization of expensive facilities and human talent, and enrich the learning experience for the individual.

Large, automated lecture halls which utilize many different types of media appear with increasing frequency on American college and university campuses. The appeal of such facilities is largely their capacity to handle large groups, but multi-media presentations for individual users are growing as well.

"Multi-media" describes anything usable to organize, store, and present information and includes everything from computers to television to slides and overhead projectors, including teachers, books and chalkboards. Libraries are becoming "media centers" where students have access to information stored in all the various forms, for information presented through the most appropriate media can create stimulating learning experiences not otherwise obtainable.

The availability of such materials to individual students can contribute to the success of individualized programs. Students could have immediate access to the best presentations of information on virtually any topic and updating could be effected quickly to keep information fresh and accurate. The best instructors could be available to individual students studying alone or to large groups of them. Different approaches are being tried which involve wide scale television presentations of information. In some, evaluation of student performance is handled through the mail, while in others students come periodically to a

central point for testing and counselling. The implications in terms of substantially reduced campus facilities are significant.

Student Housing

Another trend in higher education deals with student housing. The interacting forces include demands of students for social arrangements like those of the host society and the rising costs of construction. Students often dislike the regimentation of dorm life, the monotony of the facilities, and the lack of privacy and opt for private housing when and where they can. Frequently the result is a decreasing occupancy rate for dormitories which may depend on student rent fees for amortization of building bonds. Institutions are attempting to make dormitory life more attractive by revising regulations and by making facilities more pleasant. New housing being provided emphasizes more control of the living environment by the occupants, less institutionalized appearance, and smaller often heterogeneous groupings.

Some institutions have recognized the value of student housing as an instrument of learning. Mixed or proximal residential arrangements are being used to bridge the gap between students and professors. Some authorities project that widescale introduction of multi-media facilities into the living environment could contribute to the effectiveness of self-paced study programs.

Inter-College Consortia

In various sections of the U.S., colleges and universities are becoming involved in joint ventures for mutual economic and academic advantage. By pooling their mutual needs, these institutions are able to aggregate markets large enough to effect economies in purchases of equipment and materials. Pooling their respective resources, they are able to complement each others academic programs and to share professors and expensive facilities, thereby avoiding needless duplication.

There are of course many other ways in which higher education is changing which have not been mentioned. These have been discussed because they seem to indicate general direction.

2.2 Architectural Implications

Higher education is changing at an increasingly rapid rate so that that which we know and understand as standard today may not be so in a few years. The great bulk of buildings on campuses in this country, however, will remain fundamentally unchanged due to the inflexibility of their designs and intended permanence of their construction. This disparity between function and facility will become even more restrictive as educators try to update their programs in the ways discussed. Pressures will mount for facilities which can more readily support these programs, the architectural implications of which may lead to buildings based on present and future, instead of past, concepts and needs.

The major concepts which can be generalized from trends in higher education include a pervasive emphasis on individual control, recognition of the synergistic educational value of group interaction, an awareness of the value of multimedia presentations of information, and the restraints of economy. These concepts are closely interrelated and effect similarly interrelated architectural responses.

Individualized Programs

Facilities intended to house and support individualized programs will have to allow for more user control. "User" in this sense could mean the individual student studying alone in a carrel, a professor or administrator in his office, or the institution itself in the day-to-day operation of campus facilities.

One obvious way to enhance user control is to permit the user to change certain aspects of his physical environment such as lighting, atmosphere,

or spatial arrangement. This sort of rather immediate control could help make an office, study space, or dorm room a more personalized space.

Another way would be to make available to users, especially students, a wide variety of spaces for their use. Study spaces, for instance, could be varied in location, size, type, related equipment, arrangement of groupings, finishes, colors, furnishings, and in other ways to let students choose the spaces they use. Accessibility to different types of spaces becomes increasingly important as new concepts in higher education de-emphasize the lecture system of instruction and the traditional classroom gives way to a variety of other learning spaces.

Independent Study

The influence of independent study programs is here most obvious. Students will need access to individual study spaces. But they will not spend all their time in solitary study. They will be involved in group activities through seminars and projects. The implications of these variable groupings demand different provisions which should be mentioned separately starting with facilities for independent study.

No single facility should be set aside to contain all the independent study spaces for an institution. These areas are best scattered throughout the campus. There will be a need for a large number of such spaces in and around information resource centers and there should be spaces close to project and seminar areas where students can get together and share learning experiences. Some independent study areas should also be located near discipline-oriented facilities, equipment, and personnel. Nearby social or commons areas for interaction and relaxation are also desirable.

Independent study units function best if grouped in small clusters so that they can share common services. If many units (carrels, for example)

are assembled in one place, it is important to visually and functionally vary the space to avoid monotony and to create an inviting study environment. Placing study units adjacent to circulation spaces can create noise problems and distractions for many students. Finally, spaces for instructors should be close to independent study areas to facilitate consultation and counselling.

Many types of independent study units can be provided: enclosed, semi-enclosed, open, special purpose (i.e. typing, recording, viewing, computer), with or without storage space, lockable or not, and assigned or unassigned. No one type should be used exclusively, but rather a mix of several types should be provided to best meet student needs.

Group Facilities

Large group facilities are perhaps the most difficult of any type space as far as planning considerations go. These spaces will tend toward 300-400 person capacity with the capability to subdivide into 80 or 100 seat units. Since these areas are often used for visual presentations, stepped or sloped floors are necessary. Aisles and circulation should not interfere with the viewing area, nor should sound from adjacent spaces or projection equipment interfere with hearing. It should be pointed out also that in facilities for large groups windows and natural light are often more bothersome than beneficial.

Small group facilities will be needed to supplement both individual and large group areas. Such spaces could be provided as part of a resource center and used by groups of students with and without instructors to review and learn from resource materials. Small group space could be incorporated into a professor's office area or scattered around the campus as scheduled or informal spaces. A variety of seating arrangements could be adopted to compliment group discussion, or review. And multi-media

equipment could be introduced to supplement other activities. Two levels of lighting to allow for projection and discussion would be desirable. Carpeting should be used for sound control and to make the space more informal so that interaction would be enhanced.

In all situations large group, small group, or individual, student control over learning experiences will be enhanced by making a variety of different spaces available.

Spatial variety will also be important to the institution. The complex problems created by flexible scheduling and grouping demand dynamic space allocation systems to handle a great variety of spaces.

But economic restraints prohibit stockpiling space types to meet peak demands. Facilities need to be multi-functional or flexible to meet similar, simultaneous space needs within economic limits. In facilities with less immediate alteration requirements, interior flexibility can allow for major modification without excessive cost or interruption of services.

Architectural Response

Flexibility then, as a function of anticipated change, desired spatial variety, and economy, implies some very specific architectural responses. One of the more obvious is the need for clear space which means long structural spans. Another is the need for a malleable system of space division. Movable and operable interior partitioning could answer this need especially if supplemented with multi-functional furnishings. Environmental factors call for lighting systems which are changeable in intensity and location; relocatable air conditioning ducts and diffusers; relocatable mechanical and electrical distribution networks; relocatable control systems for lighting, electricity, air conditioning; and provisions for sound control (carpeting, finishes, traffic patterns). Other parameters which could contribute to spatial flexibility include an efficient, changeable signage system, functional wall finishes

(chalk, display, projection), empty conduits and cable trays for the addition of new services and/or equipment, and storage space for partitions, furniture, maintenance and multi-media equipment.

Colleges and universities are not only experiencing demands for flexibility of academic facilities. Growing student dissatisfaction with dormitory living and changing ideas about student housing are producing demands for flexible residential facilities. Many believe that student housing should narrow the gap between faculty and students, the classroom and the living room. The most important step in achieving such a goal is to provide students with two fundamental needs: privacy and participation. This means individual rooms and the opportunity to identify with a group small enough to be comprehendable.

The single room assumes central importance, then. Single rooms could be combined in suites and these perhaps clustered around a courtyard with access to common recreational, meeting, and dining facilities. Providing family suites among single student types would encourage married students to participate more actively in the college community. Mixing students with professors in residential arrangements could stimulate useful educational associations for both groups.

The educational value of housing could be improved further by introducing multi-media facilities for occupants' use. Television, a common feature of most lounge areas, could be used for in-residence instruction. Small media centers or libraries could contain standard reference and other forms of educational materials. Commons areas could be utilized more flexibly for educational displays of science or art and could in this way capitalize on a campus facility not normally used for educational purposes.

Throughout this discussion on the architectural implications of trends in higher education, flexibility seemed to appear as the implication most

common to all the trends. And, indeed it is, for flexibility not only allows institutions to offer great spatial variety within reasonable economic restraints. It also allows them to adapt more easily to unanticipated developments - like more new trends in higher educational thought and programs. As costs of construction rise, being able to use an expensive facility flexibly may help extend its useful life and forestall the difficult, expensive, and time-consuming process of building a replacement.

3 Building Delivery

3.1 Conventional Process

Two concepts shape current institutional building delivery practices. First, each new building is viewed as a separate entity satisfying a unique set of project requirements. Second, the steps necessary to produce a building are perceived as independent separate activities.

Visits to recently completed college buildings reveal only cosmetic differences in building appearance, equipment, and finishes for facilities serving similar functional requirements. Yet each new building is produced as if it were a significantly different structure through a lock-step sequence of activities:

- Recognize Need
  - identify building requirement
  - arrange financing
  - locate site
- Design
  - program specific building requirements
  - design
  - produce contract documents
  - bid
  - award
- Construct
  - manufacture components
  - deliver
  - assemble
- Occupy

A series of institutional approvals required at each step in the process effectively separate the interdependent building activities.

3.1.1 Costs

Trends

Nationally the cost of construction increased 36% between 1965 and 1970. Recent increases have been more severe: exceeding 10% in 69 - 70 and currently averaging 12% per year. National building cost statistics for the 65 - 70 period also provide information on the proportion of labor

and material in a generalized construction project. While building costs increased 36%, labor costs jumped 47% and material costs were up 17%. These figures indicate that labor has had twice the impact of material on total construction costs.

Sample

To develop specific information concerning the costs of higher education facilities in Texas, cost data was assembled from a number of recent university building projects. The sample included some 60 recent buildings from 2 year, 4 year, and advanced degree institutions at 10 different campuses across the state. (See Appendix A-2 for specific cost summary sheets.)

Findings

Contractor cost breakdown information used to develop cost data is the best available source of specific conventional building cost data. Findings from the sample have been averaged and adjusted to reflect 1971 costs.

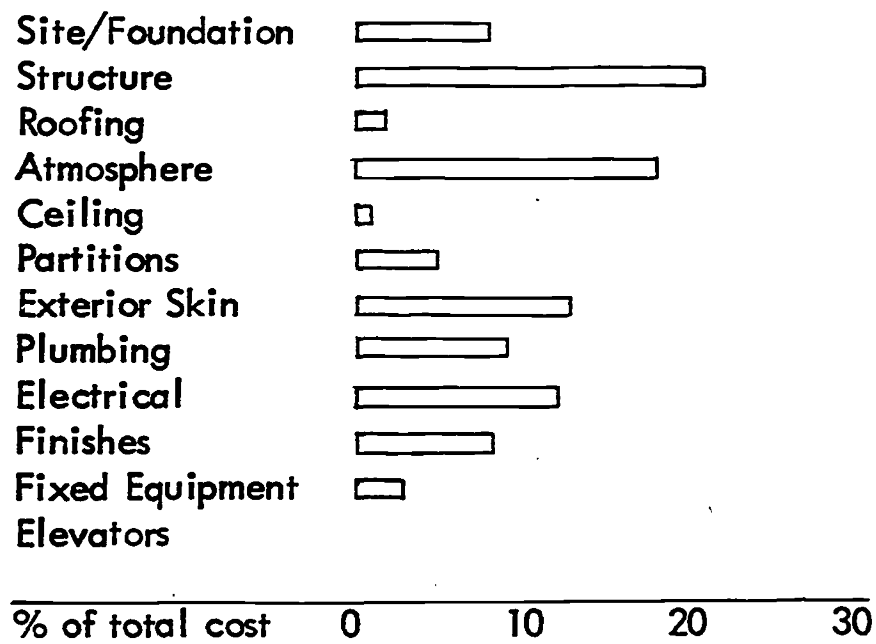
Current costs per square foot for the following campus building types sampled are:

Classroom	$ 27.00 psf
Laboratory	$ 37.00 psf
Residence	$ 27.40 psf

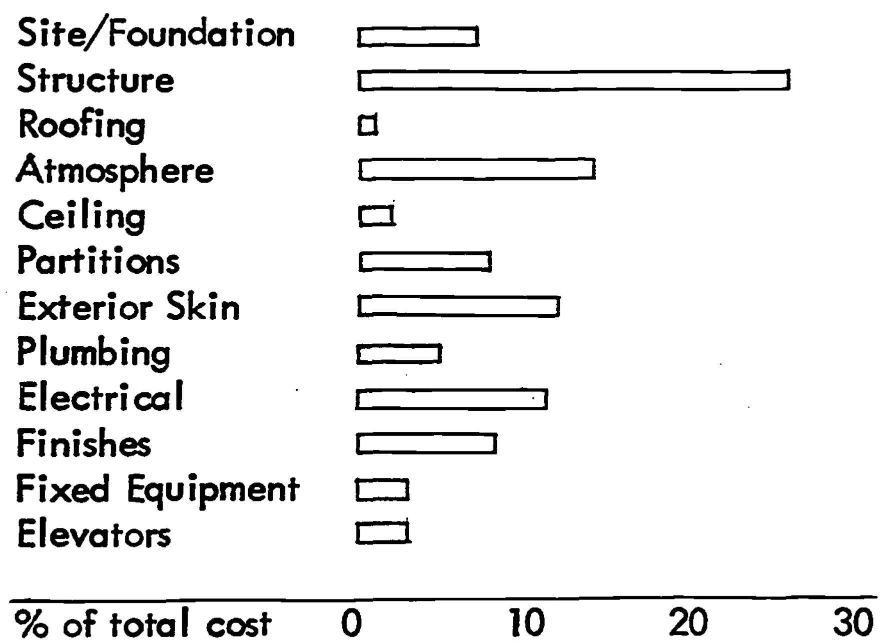
The sample did not show significant cost variations for single story as opposed to multi-story buildings.

More important for this study than square foot costs are the percentages of total building costs allocated to the various subsystems. Distribution of building costs among subsystems is a more reliable basis for comparison than square foot costs because it is less affected by project location, variations in competition or year of construction. Based on analysis of building costs at 10 typical

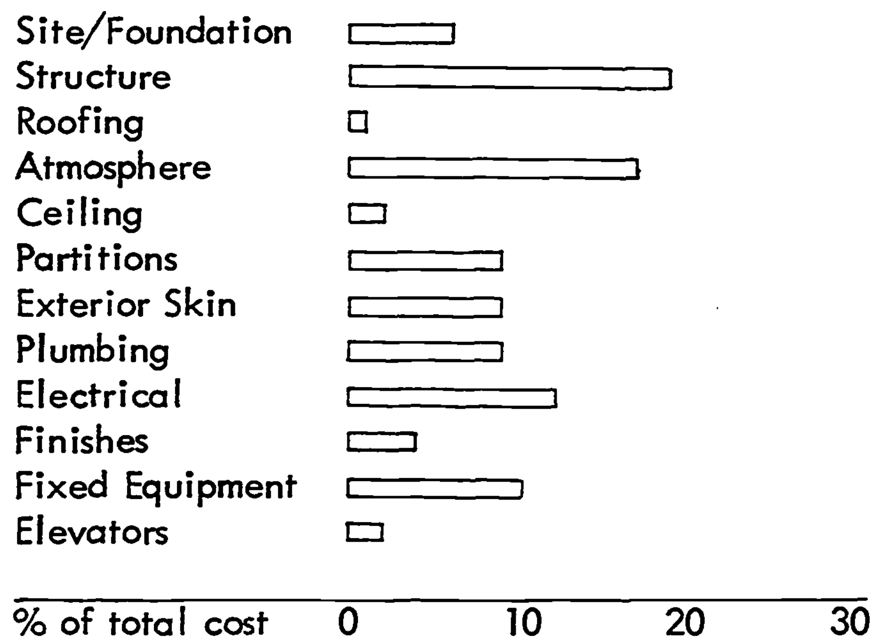
institutions the following graphs indicate average cost distributions for selected building types.



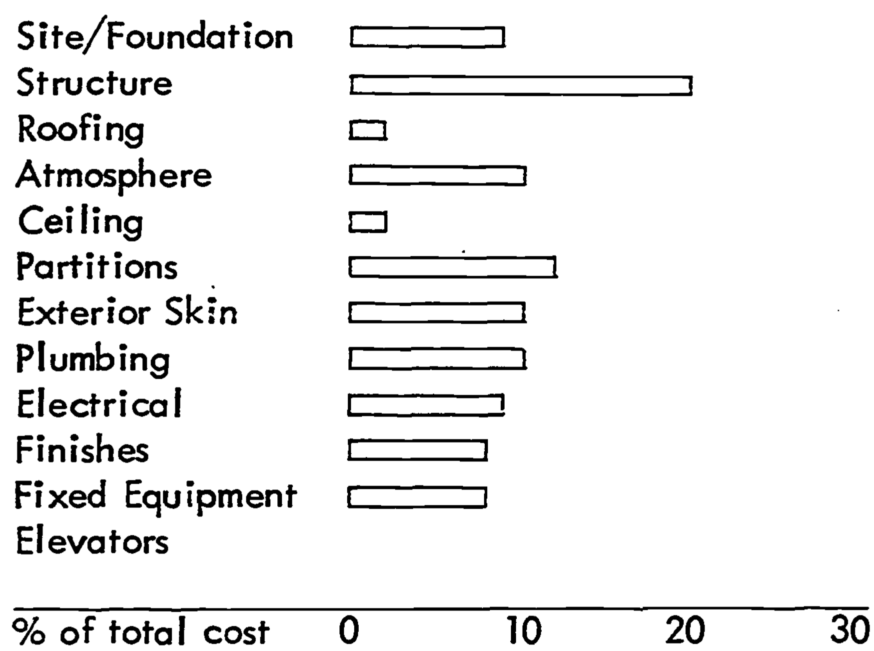
Classroom Building (single story)



Classroom Building (multi-story)



Laboratory Building



Residence Building

Several findings are noteworthy in the conventional cost data surveyed:

- Largest single elements of building cost are structure and heating-cooling subsystems.
- In combination site and structural costs are 1/3 of total building cost.
- Costs for mechanical support systems in combination (heating-cooling, electrical and plumbing) comprise 1/3 or more of total building costs.

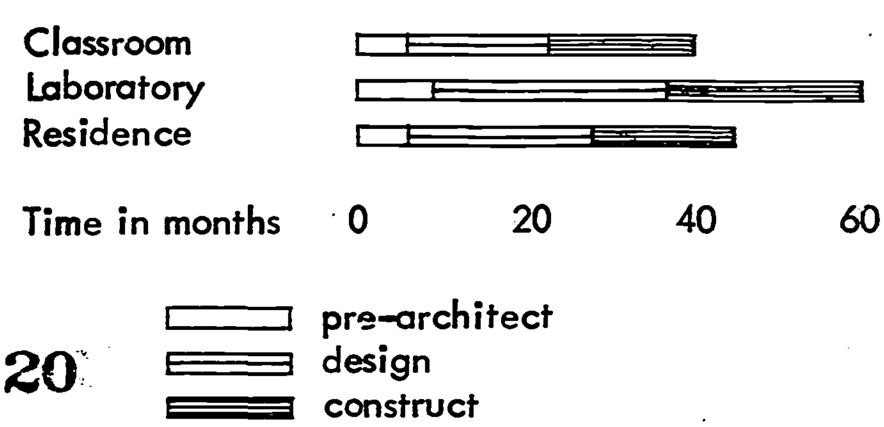
• The exterior skin of a building makes up 10% of total building cost.

Cost data was extracted from successful contractor cost breakdown forms and assembled in a format that will permit comparison with building system cost information presented later in this study. It must be noted at this point that contractor cost breakdowns are not totally accurate sources of information. The total building cost is of course correct and subcontracted work (electrical, mechanical, plumbing) tends to be accurately quoted. As a rule however general contractors increase the costs of site work and structure at the expense of partitions, ceilings and finish work to obtain faster cash return. Institutions with cumbersome progress payment procedures force contractors to take such an approach and to add higher interim financing charges in their bid prices.

3.1.2 Time

Nationally building delivery time for university buildings averages 42 - 48 months. This means that a building project conceived today will be bid at prices effective 2 to 3 years in the future. At current cost escalation rates, todays one million dollar building will cost an additional four hundred thousand dollars in three years.

Total project delivery time for the Texas sample of building projects was obtained from university records. This data is reliable for design and construction activities. Institutional project work previous to architectural contract is estimated from available data. The following graph indicates average delivery time for the building types sampled.



It should be noted that time considerations are separated from cost considerations only for purposes of analysis; building time and cost are directly related and interdependent. Actually the many steps of the building process are also interdependent despite the fact that conventional methods separate them into a linear sequence of non-contiguous events.

3.2 Systems Building

Systems building is a comprehensive management process which attempts to optimize the cost, delivery time, and quality of building projects. A systems building approach to a building program recognizes that similar functional requirements result in similar requirements for building structure, mechanical subsystems, partitioning, and other building components. Three systems building techniques are of primary importance to this study:

- Accelerated Scheduling
- Market Aggregation
- Building Systems

Accelerated Scheduling

The nearly four year building delivery period typical of much university work wastes millions of dollars in escalated building costs and delayed educational programs. Accelerated scheduling overlaps design and construction activities conventionally performed in a linear sequence. Construction of building subsystems such as foundations and structure is begun while finish details and specific partition layouts are being determined. Prebidding of basic subsystems fixes the costs of these items early in the job enhancing cost control. In addition prebidding speeds building delivery by authorizing manufacture and delivery of certain subsystems before architectural work is complete.

Market Aggregation

Differing buildings have many similar subsystem and equipment requirements. Market aggregation techniques combine these requirements to

reduce material costs by bulk purchasing. Universities in Texas for example will buy plumbing fixtures for the many building projects now under construction by separate contractor purchase orders processed through a variety of suppliers and dealers. Competitive bidding of a single large guaranteed order could substantially reduce the cost of fixtures for State institutions.

Building Systems

This systems building technique is based on the use of sets of building components designed and manufactured to be assembled with a minimum of field labor. Building system components can be economically manufactured due to the repetitive aspects of their design; and reductions in field labor can also lower building costs. Designed to serve generalized building problems such as span, heating-cooling, or partitioning, building system components can be applied to many building requirements and can provide variety in appearance as well as function.

Other techniques such as automated design, continued production and construction, component evaluation and improvement are significant second state activities for a systems building program.

Experience

• Internationally, systems building has been used extensively for both educational and public building programs. England began using building systems to rebuild the country after World War 2. Advanced versions of the original system are now being used in higher education construction for laboratory, dormitory, classroom and other buildings. Approximately one half of all educational buildings in England are constructed using the systems building approach. Similar experiences are typical throughout Europe: the University of Marburg in Germany manufactures building components on campus for an extensive continuing program of construction which includes many complex laboratories.

• In North America two systems development projects have been completed for educational buildings and three others with specific university potential are underway. SCSD (School Construction Systems Development) built 13 schools in California in 1966 - 67 using compatible subsystems based on performance requirements. Since then the building systems components have been used in more than 1300 school projects in the U.S. The SCSD components could satisfy the functional requirements of many junior college buildings now planned or under construction.

• A systems building program in Toronto, SEF (Study of Educational Facilities), is now completing its second series of 10 multi-story urban schools. The building subsystems developed for Toronto can be directly applied to the requirements of U.S. college and university classroom buildings. As to U.S. availability, SEF system components are now being used in Boston and Detroit. A study for the New York State University Construction Fund indicated that as much as 80% of the Funds new university construction could be accomplished with SEF components.

• Montreal's Catholic School Commission has developed a multi-story concrete building system for use in its school building program. These building components could also serve many college and university building needs in the U.S.

• The State of Florida has built 25% of its new schools since 1967 using systems building techniques and components. A systems approach for junior college building programs is now underway.

• The first building in a systems program for student housing (University Residence Building System) is now under construction at the University of California's San Deigo campus.

• A process for constructing college buildings using building components currently on the market

is being developed for California and Indiana Universities.

• The Texas department of Mental Health and Mental Retardation is applying limited systems building techniques to its new facility construction programs.

Process

The development or use of system building techniques in institutional construction programs demands changes in traditional processes of building delivery:

• Owners will have to make many rapid decisions on costs, design and equipment; a rigid approval process at each step of the building development can eliminate the potential cost and time advantages of a systems building program. Owners in fact will be challenged to improve and expand their building administrative activities issuing more contracts at various times during the job, seeking competition and cost discounts, perhaps even coordinating subcontracted work.

• Architects will find less demand for drafting services but vastly increased demand for principal time to coordinate various project responsibilities. The architects design freedom is limited essentially by his abilities, not by building components; examples of both well designed and poorly designed systems buildings can be found. It is desirable to retain local architects to design systems buildings. Their knowledge of local labor supply, technological capacity, manufactured goods, and competition will be invaluable to any serious building program.

• General contractors roles will be reduced in systems building projects as a result of pre-bid building subsystems. Some general contractors involved with systems building programs have established themselves as construction management firms in order to capitalize on their familarity

with local market conditions. Subcontractors roles in the systems building process are little changed.

• Manufacturers can look to systems building for larger single purchases and continuing markets for given products. Additionally, feed back evaluation will assist them in improving and updating their products. Pre-bidding will cause manufacturers to train their own installation crews or license local representatives.

• Labor has participated efficiently in all of the systems building programs completed to date. In fact labor, when consulted early in program development, has contributed to efficient job organization and definition of responsibilities.

3.2.1 Costs

Three selection criteria were used to develop systems building cost data pertinent to Texas higher education. Selections emphasized:
• Systems building programs with building experience in North America.
• Building systems in which system components account for more than 40% of total building cost.
• Building programs for educational use with possible applications in higher education.

Construction costs for the first series of buildings in a new systems building program were often 5 to 10% higher than similar conventional projects. The comparison is somewhat unfair in that the systems buildings offer higher quality and easier plan reconfiguration than their conventionally built counterparts. However, the comparison is sure to be made; the cost overruns in the first series appear to result from unfamiliarity of owners, architects, contractors, and manufacturers with the new building process, rather than from premiums paid for added quality.

Subsequent building programs using a tested systems building process have demonstrated cost advantages. SSP (Schoolhouse System Program),

Florida's school building program, for example demonstrated a 5 to 10% cost advantage over similar conventional projects after 3 years of operation. Two factors account for these cost advantages.

• Contractors and manufacturers become more competitive as they improve their techniques of building delivery in a continuing program.

• Repetitive building system components are less subject to cost escalation than their conventional counterparts.

The following cost data pertaining to two types of classroom buildings constructed under systems building programs are presented for purposes of comparison. Cost data for systems residential or laboratory buildings were not available in sufficient quantity to permit comparative cost summaries.

• Information on single story classroom buildings was developed from projects in California, Georgia, and Florida. The sample represents 46 projects with a total area of approximately 3.5 million square feet. These building types are similar to many buildings now under construction on Texas junior college campuses.

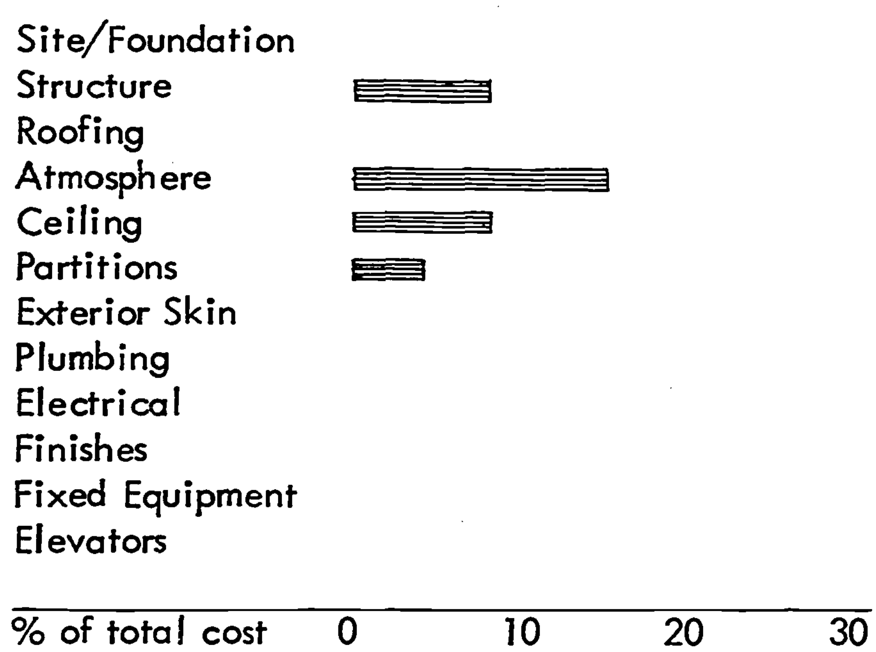
• Information on multi-story classroom buildings was developed from the 11 completed urban school projects in Toronto's SEF program. These buildings could function as multi-story classroom space on many Texas college and university campuses. Costs per square foot have been averaged and adjusted to reflect current 1971 price levels. These costs are not considered to be directly comparable to those developed for Texas conventional construction experience in that they represent distinctly different regions and bidding markets.

Cost per square foot for systems building projects:

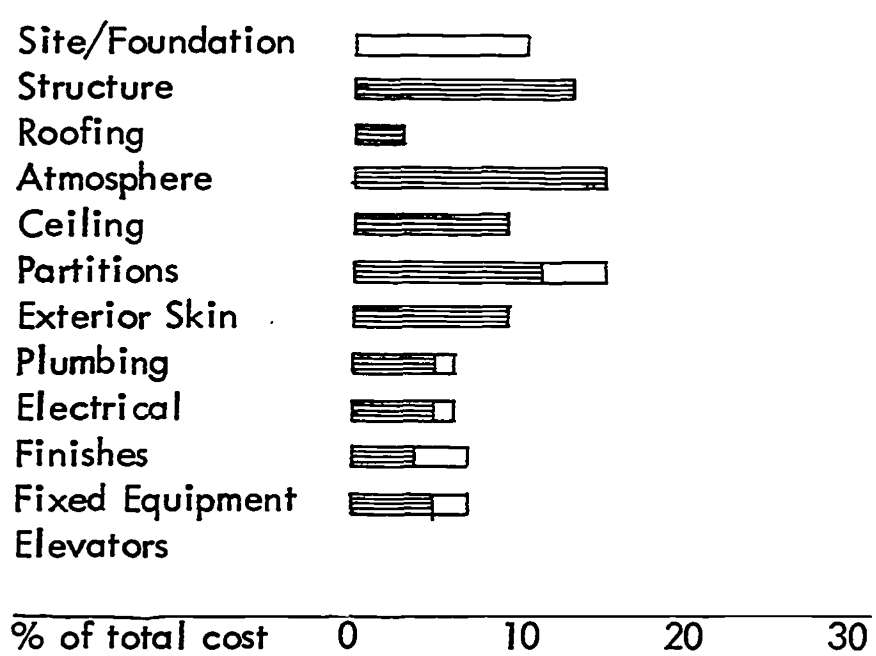
Classroom (1 story)	$ 22.40 psf
Classroom (multi story)	$ 24.75 psf

Of greater interest for comparative purposes is

the distribution of construction costs among subsystems. The following graphs show the percentage cost of building subsystems in the surveyed projects.



Classroom single story (cost distribution for non-system items not available).



Classroom multi story SEF
non system
building system

Several items are noteworthy in comparing the distribution of total building cost for systems

building programs to conventional building programs in Texas (see 3.1.1).

• Systems buildings spent half as much as conventional buildings for structure. This difference is noteworthy in view of the fact that the systems buildings studied used long span structures to accommodate changing interior space requirements.

• Systems buildings spent as much of their construction dollar on mechanical support subsystems (heating, air conditioning, plumbing, electrical) as their conventional counterparts. The systems buildings mechanical subsystems, however, are more responsive to changing needs than conventional installations. Supply ducts and electrical panels can be easily relocated.

• Systems projects spent more of their construction dollar for interior partitions; partitions components are moveable and pre-finished.

• Systems projects spent less than conventional projects on interior finishes as a result of the many factory finished building components employed.

Accelerated Scheduling

Overlapping design and construction activities have demonstrated reductions of as much as 50% in building delivery time. Initial cost advantages of this technique are directly related to the prevailing rate of construction cost escalation. At present rates, accelerated scheduling can produce a 6% savings in total building cost by bidding one half of a building's subsystems 12 months earlier than a conventional building delivery effort. Early bidding fixes project costs for certain building subsystems promoting effective cost control.

Experience indicates that cost savings accomplished in prebidding are often used to obtain higher quality or increased space.

Market Aggregation

Building system components used for single independent projects can offer better building quality but initial cost savings are unlikely. Florida's experience indicates that a construction market of 8 to 10 million dollars in a single bid period is necessary to obtain significant price discounts using available coordinated building subsystems. Cost savings on the order of 20% have been obtained in markets of this size because the volume is sufficient to justify pricing at the manufacturer level, thereby significantly reducing manufacterers' selling costs.

Since building subsystems are pre-bid, it is unlikely that the full cost savings achieved through volume purchasing will be reflected in the final building price. Owners who realize a cost saving early in a construction project almost always utilize the savings to build more space or improve quality. Refunds of cost savings are unusual.

Building Systems

Historical trends of labor cost increase for industrial as opposed to construction workers show industrial labor costs rising at half the rate of construction labor costs. This trend points to significant future cost savings through the use of component building systems. Such components offer the economies of factory production and the opportunity for continuing product improvement.

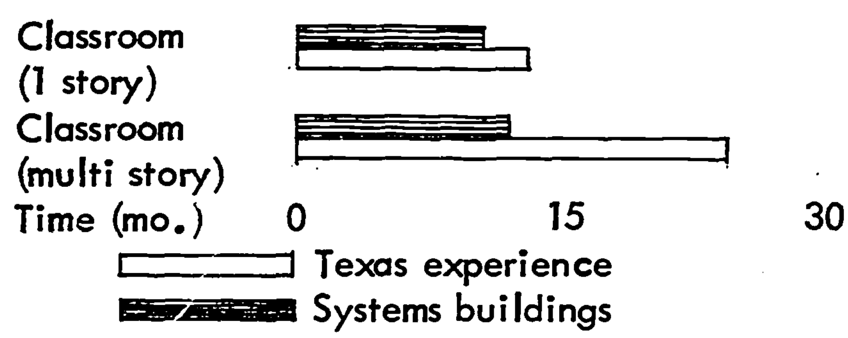
A few words concerning development costs for a new building system are appropriate. Direct development costs for systems building programs have ranged from $650,000 to $2,200,000; in addition a guaranteed construction volume of $20 to $30 million dollars has been necessary to support manufacturer participation in the development effort. To begin development work on a new building system today, serving a particular set of educational program requirements, a market guarantee of $30,000,000 and a direct technical development cost of $1,000,000 are likely

minimums.

3.2.2 Time

Systems building techniques have demonstrated markedadvantages over conventional methods in building delivery time. Accelerated scheduling, prebidding, and building systems used together have cut total project delivery time by up to 50% in many completed projects. It should be noted that application of these techniques brings demands for quick decisions by clients, architects, and contractors and in fact imply basic changes in the traditional architect-client-builder relationships.

For comparative purposes construction time experience for single and multi-story systems building examples is contrasted with construction time experience for similar conventional buildings in Texas.



The following brief summary of delivery time experience for completed or active system building projects expands the previous comparison:

• Florida's SSP program in 1968 - 69 built 8 secondary schools in an average of 281 days; 8 similar conventional schools built in the same time period averaged 451 days under construction.

• Toronto's current SEF program (10 multi-story schools) allows 8 months for construction. 15 to 18 months construction experience was typical of previous conventional Toronto school projects.

• In Merrick Long Island a program to build three small school additions (totaling 25,000 sq. ft.)

completed and occupied one building 12 months after retaining the architect. The two remaining additions were completed three months later.

• Two industrial schools, one in Arizona (67,000 sq. ft.), one in Ohio (45,000 sq. ft.), are currently under construction with a contracted date of occupancy 9 months after retaining the architect (verify in September 71).

• Boston is building two urgently needed public schools in 13 months using SEF system concepts. School construction time in the area has typically been 24 to 30 months.

A major strength of the systems building approach is obviously reduced building delivery time. This strength represents a capacity to meet difficult building schedules and a second potential to reduce construction costs by reducing the costs of interim financing related to a long construction effort.

note: documentary information pertinent to this section may be found in appendix A-2.

4 Utilization

4.1 Trends

National projections anticipate a growth of 20% in the college age population (18 - 24) between 1970 and 1980. During the ten year period however, college enrollments are expected to increase 65%. A greater percentage of the college age population seeking higher education and longer enrollments for advance of degrees cause the impressive difference between population growth and enrollment growth.

1980 Texas enrollments are expected to increase 281,000 from the 1970 count of 427,000. Most of this enrollment growth will be borne by public colleges and universities whose 1970 enrollments are expected to increase 75% (270,000 students) during the ten year period.

Texas public campus profiles, by building type, show that residential buildings account for nearly 1/3 of total campus facilities. Laboratories offices and classrooms are other major categories in the profile. Junior college profiles vary substantially from the averaged public campus; only 11% of the junior college space inventory is used for residence with resultant increases in the proportions of laboratories classrooms and offices.

Campus space distribution by major facility type.

	All Texas Public	Texas Public Jr. Colleges
Residential	32%	11%
Laboratory	14%	21%
Office	11%	10%
Classroom	9%	15%

On the average Texas public institutions provide nearly 200 total square feet of building space for each enrolled student. Simply meeting the anticipated enrollment growth at today's space standards, without consideration of changing needs or requirements for building renovation, Texas public colleges will build 5,400,000 square feet of new facilities over the next 10 years. At current prices this plant expansion will require an investment of $1.5 billion. At

escalated prices the total cost could easily double during the decade. One way to effectively increase enrollment capacity without increased facilities expenditures is to make more efficient use of existing college and university facilities.

4.2 Academic Scheduling

One of the most detrimental factors inhibiting effective utilization of college and university facilities is the academic calendar. Texas' public college and university fall enrollments are reduced to 93% of capacity in the spring and 46% of capacity during summer sessions. These normal enrollment fluctuations mean that half of the State's facilities are not used for 4 months a year. Plans have been developed for academic scheduling which use facilities 12 months a year while allowing faculty and students the opportunity to choose between long vacations, periods of professional development, or year-round academic pursuits. These plans demand extensive scheduling changes but are effective in reducing facility needs. Judging by present enrollment patterns, Texas public institutions could support an 18% increase in annual enrollments (i.e. 50,000 more students) in existing college and university buildings by scheduling 48 weeks of annual utilization and maintaining enrollments at 90% of present capacity for the full year.

The utilization of classroom space is a second area where increased scheduling efficiency could increase institutional capacity. Disregarding the wastefulness of the academic calendar, guidelines for classroom utilization in Texas seek to schedule classroom space 30 hours weekly and fill 1/2 of the available student stations. If it were possible to schedule classrooms for 40 hours of weekly instruction and fill 3/4 of the student spaces, present student capacity would be doubled. This projected increase is not totally realistic because residence, laboratory, and supporting facilities would have to grow in support of increased classroom enrollments. It does however point out the lack of design flexibility of existing buildings.

Given 10 classrooms to seat 30 and 10 classes with enrollments varying from 6 to 50, inefficient utilization of space is likely if not certain.

4.3 Adaptability

As defined building systems are sets of building components designed and manufactured to be assembled with a minimum of field labor. The definition implies more than potential for simple assembly; it suggests that the building system components are designed to solve a variety of functional building requirements. The design necessity to solve many problems results in components that may be arranged in many ways in a first building design and therefore can be easily adapted to changing facility needs. Specifically it is easier, faster, and less costly to convert the systems building to another use as college needs change. Some examples of a building systems inherent ability to respond to changing needs are the utility services column which permits plug in connection of phones, clocks, intercom, power outlets, lighting, etc., on 5 foot grid lines, the building system ceiling which accepts air supply along any grid line; and the building system partition walls which can be relocated with minimal labor.

4.4 Financing

Financing of new educational facilities is a critical element of the building process.

Three basic sources of funds are used to support new construction for Texas Public higher education.

- Earnings of the Permanent University Fund are available to two university systems.
- Ad valorem tax receipts are available to institutions which do not participate in the Permanent University Fund.
- All institutions can utilize appropriate student fee income.

The Permanent University Fund commands a high bond rating (and low interest rate) for user universities; bond ratings for institutions relying on other income sources are not as high, resulting in increased borrowing costs for those institutions.

note: See appendix A3 for background data

5 Conclusions and Recommendations

Texas colleges and universities face significant demands for new facilities over the next ten years. Growing enrollments and longer degree programs will require a capital expenditure of 1.5 billion dollars for new construction at today's price levels. Rapidly escalating construction costs could double this necessary investment during the decade.

Systems building, a process of building delivery which seeks to optimize facility cost, quality, and delivery time, can play a significant role in meeting Texas' commitment to quality higher education. Techniques of the systems building process will be most effective initially in reducing delivery time; such time savings can make the difference between starting or delaying essential educational programs. As colleges and universities continue to apply systems techniques, rational cost control, long range price stabilization, and eventual first cost savings will be realized in building programs.

The systems building process must be understood as a complex and demanding management task. Attempts to apply the process in a framework of conventional institutional procedures in unlikely to produce significant results. The following conclusions and recommendations define the potential of systems building techniques and improved utilization to contribute to higher education needs in Texas.

5.1 Accelerated Scheduling

Conclusions

Accelerated scheduling techniques such as overlapping design and construction and prebidding building subsystems can reduce building delivery time as much as 50% and assist a program of cost control. These techniques may be easily applied to urgent building projects by a willing university client and a capable architect.

Recommendation

Individual college and university building departments should apply accelerated scheduling

techniques for any building project where completion time is a critical consideration. A rapid institutional decision and approval process is essential in undertaking such a program.

5.2
Aggregated
Markets

Conclusion

Market aggregation can achieve significant reductions in building materials costs if the minimum 8 to 10 million dollar single bid volume necessary for cost savings is maintained over time. But even the State's largest universities cannot individually assemble and maintain a market of this size. A centrally coordinated program which aggregates similar building needs and initiates purchase agreements on a continuing basis is essential for successful application of this technique.

Recommendation

The Texas Coordinating Board as the single entity able to determine specific statewide college and university needs for building materials should establish a voluntary market aggregation service available to all state institutions of higher education. The Board would begin the service by bidding open ended supply contracts for basic building components such as plumbing fixtures, flooring, and ceiling subsystems. Because no institution would have to participate bids would be taken for various quantities of materials. The larger the assembled market the greater the likelihood of lower prices. As the program succeeds in delivering cost advantages it should be expanded to include a variety of partitioning and structural subsystems, exterior wall components, and electrical-mechanical items. When fully developed the Board's market aggregation capabilities should include a selection of modularly coordinated building systems to serve a variety of higher education building needs.

5.3
Building
Systems

Conclusion

The potential now exists to provide a variety of single and multi-story university classroom facilities, utilizing available on market building

system components. Soon to be completed development projects will extend this capability to residence buildings and laboratories. But education of administrators, architects, and contractors will be necessary to exploit this capacity.

Building systems can offer quality advantages, variety of appearance and plan configuration, and long term cost savings by virtue of their ability to adapt economically to changing space needs. The use of building systems can reduce planning time and encourage better design by freeing architects from dull repetitive detailing problems.

The development work necessary to produce a comprehensive new set of building components and implementation techniques for a specific college building type is both extensive and expensive. From the date of work start approximately 4 years will be required until the first building is ready for occupancy. Direct development costs on the order of 1 million dollars and market guarantees for approximately 30 million dollars of construction value over the first 2 years of implementation will be necessary.

Recommendations

• It is recommended that individual institutions utilize available building systems where appropriate to proposed construction projects. This will speed building delivery, and provide high quality facilities which can respond to the changing needs of future educational programs. First cost savings are unlikely in single one time building system applications, but long term cost stabilization and eventual first cost savings can be obtained through continuing high volume use and of building systems components.

• It is recommended that the Coordinating Board assemble a building system development consulting group to assist colleges and universities embarking on initial building system programs.

• It is recommended that the Coordinating Board seek State or Federal support for three demonstration building systems programs at selected Texas colleges and universities. Project cost and time experience would be made available to all State institutions.

• Development of a new comprehensive building system for Texas colleges is not recommended. Available existing systems represent a quicker, more economical way to meet Texas higher education needs than a new development program. However, development of improved building subsystems by capable Texas manufacturers and builders should be encouraged in order to provide a wide variety of compatible building components in the future.

5.4 Utilization

Conclusions

• The academic calendar does not encourage efficient utilization of the State's higher education facilities.

• Present utilization rates for specific classroom spaces could be significantly improved.

• Financing methods for new college and university facilities do not utilize the State's resources effectively.

Recommendations

• The Coordinating Board should assist the State's universities in preparing and adopting an academic calendar which makes full time use of existing educational facilities.

• University building programs should incorporate design concepts and building components which permit new facilities to adapt to future space and functional requirement changes.

• A computer scheduling service for academic space utilization should be made available to all interested State institutions.

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Appendix A-4 lists professionals whose enthusiastic encouragement and advice contributed substantially to the research effort

7 Appendix

Background data for the information developed in this work report is organized as follows:

A-1	Educational Trends
A-2	Building Delivery
A-3	Utilization
A-4	Participants & Consultants
A-5	Selected Bibliography

Appendix A-1
Educational
Trends

Background

Today in virtually every aspect of American life, conventional ways of thinking and doing are being re-examined and challenged. Changes result which test cultural assumptions previously held above question. The over-riding theme of current cultural concern is turmoil, and change itself has become one of the most basic facts of modern existence.

Changes appear not only in obvious physical symbols but as well in our basic social arrangements: in religion, government, business, and in education. We are becoming aware of the arbitrary and circumstantial origins of existing institutions. Instead of their being viewed as sacrosanct and immutable, they are being challenged to re-evaluate the norms of an earlier culture and reorganize in ways more consistent with modern experience and needs.

Educators tell us of developing generations which regard change as normal and necessary rather than as annoying or damaging. They are aware of this trend in today's young not only because they interact frequently with but also because they are partly responsible for it. Education more than any other social institution besides the home meditates the environment to the young. In a time when knowledge expands at unprecedented rates and few conventional assumptions go unquestioned, the lessons delivered to young people through changing educational experience takes root in fertile imaginations and frees them of the cultural baggage of their elders.

The development of new cultural responses appear most obvious in college students because they have longest been exposed to the rapidly changing social environment during their formative years and have reached the age when they are more capable and likely to effect new structures. Higher education, the cultural medium for these students, is presured from within and without to change. The changing social scene, the growing body of knowledge and technology, rising costs, and the increasing population force colleges and universities to reevaluate the quality and

efficiency of their programs and facilities. This is to be expected. For in a time of great cultural flux, educational programs cannot long remain viable without changing to suit the society served.

The fact is that higher education is and has been changing for some time, andhas contributed its large part to the generation of new ideas. But surprisingly the college facilities, the buildings which house these increasingly dynamic institutions, have not significantly changed. Although they may still provide adequate shelter, just how much support they may give to the changing activities within is questionable. The purpose of this writing is to describe the changes occurring in higher education, to identify trends if possible and to set the stage for a discussion of the implications of these trends for facility planning and design.

Perhaps the best way to begin is by analyzing the forces exerting pressures on higher education in America -- the pressures responsible for subsequent changes or trends. A following statement of the trends themselves will then have more meaning.

Pressures on Higher Education

Forces exerting pressures on higher education may be grouped into four broad categories:

- populations
- knowledge
- society
- finances

- Populations

Along with an increasing population, a larger percentage is attending college than previously. More importantly the character of this increasing college student population is changing. More students elect to go to graduate school than ever before. More are married. And more are women. Entering students tend to be more broadly exposed to real world problems in general now than in times past. Whether traceable to the effects of mass media, increased social mobility, current cultural upheavals or a host of other possible causes, their relative sophistication makes them

less reticent to question fundamental assumptions and less willing to accept the pat answers of stylized and static curricula of another day. It takes well qualified instructors to meet these demands. But the supply of such professionals is relatively smaller than ever before due to the increasing student population.

Enrollment pressures also place increasing demands on existing facilities. Not only more facilities are needed but different ones: buildings which are more conducive to the changing populations and programs housed.

- Knowledge

Other pressures stem from the changing nature of knowledge. The body of existing knowledge, especially scientific knowledge, is multiplying at a geometric rate. Many scientific disciplines existing today did not exist 10 to 20 years ago. The rapid obsolescence of knowledge and the seemingly endless unknown indicate that further changes are likely.

Technology expands at a rapid rate as well. Whole new technical fields and vocations have recently appeared, while others have become obsolete. Modern life depends on technology to supply basic community services such as food, shelter, health, transportation, and information. Without technology's ability to rapidly assimilate and utilize new knowledge, society would not realize the benefits of such additions. The effects of the communications explosion and data processing on education, for instance, have led to the development of new teaching aids and methods which help both teachers and students keep up with rapid changes in the general body of knowledge.

Developments in the behavioral sciences and educational theory itself obviously influence trends in higher education. Most recently educators in lower levels of education are recognizing the autonomy of the individual student and allowing him more control in the educational process--especially in study time and choice of subject

Trends in Higher Education

matter. Similar student control has existed in graduate programs for many years, but current pressures mount for higher education on all levels to re-think its basic tenets and adapt. As professors find increasing amounts of new information to be covered in their lectures, students find the traditional lecture-oriented educational system increasingly less adequate for satisfying the new demands of learning.

- Society

Education is being viewed world-wide as the primary need for society. For undeveloped or developed nations, it assumes highest social priority for its survival value in social and cultural as well as simple physical terms. American society, as a result of expanding technology and automation, demands that higher education provide more problem-oriented studies along with cultural exposure.

Social pressures on higher education are also linked to the equalizing effects of mass communication and social mobility. American populations are too fluid and well-informed by the media to permit regional and ethnic inequities in educational opportunities to exist.

- Finances

As higher education struggles to provide opportunities and facilities for more and more students, expenses continue to rise. Construction costs are rising faster than other costs incurred by higher education. Educational materials and equipment costs go up steadily as do the salaries of a relatively smaller supply of qualified instructors. The problem presently is compounded by the fact that just when development and operating costs of the expanding educational system require more financial support from traditional public sources, government on all levels, competition from other publically sponsored systems is intense.

The responses of higher education to the various complex and interrelated forces exerting pressures on it give direction to evolving trends. New procedures and technology are constantly reshaping

the educational process so that colleges are pressured to change as fast as they grow. Although the changes differ from institution to institution and may be neither evolutional nor sequential, several discernible patterns emerge.

- Independent Study

One growing trend in higher education is that of independent study or individualized programs. The basic feature of this trend is student control of time, subject matter, and extent and depth of study. These concepts, long used in graduate programs, are currently being implemented in many elementary education programs. Allowing undergraduate college students to choose with more freedom what and when they study is not really new. What is new is the extent of the freedom being allowed.

Ideally the student works on his own time, in his own direction with help from instructors when requested. A faculty advisor consults with him on a plan of attack, on the anticipated depth and scope of the study, and about his expectations for the student's activities. The dialogue continues until the goals agreed upon are realized.

Individualized programming recognizes that people learn at different rates and attempts to accommodate the differences by allowing students to study not only what they want but also when and for how long. Schedules are evolved which suit individual rather than institutional needs. The needs considered include those of the instructors as well. Whereas conventional schedules deny autonomy to teachers and students alike, the newer concept views time control as personal and scheduling as a flexible tool for optimizing time use for both groups.

Flexible scheduling as one of the basic differences between conventional and individualized programs relates to other differences. One is the need to have appropriate instructional materials easily accessible to students. Thus the need for information centers similar to the typical library

in concept but different in hours of operation and types of materials offered. It is not at all clear that books are the most efficient dydactic materials. Multi-media presentations of information are rapidly supplanting these conventional methods. This trend of considerable magnitude will be discussed at length later.

Another concept vital to individualized programs and different from conventional methods is that of flexible grouping of students. Individual students studying at their own rates may well desire and be directed toward involvement in small groups where discussion can be freely shared. Students change. Their interests fluctuate and they differ in abilities and achievements. Flexible grouping can allow for these differences and capitalize on the stimulating interactions which occur in heterogeneous groups. Dynamic allocation of space for changing groups meeting at different times and for varying periods of time becomes an important consideration and one not customarily faced in conventional programs.

• Grading
Conventional programs also are not typically faced with the problems of evaluation that face individualized programs. When students have freedom in determining not only what but how, when and to what extent they study, evaluating them becomes a difficult matter. Faculty advisors may judge their progress but they may not be proficient in all the fields their students delve into. To determine what they have or have not learned, a possible solution to this problem involves deletion of the traditional grading system for a newer "pass-fail" concept. Under the new system, students do not receive "grades" on a graded scale but rather as simply either "pass or fail". The idea is to relieve the tension of the competitive graded system and encourage motivation by natural curiosity and individual control.

• Continuing Education
Another growing trend in higher education views continuing education as a means of solving the

problems related to technological obsolescence, use of leisure time and old age. Individuals involved in such programs can learn new technical skills and keep up with additions in general knowledge as well.

• Extended Campus
One of the newest trends in higher education relates college and university services directly to host communities. The "extended campus" concept means that instead of working people in the community rushing home after a full day's work to hurriedly eat, dress, and travel to a night class at a nearby institution, the college or university sends professors out to the people to instruct them during the noon or coffee breaks or after work at their places of business. So far the plan has attracted enthusiastic participation on the part of businessmen who realize the value of such programs in terms of better trained employees, employee morale, and the introduction of new ideas into the work atmosphere. Some employees and some allow them to take college work during regular working hours, a more subtle form of financial support.

The college benefits by being able to operate with less overhead for instructional space and equipment. Borrowed or donated space for classrooms comes in the form of conference rooms, cafeterias, offices, and other work areas. Idle equipment is made available for demonstration purposes as whole factories become temporary laboratories.

The students save time by not having to travel to the institution. They save money from the reduced rates colleges can offer and the support their company's offer. And they learn more efficiently since they are less fatigued during class and have evenings free for study. The extended campus trend brings higher education to more people at less cost and promotes better relations between college and community.

• Interdisciplinary Studies
The trend toward interdisciplinary studies has been growing rapidly as scholars and students

realize the value of heterogeneous team effort and the fundamental similarities in subject matter and technique among the various disciplines. The trend has shown itself in the proliferation of courses, indeed whole disciplines, which draw from other discipline sources: behavioral geography, biophysics, economic geography, biochemistry, social anthropology, architectural psychology, etc. This movement toward more interdisciplinary relationships will be increased as higher education programs become more individualized and students have the freedom to delve into widely differing fields.

- Multi-Media Presentations

The increasing use of a variety of media to present information to students finds its impetus in the search for more efficient means of teaching, technological advancements, and the demands of rising enrollments. Multi-media presentations of information used appropriately can increase the opportunities and likelihood of learning. The use of such techniques can bring education to more people, improve the utilization of expensive facilities and human talent, and enrich the learning experience for the individual learner.

Large, automated lecture halls which utilize many different types of media appear with increasing frequency on American college and university campuses. The appeal of such facilities is largely their capacity to handle large groups, but multi-media presentations for individual users are growing as well.

"Multi-media" describes anything usable to organize, store, and present information and includes everything from computers to television to slides and overhead projectors, including teachers, books and chalkboards. Libraries are becoming "media centers" where students have access to information stored in all the various forms, for information presented through the most appropriate media can create stimulating learning experiences not otherwise obtainable.

The availability of such materials to individual students can contribute to the success of individualized programs. Students could have immediate access to the best presentations of information on virtually any topic. Updating could be effected quickly to keep information fresh and accurate. The best instructors could be available to any student studying alone or to many as has been tried in some institutions. These experiments involve wide scale television presentations of information. In some projects evaluation of student performance is handled through the mail, while in others students come periodically to a central point for testing and counselling. The implications in terms of substantially reduced campus facilities are significant.

- Student Housing

Another trend in higher education seeks to capitalize on student housing as an instrument or learning. The interacting forces include demands of students for social arrangements like those of the host society and the rising costs of construction. Institutions involved attempt to bridge the gap between students and teachers through mixed or proximal residential arrangements and living environments more hospitable and conducive to learning. Some authorities project that the use of multi-media equipment in the residential setting could contribute to the effectiveness of independent study programs.

Individualization

- No student will spend all his time in independent study.
- Independent study needs to be complemented by group activities, especially two way communication through seminars and project situations which allow group sharing of experiences.
- Programs utilizing a high degree of independent study will place different demands on the instructors, support staff, resources, and facilities.

Facilities for Independent Study

- No single room in the school building should be set aside as an independent study room -- these areas are best scattered throughout the building to where the students are.
- Independent study units function best if grouped in small clusters. In this way they can share common services yet avoid monotonous repetitive appearance.
- There will be a need for larger groupings in and around information resource centers.
- If many study units (carrels for example) are brought together it is important to visually and functionally "break-up" the space in which they are situated to avoid monotony and create an inviting study space.
- Placing study units in or adjacent to circulation spaces will add noise problems and distractions.
- Independent study spaces should be close to project and seminar areas where students can get together and share learning experiences.
- Independent study areas will need a close relation to discipline-oriented facilities.
- Spaces for teachers should be close to independent study areas in order to allow for consultation, conference, and close student-teacher contact.

- Nearby social or common areas for interaction and relaxation are desirable.
- Evaluation (testing?) facilities of some type will be necessary.

Study Unit Types
- enclosed
- semi-enclosed
- open
- assigned
- unassigned
- special purpose (i.e. typing, recording, viewing, computer)
- general purpose
- storage space
- no storage space

General

No one type of study space should be provided exclusively -- a mix of many kinds, functions, and groupings will best meet the students' needs. Units may be of many types ranging from simple (but comfortable) tables and chairs to complex carrels which provide for reception of audio and video information.

Individual Environment

Lighting
- overall should be soft with the emphasis on working surfaces
- individual control to some degree is desirable in terms of quantity and quality and the task at hand.

Acoustics vary according to the function and type of unit:
- typing, recording, etc., should be isolated.
- head phone sets may negate sound considerations.

Ventilation
- limited individual control is desirable.
- smoking should be restricted to certain areas.

General
- Students in independent study areas should be as free as possible from distractions of sound, movement, light changes, large variations in temperatures.

Large Group Facilities

• The most critical of any type of space as far as planning considerations.

• Probably very large (i.e. 300-400) with subdivision capability into 80-100 seat units.

• Optimum viewing area as defined by the various display surfaces.

• Stepped or sloped floors are necessary and the rise should be determined by the undisturbed sight line of the student to the bottom of the viewing surface.

• Rows of seating should be off set.

• In very large rooms continental seating should be considered to allow students to move in and out without disruption.

• Aisles and circulation should be kept out of the viewing area.

• Windows and natural light are a liability rather than an asset.

• Acoustic isolation from interfering adjacent room sound and distracting projector noise.

• At least three levels of illumination will be needed.

• The display surfaces are an integral part of the room and that equipment should be located for proper functioning.

• Success of these spaces depends upon their relationship to storage, projection and preparation areas.

Small Group Facilities

Spaces of this type will be needed to supplement both individual and large group processes.

Part of a resource center:
• Used by groups of students with and without teachers to review and learn from resource materials (films, slides, tapes, etc.).

• nonscheduled, use on demand
• scheduled, in advance

Part of a teacher's office area
• encouraging informal and nonscheduled conferences and seminars (especially in individualized programs)
• this concept may take the form of separate spaces or may actually be incorporated directly into the office making it the conference space.

Scattered about buildings as scheduled and informal spaces.

Considerations

• A variety of seating arrangements are possible to compliment group discussion, review, etc.

• Different types of small, light weight, and relatively inexpensive projectors are available to supplement analysis and discussion for use in these spaces.

• With small images of high brightness either front or rear projection may be used. (White plaster walls can be used for front projection or self contained cabinets can be built in for rear projection.)

• For rooms of this size a single 23" or 24" T.V. receiver will provide good viewing.

• Two levels of lighting are desirable; a lower level for projection and a higher one for discussion.

• Carpeting is desirable to deaden sound and to introduce a character of informality. Furniture too should be chosen with this in mind.

• Sound privacy is required. Visual privacy is not.

Laboratories

Introduction

The actual performance of experimental work demands many support facility requirements different from generalized educational space. Ventilation, chemical storage, utility needs, temperature control, and personal safety dictate the actual laboratory spaces be separate from more generalized spaces, though spaces such as seminars, multimedia centers and study carrels can support and complement laboratory based curricula and visa versa.

Laboratory facilities generally support educational programs requiring indivdual or team lab stations in preference to large group laboratories. Basic classes may be served by mobile equipment with self-contained gas, water and utility services using generalized educational spaces. However, more private facilities are necessary for advanced course work and research where continuous experiments demand extended use of apparatus.

Implications

- A close relationship of laboratory, office, and educational spaces.
- Compact centralized vertical distribution of utility services.
- Flexible horizontal distribution of services.
- Provision of space for services not now needed.
- Provision for mobile lab equipment.
- Adaptability to changes in relative demand for physics, chemistry, biology, etc.
- Multiple use by all disciplines.
- Faculty and/or student ability to modify spaces and equipment.

Student Housing

Direction

- Institutions are housing more of their students because they must. Private sources are simply not absorbing the overflow as enrollments swell.
- At the same time students are objecting to university imposed rules and regulations, isolation of the sexes, and what they refer to as the dehumanizing effects of present day dorm life; for these and other reasons larger and larger numbers of students prefer to live off campus.
- When and if housing is provided it should be above all educationally productive.
- What should housing contribute to education?
  - Social competence
    - cooperation
    - citizenship
    - identification
    - leadership
  - Academic competence
    - purpose
    - direction
    - scheduling
    - study
- The residence should narrow the gap between teacher and student, classroom and living room, school and community.

Individualization

- The only way to accomplish this is to provide for two fundamental needs, privacy and participation. Only a room of one's own will give any real sense of privacy; participation, if desired, should be encouraged by the ability to identify with a group.
- The single room then becomes the basic building block. A total population of about 250 is small enough for each resident to know the others by name but large enough to support provided facilities.

Housing as an instrument of learning

· Single rooms can be combined in suites and these in turn could be clustered around a court yard with access to common library, game, music, office, seminar and dining facilities.

· Semi-private baths not only reduce maintenance cost and permit more efficient use of space but also make possible the use of rooms for other purposes such as housing people attending conferences and meetings during school breaks.

· If groupings are kept small and clustered around common areas horizontal circulation space can be minimized in high rise and even eliminated in low rise residences.

· Providing family suites, as well as the traditional single student type, makes it possible for the married student to participate in the college community.

Should instruction remain centered in the academic area?

· Unless enough residents are taking the same course it is difficult to reserve space for formal lecture.

· Television is a common feature of every lounge area and in-residence instruction at some schools is demonstrating its teaching potential.

· In small media centers or libraries collections of standard reference material, popular paperbacks, and periodicol literature can be provided.

· Common areas can be made very useful to education through the display of exhibitions (art, science, etc.) by both professionals and students.

· Independent study offers an opportunity to shift the focus of some academic work from the class room lecture to tutorial, seminar, and types of instruction that are more at home in a living room atmosphere.

Conclusion

· A good living climate is also a hospitable learning climate.

· The introduction of books, music, and art is essential to creating a living environment conducive to education by opening the door to unstructured experiences simply by building and furnishing in a way that fills the residents needs as students and human beings.

· "Students and faculty members, associating in such residential units, can do much to educate each other in ways that are not encouraged by the formal curriculum."

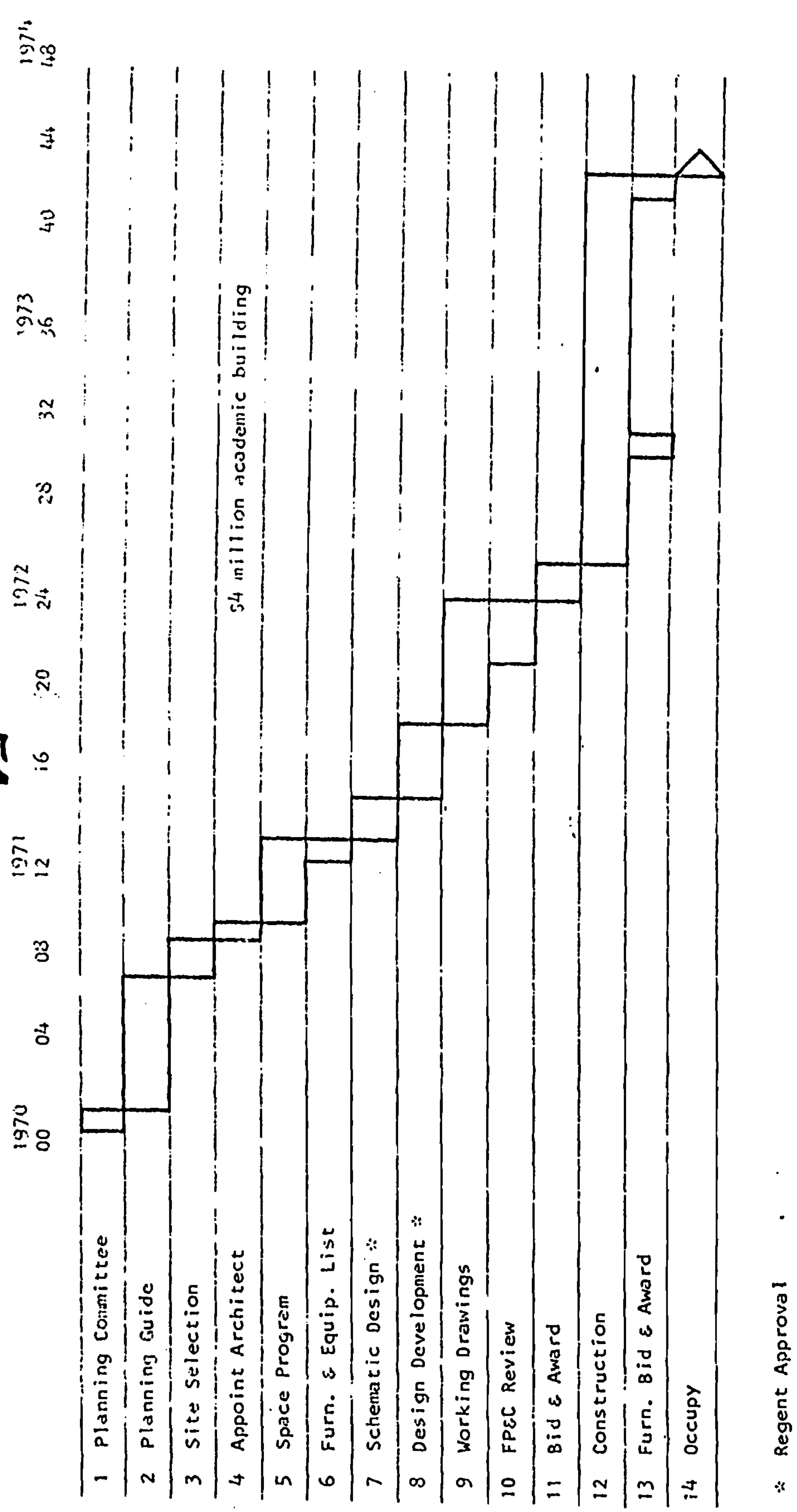
Appendix A-2
Building
Delivery

Building
Delivery

Cost information for conventional construction was taken from successful contractor cost breakdowns for recent Texas college and university building projects. Costs were distributed into 12 cost categories used in Toronto's Study of Educational Facilities project to permit comparison of systems building and conventional construction costs. The following conventional costs are included in the specified building subsystem categories:

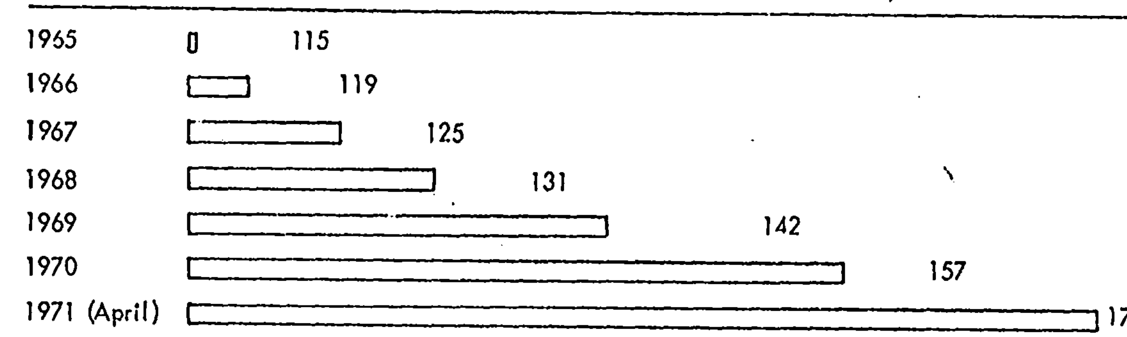
Site and Found.	excavation, foundations, basements, ground floor slab, (site utilities and landscape if in building contract)
Structure	all structural components above ground floor slab
Roofing	insulation, flashing, and roofing (roof deck excluded)
Atmosphere	heating, ventilating, air conditioning (by subcontract)
Ceilings	self explanatory
Exterior Skin	masonry or curtain wall, windows, entry doors and hardware, damp-roofing
Partitions	walls, doors, hardware
Plumbing	self explanatory (plus accessories; i.e. toilet partitions)
Electrical	self explanatory
Finishes	carpet or floor covering, painting or wall covering, etc.
Equipment	fixed equipment in building contract (i.e. cabinets, counters, kitchen equipment, etc.)
Elevators	self explanatory (shaft excluded)

Contractor set up supervision, clean up, and other generalized costs were proportionally prorated into the 12 cost categories.

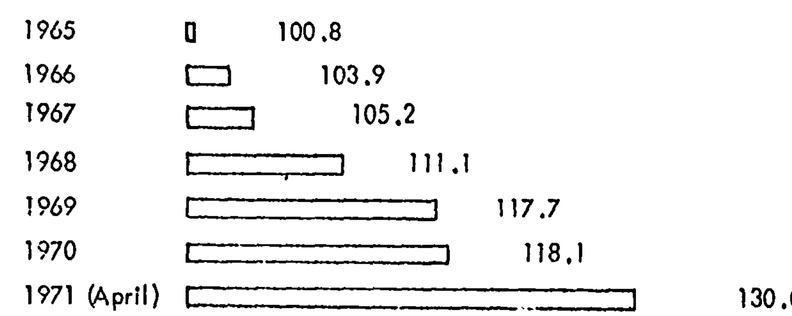


* Regent Approval

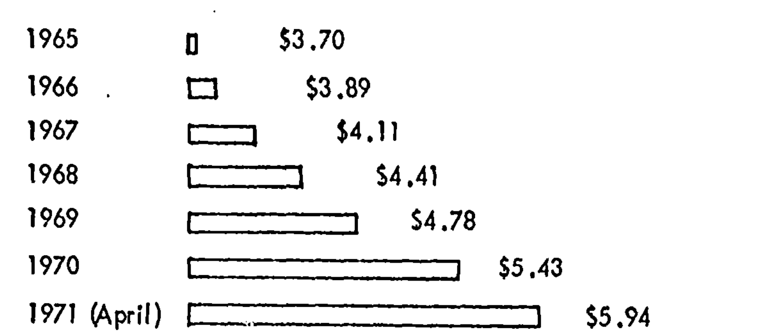
typical building project schedule University of Houston



Cost of construction index (1959 = 100)



Wholesale prices of all construction materials



Average hourly earnings, all contract construction

(Source: 1965-1970; Construction Review, U.S. Department of Commerce, January 1970, 1971; Engineering News Record, April 1, 1971)

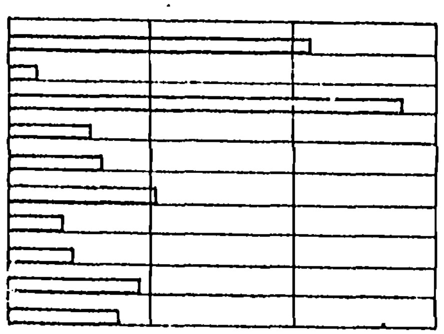
SUCF (Classroom Building)
Construction Agency for State University of New York

Percentage of total building cost accounted for by system components

Systems 0% Conventional 100%

Cost Breakdown by Subsystem

Subsystem	Cost psf. *	Percentage of Total Construction Cost
01 Structure	5.41	21.2%
02 Roofing	.50	2.0%
03 Atmosphere	6.96	27.4%
04 Lighting/Ceiling	1.60	6.3%
05 Interior Partitions	1.69	6.7%
06 Exterior Skin	2.74	10.7%
07 Plumbing	.99	3.9%
08 Electrical/Electronic	1.20	4.7%
09 Interior Finishes	2.36	9.3%
10 Furnishings/Equipment	1.98	7.8%
Total Cost $	25.43	
Systems Cost $		



* information source 1969 State Construction fund cost experience summary (unpublished)

Conventional Construction Cost and Area Comparison*

Building Type	Cost psf	% of gross area usable
01 Administration	26.38	59%
02 Classroom	25.43	67%
03 Industrial	30.81	62%
04 Research Lab	41.40	60%
05 Student Union	28.31	59%
06 Teaching Science	31.19	61%
07 Engineering	31.95	62%
08 Physical Ed.	24.90	70%
09 Library	26.20	76%
10 Dining Hall	35.36	73%
11 Auditorium	32.34	80%

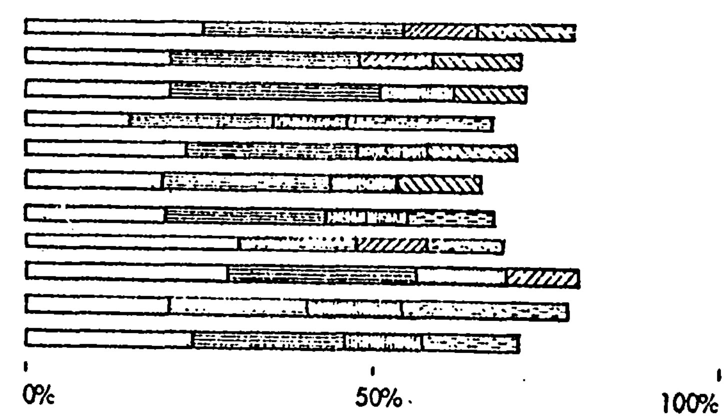
note: all costs include an conditioning except Physical Ed. building type

Costs of 4 Major Building Subsystems*

Structure Atmosphere Electrical Exterior Skin Partitions Equipment

Building Type — Subsystem cost (% of total building cost)

01 Administration
02 Classroom
03 Industrial
04 Research Lab
05 Student Union
06 Teaching Science
07 Engineering
08 Physical Ed.
09 Library
10 Dining Hall
11 Auditorium



* Information source 1969 N.Y. University Construction Fund experience tabulation (unpublished)

System	Name		State University Construction Fund
	Origin		New York State
	Used In		New York State University construction (33 campuses; 230,000 students)
	Building Types		All
	$ Volume/year		$1 billion value of construction placed since 1962. 1970 value estimate $400 million.
	Developer		State University of New York
	Sponsor		The Construction Fund is a public benefit corporation organized to build for the State University.
	Manufacturer		Not applicable
		Patent/License	Not applicable
	Organization	Planning	Projected University space requirements are translated into specific building programs and cost projections by the Fund.
		Production	Selected architect designs buildings to meet program and cost projections.
		Erection	Conventional construction methods.
	Development	Cost	Not available
		Time	Fund established 1962
		Staff	Currently approximately 100
			note: (technical information is not included in this summary since construction materials and methods are conventional).
Evaluation	Cost Data		All New York University academic facilities are built on a self amortizing basis using tuition income. Cost and quality control are the functions of the State Construction Fund. The Fund develops detailed building programs and cost estimates and

	then seeks imaginative design solutions from qualified architects. Over the past 8 years the Fund's cost projections have been 2% above actual construction costs on a $1 billion construction volume in place.
Construction Time Data	Fund methods have not reduced building construction time. The Fund implements the space requirements of the Long Range University Educational Program with sufficient lead time to deliver buildings "when required" in spite of a 2 to 4 year design and construction process.
	A recent experiment to reduce the design, construction process time produced a building in one year using market available components. Costs were close to conventional building experience, but the building was not carefully suited to the campus master plan.
Comments and Conclusions	The Fund's public benefit corporation status permits it to avoid bureaucratic delays by contracting for all construction related activities. At the same time it can issue tax free bonds as obligations of New York State. Freedom of action, combined with the Fund's demand for quality building and sophisticated long range planning; have resulted in the construction of many fine buildings and campuses. Cost control for the completed projects has been excellent. The Fund's method permits open use of materials or techniques for a given project and can therefore be carefully tailored to particular localities, sites, and campus styles.
	The fund is the best example of a successful systems building operation in the U.S. in spite of the fact that it does not employ specific building systems for its projects.

Site Visit Report 01

State University Construction Fund
Albany, New York, August 20, 1970

Organization

The Fund was organized in response to a rapidly growing demand for new educational facilities and the inability of staff architects to meet the demand in short time periods. The Fund is responsible for all construction (except dormitories) of the State University of New York. The State University serves 230,000 students at 33 campuses which include 4 University Centers, 20 Colleges, and 9 two year Agricultural and Technical Institutions. Planning, Construction, Financing, and Marketing Divisions are the major departments of the Fund.

The organizational key to the Fund's operation is its status as a "Public Benefit Corporation". New Buildings are financed through tax free revenue bonds which are retired by tuition income. Interim construction funds are provided by the State Treasury after legislative approval of new construction projects. The Fund owns buildings until bonds are retired and maintains a lease purchase agreement with the user institution. Operating expenses of the institutional plants are provided by the legislature.

Operation

Construction requirements are established by the State University's Academic Master Plan. This plan projects student population and academic disciplines, to determine net future space requirements. The Fund translates academic requirements into an Action Plan for construction which includes a detailed space description, timetable for design and construction, and a detailed cost estimate corrected for inflation (now 10-12% per year in New York experience) locality, and special site conditions. In response to a specific Action Plan requirement the Fund engages architects, awards contracts, and disburses construction funds. Individual institution master plans and construction guidelines are also prepared by the Fund.

Architects compensation is limited to a percentage of the Funds estimate of construction cost to reward economical designs and limit cost over-runs. Architects are required to submit detailed cost estimates to the fund as designs develop; on the billion dollar value of construction placed since 1962 the Funds cost estimates have exceeded actual costs by 2%.

Innovative design and quality construction are encouraged in spite of the rigid cost control program. The variety and honors awarded to State University campuses attests to the success of both program and product. By 1975 the Fund will place an additional 3 billion dollar value of construction (approximately 5% of the total State construction volume).

Systems Building

The Fund is exploring available system building technology and future building system potential with BOSTI and MIT though currently available building systems are not considered appropriate to the State University's present building needs. In response to an urgent space requirement at Stoneybrook, an accelerated construction project was undertaken utilizing available building elements (Butler space frame, Lennox octopus A/C, metal wall panels) and individual task bidding. The project was completed in record time; costs were comparable to similar conventionally built Fund projects.

Conclusions

The Fund's management and cost control program has optimized the conventional construction process for the State University. With proper advance planning they construct immaginative and functional university facilities in a controlled cost/time framework.

Reactions to the accelerated construction project vary. One group contends that in view of rapid cost inflation the reduced time methods should be applied to all future construction. The opposition contends that with proper academic need planning the accelerated building process is unnecessary, tending to compromise institutional master plans, and reduce the quality of new construction.

Building: Faculty — Area (sq. ft.): 10,648 (net 65%)

Location: Tarrant Co. Jr. College — Const. Contract: $365,300.

Function: Offices, Conference — Completion Date: Sept. 67

General Descriptors

Structure	Concrete	Exterior Skin	brick
No. Floors	1	Interior Partitions	drywall
Air Cond.	cent. plant	Spl. Equipment	no

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	4.10	12
Structure	5.20	15
Roofing	.70	02
Atmosphere	9.90	29
Ceiling	.30	01
Int. Partitions	1.40	04
Exterior Skin	2.70	08
Plumbing	2.10	06
Electrical	4.10	12
Int. Finishes	2.70	08
Fixed Equip.	1.00	03
Elevators	-	-
Total	34.20	

Other Cost Information
- Architects Fee Rate
- Moveable Equipment
- Labor/Materials Breakdown

Time Information

	no. months	date
Preliminary Study		
Architectural Contract	9	12.65
Construction Contract	13	08.66
Occupy		09.67

Sources: Contractor cost breakdown (McCann Const. Co.) and architects records (Parker Croston)

Building: Tarrant County Jr. College (Complete Campus) — Area (sq. ft.): 358,955 (total campus)

Location: Ft. Worth, Texas — Const. Contract: $8,617,455

Function: 2yr Jr. College 2,500 students — Completion Date: Sept. 67 (5 bldgs. later)

General Descriptors *

Structure	concrete	Exterior Skin	brick
No. Floors	1 (library 2)	Interior Partitions	dry wall
Air Cond.	cent. plant	Spl. Equipment	no

Cost Breakdown

Academic Bldg's.	38
Faculty & Admin. Bldg's.	08
Student Union	12
Library	08
Power & Services Bldg's.	10
Physical Education	12
Utility Distribution	06
Site Work	06

Sq. ft. per student (total campus) 140
Cost per student (total campus) $3,400

Total Cost (averaged for all contract work) $24.00 psf.

Other Cost Information
- Architects Fee Rate
- Moveable Equip.
- Labor/Materials Breakdown 33% / 67%

Time Information

	no. months	date
Preliminary Study		
Architectural Contract	8	12.65
Construction Contract	13 (5 bldgs; 3 to 6 mo. add'l.)	08.66
Occupy		09.67

* note: This summary covers a total new campus including 21 buildings. Individual building cost distribution data will be found on other Summary Sheets.

Sources: Contractor cost breakdown (McCann Const. Co.) and architects records (Parker Croston).

Texas A&M University
College of Architecture & Environmental Design
Architecture Research Center
Trost

HEF : SBA 03.08.71 Page 69
Higher Education Facilities
Systems Building Analysis
Building Experience Summary

Building: Academic (4 units)

Area (sq. ft.): 38,154 (net 65%)

Location: Torront Co. Jr. College

Const. Contract: $675.600

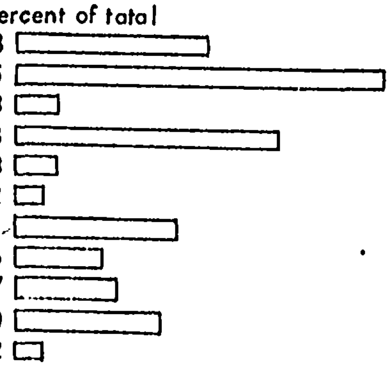
Function: Classrooms

Completion Date: Sept. 67

General Descriptors

Structure	concrete	Exterior Skin	brick
No. Floors	1	Interior Partitions	dry wall
Air Cond.	Cent. plant	Spl. Equipment	-

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	2.30	13
Structure	4.40	25
Roofing	50	03
Atmosphere	3.20	18
Ceiling	50	03
Int. Partitions	40	02
Exterior Skin	1.90	11
Plumbing	1.10	06
Electrical	1.20	07
Int. Finishes	1.80	10
Fixed Equip.	40	02
Elevators	-	-
Total	17.70	



Other Cost Information
- Architects Fee Rate
- Moveable Equipment
- Labor/Materials Breakdown 45/55

Time Information	no. months	date
Preliminary Study		
Architectural Contract	9	12.65
Construction Contract	13	06.66
Occupy		09.67

Sources: Contractor cost breakdown (McCann Const. Co.) and architects records (Parker Croston)

Texas A&M University
College of Architecture & Environmental Design
Architecture Research Center
Trost

HEF : SBA 03.08.71 Page 70
Higher Education Facilities
Systems Building Analysis
Building Experience Summary

Building: Technical

Area (sq. ft.): 14,111 (net 65%)

Location: Tarrant Co. Jr. College

Const. Contract: $273,600

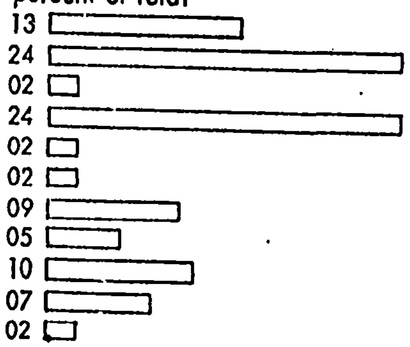
Function: Industrial arts

Completion Date: Sept. 67

General Descriptors

Structure	concrete	Exterior Skin	brick
No. Floors	1	Interior Partitions	drywell
Air Cond.	Cent. plant	Spl. Equipment	no

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	2.50	13
Structure	4.60	24
Roofing	.40	02
Atmosphere	4.70	24
Ceiling	.40	02
Int. Partitions	.40	02
Exterior Skin	1.70	09
Plumbing	1.00	05
Electrical	1.90	10
Int. Finishes	1.40	07
Fixed Equip.	.40	02
Elevators	-	-
Total	19.40	



Other Cost Information
- Architects Fee Rate
- Moveable Equipment
- Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		
Architectural Contract	9	12.65
Construction Contract	13	08.66
Occupy		09.67

Sources: Contractor cost breakdown $ (McCann Const. Co.) and architects records (Parker Croston)

Building: Western Texas College (1000 students)
Location: Snyder, Texas
Function: Complete 1st phase campus (10 buildings)

Area (sq. ft.): 116,387 (total 10 bldg's.)
Const. Contract: 2,908,000.
Completion Date: Dec. 71 (est.)

General Descriptors *

Structure	Steel frame	Exterior Skin	Stucco
No. Floors	1	Interior Partitions	dry wall
Air Cond.	cent. plant	Spl. Equipment	no

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	1.20	05
Structure	5.30	21
Roofing	50	02
Atmosphere	3.80	15
Ceiling	30	01
Int. Partitions	1.50	06
Exterior Skin	3.80	15
Plumbing	2.70	11
Electrical	3.20	13
Int. Finishes	1.70	07
Fixed Equip.	1.00	04
Elevators	-	-
Total	25.00	

Other Cost Information
Architects Fee Rate
Moveable Equipment
Labor/Materials Breakdown

Time information

	no. months	date
Preliminary Study		
Architectural Contract	09	02.70
Construction Contract	13 (est.)	11.70
Occupy		12.71 (est.)

* note: Descriptors and Cost Breakdown is based on a complete new campus; 10 buildings including Academic andScience (2), Science (4), Fine Arts (1), Library (1), Administration (1) and Power Plant (1). Utility distribution costs are prorated into building costs; landscaping is not included.

Sources: Contractor cost breakdowns (Area Builders Inc.) and Architects records. (Parker Croston)

Building: Office and Classroom
Location: Texas A&M University
Function: Classrooms, offices

Area (sq. ft.): 114,391 (net 61,5??)
Const. Contract: 3,098,584
Completion Date: Sept. 72 est.

General Descriptors

Structure	concrete	Exterior Skin	brick
No. Floors	8 (+ bsmt.)	Interior Partitions	Dry wall
Air Cond.	Cent. plant	Spl. Equipment	-

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	1.90	07
Structure	6.30	23
Roofing	.50	02
Atmosphere	3.00	11
Ceiling	.50	02
Int. Partitions	2.40	09
Exterior Skin	4.40	16
Plumbing	1.10	04
Electrical	3.30	12
Int. Finishes	1.60	06
Fixed Equip.	.80	03
Elevators	1.40	05
Total	27.20	

Other Cost Information
Architects Fee Rate
Moveable Equipment
Labor/Materials Breakdown

Time Information

	no. months	date
Preliminary Study		
Architectural Contract	15	12.69
Construction Contract	18 (est.)	03.71
Occupy		09.72

Sources:

Building: Burdine Hall

Area (sq. ft.): 103,441 (net 55%)

Location: University of Texas/Austin

Const. Contract: $ 1,852,417

Function: C.R. Office

Completion Date: May 1970

General Descriptors

Structure	concrete	Exterior Skin	brick
No. Floors	5	Interior Partitions	mas + dry wall
Air Cond.	cent. plant	Spl. Equipment	

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	1.10	06
Structure	4.50	25
Roofing	.20	01
Atmosphere	2.70	15
Ceiling	.40	02
Int. Partitions	1.60	09
Exterior Skin	2.50	14
Plumbing	1.30	07
Electrical	1.80	10
Int. Finishes	1.40	08
Fixed Equip.		
Elevators	.40	03
Total	17.90	

Other Cost Information

Architects Fee Rate	6%
Moveable Equipment	$120,942
Labor/Materials Breakdown	

Time Information	no. months	date
Preliminary Study	] 28	08.65
Architectural Contract		
Construction Contract	29	12.67
Occupy		05.70

Sources: University of Texas records (site and finish cost distribution estimated)

Building: College of Education

Area (sq. ft.): 130,391

Location: University of Houston

Const. Contract: $2,899,000

Function: Classrooms, offices

Completion Date: Jan 71

General Descriptors

Structure	concrete	Exterior Skin	pre cast concrete
No. Floors	4 (+ part bsmt.)	Interior Partitions	dry wall
Air Cond.	cent. plant	Spl. Equipment	

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	2.00	09
Structure	5.70	26
Roofing	.20	01
Atmosphere	2.70	12
Ceiling	.40	02
Int. Partitions	2.00	09
Exterior Skin	1.60	07
Plumbing	.90	04
Electrical	3.30	15
Int. Finishes	2.00	09
Fixed Equip.	.70	03
Elevators	.70	03
Total	22.20	

Other Cost Information

Architects Fee Rate
Moveable Equipment
Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		
Architectural Contract	27	10.66
Construction Contract	24	01.69
Occupy		01.71

Sources: Contractor cost breakdown (Manhattan Const. Co.) and University records.

Building: Teaching Unit, Law College — Area (sq. ft.): 65,000

Location: University of Houston — Const. Contract: 1,372,800

Function: Law classrooms — Completion Date: Feb. 69

General Descriptors

Structure	concrete	Exterior Skin	pre cast concrete
No. Floors	3 (+ bsmt.)	Interior Partitions	plaster
Air Cond.	cent. plant	Spl. Equipment	carrels

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	1.70	08
Structure	7.30	34
Roofing	.60	03
Atmosphere	1.90	09
Ceiling	.10	-
Int. Partitions	1.90	09
Exterior Skin	1.90	09
Plumbing	.20	01
Electrical	1.70	08
Int. Finishes	2.10	10
Fixed Equip.	1.50	07
Elevators	.20	01
Total	21.10	

Other Cost Information
- Architects Fee Rate
- Moveable Equipment
- Labor/Materials Breakdown

Time Information

	no. months	date
Preliminary Study		
Architectural Contract	18	09.65
Construction Contract	23	03.67
Occupy		02.69

Sources: Contractor cost breakdowns (W.S. Bellows) and University records.

Building: Law College, A Central Facility — Area (sq. ft.): 40,000

Location: University of Houston — Const. Contract: $859,200

Function: Law court & offices — Completion Date: Feb. 69

General Descriptors

Structure	concrete	Exterior Skin	pre cast concrete
No. Floors	(3 + bsmt.)	Interior Partitions	plaster
Air Cond.	cent. plant	Spl. Equipment	

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	1.90	09
Structure	7.70	36
Roofing	.60	03
Atmosphere	2.10	10
Ceiling	.10	
Int. Partitions	.90	04
Exterior Skin	1.90	09
Plumbing	.20	01
Electrical	3.90	18
Int. Finishes	1.50	07
Fixed Equip.	.20	01
Elevators	.40	02
Total	21.40	

Other Cost Information
- Architects Fee Rate
- Moveable Equipment
- Labor/Materials Breakdown

Time Information

	no. months	date
Preliminary Study		
Architectural Contract	18	09.65
Construction Contract	23	03.67
Occupy		02.69

Sources: Contractor cost breakdown (W.S. Bellows) and university records.

Building: Cameron Bldg. Area (sq. ft.): 32,750

Location: Univ. of Houston Const. Contract: $829,967

Function: Nursery, Home Ec. Labs., offices Completion Date: Feb 70

General Descriptors

Structure	concrete	Exterior Skin	brick & stucco
No. Floors	2	Interior Partitions	plaster
Air Cond.	own (roof top)	Spl. Equipment	kit. equ'p. builtins

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	2.30	09
Structure	4.20	17
Roofing	.30	01
Atmosphere	3.80	15
Ceiling	.30	01
Int. Partitions	2.30	09
Exterior Skin	2.30	09
Plumbing	2.30	09
Electrical	2.90	12
Int. Finishes	1.50	06
Fixed Equip.	2.70	11
Elevators	.30	01
Total	25.20	

Other Cost Information
- Architects Fee Rate
- Moveable Equipment
- Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		
Architectural Contract	26	10.66
Construction Contract	14	12.68
Occupy		02.70

Sources: Contractor cost breakdown (Fleetwood Const. Co.) and University records

Building: Services Building (1-1452) Area (sq. ft.): 78,500 sq. ft.

Location: Texas A&M University Const. Contract: $1,252,350

Function: Classrooms, offices Completion Date: July 69

General Descriptors

Structure	Concrete	Exterior Skin	brick & concrete
No. Floors	4 (+bsmt.)	Interior Partitions	masonry
Air Cond.	Cent. plant	Spl. Equipment	no

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	1.30	8
Structure	3.50	22
Roofing	.20	1
Atmosphere	3.50	22
Ceiling	.20	1
Int. Partitions	1.10	7
Exterior Skin	1.40	9
Plumbing	1.40	9
Electrical	1.60	10
Int. Finishes	1.10	7
Fixed Equip.	.20	1
Elevators	.50	3
Total	16.00	

Other Cost Information
- Architects Fee Rate: System architect
- Moveable Equipment: $106,632
- Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		
Architectural Contract	14	02.65
Construction Contract	39	04.66
Occupy		07.69

Sources: Contractor Breakdown (Vance & Thurmond) + University records.

Building: Education Building | Area (sq. ft.): 127,949

Location: University of Texas/El Paso | Const. Contract: $ 3,085,000

Function: CR. Labs | Completion Date: July 1970

General Descriptors

Structure	concrete	Exterior Skin	pre cast concrete
No. Floors	8	Interior Partitions	dry wall + masonry
Air Cond.	cent. plant.	Spl. Equipment	

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	1.50	06
Structure	5.90	24
Roofing	.20	01
Atmosphere	3.40	14
Ceiling	.50	02
Int. Partitions	1.70	07
Exterior Skin	4.80	20
Plumbing	1.70	07
Electrical	2.00	08
Int. Finishes	1.50	06
Fixed Equip.	.70	03
Elevators	.50	02
Total	24.40	

Other Cost Information
- Architects Fee Rate
- Moveable Equipment
- Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study	19 (Preliminary Study and Architectural Contract, bracketed together)	06.67
Architectural Contract		
Construction Contract	18	01.69
Occupy		07.70

Sources: University of Texas records (site and finish cost distribution estimated)

Building: Basic Science | Area (sq. ft.): 136,282 (net 50%)

Location: University of Texas: Medical:Galveston | Const. Contract: $ 3,947,400

Function: Labs. C.R. Offices | Completion Date: May 1971 (est.)

General Descriptors

Structure	concrete	Exterior Skin	brick
No. Floors	7	Interior Partitions	masonry + dry
Air Cond.	cent. plant.	Spl. Equipment	cold rms., shielded rms., etc.

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	1.50	05
Structure	5.50	19
Roofing	.30	01
Atmosphere	7.00	24
Ceiling	.60	02
Int. Partitions	1.70	06
Exterior Skin	1.70	06
Plumbing	2.90	10
Electrical	2.90	10
Int. Finishes	1.50	05
Fixed Equip.	2.60	09
Elevators	.90	03
Total	29.00	

Other Cost Information
- Architects Fee Rate
- Moveable Equipment
- Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study	42 (Preliminary Study and Architectural Contract, bracketed together)	06.64
Architectural Contract		
Construction Contract	41	12.67 (scheduled for 07.69)
Occupy		05.71

Sources: University of Texas records (site and finish cost distribution estimated)

Texas A&M University
College of Architecture & Environmental Design
Architecture Research Center
Trost

HEF : SBA 03.03.71 Page 81
Higher Education Facilities
Systems Building Analysis
Building Experience Summary

Building: Basic Science and Research

Area (sq. ft.): 166,244

Location: University of Texas: Medical:Dallas

Const. Contract: $ 7,071,800

Function: C.R. Labs. Offices

Completion Date: August 1971 (est.)

General Descriptors

Structure	concrete	Exterior Skin	precast concrete
No. Floors	5	Interior Partitions	dry wall
Air Cond.	cent. plant.	Spl. Equipment	cold rms., shielded rms., etc.

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	2.20	05
Structure	8.80	20
Roofing	.40	01
Atmosphere	9.30	21
Ceiling	.40	01
Int. Partitions	2.20	05
Exterior Skin	2.60	06
Plumbing	2.20	05
Electrical	8.70	18
Int. Finishes	1.80	04
Fixed Equip.	5.30	12
Elevators	.90	02
Total	44.10	

Other Cost Information

Architects Fee Rate
Moveable Equipment
Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		07.65
Architectural Contract	47	
Construction Contract		06.69
Occupy		

Sources: University of Texas records (site and finish cost distribution estimated)

Texas A&M University
College of Architecture & Environmental Design
Architecture Research Center
Trost

HEF : SBA 03.03.71 Page 82
Higher Education Facilities
Systems Building Analysis
Building Experience Summary

Building: Engineering Center (1-1330)

Area (sq. ft.): 324,400 (incl 75,800 bsmt. & parking)

Location: Texas A&M University

Const. Contract: $7,540,400

Function: C.R., Labs, Auditoria, Offices etc.

Completion Date: Sept. 71 (est.)

General Descriptors

Structure	Concrete	Exterior Skin	Precase concrete
No. Floors	4 (+ parking)	Interior Partitions	mas. & dry wall
Air Cond.	Cent. plant	Spl. Equipment	Reactor

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	2.10	9
Structure	5.80	25
Roofing	.20	1
Atmosphere	3.00	13
Ceiling	.50	2
Int. Partitions	2.80	12
Exterior Skin	3.00	13
Plumbing	1.20	5
Electrical	2.80	12
Int. Finishes	.90	4
Fixed Equip.	.70	3
Elevators	.20	1
Total	23.20	

Other Cost Information

Architects Fee Rate 4 1/2% + equip.
Moveable Equipment $825,000 (allowance)
Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		
Architectural Contract	26	05.67
Construction Contract	26 est.	07.69
Occupy		09.70 (est.)

Sources: Contractor Breakdown (W.S. Bellows Corp.) and University records.

Building: Science & Research

Location: University of Houston

Function: Labs. offices

Area (sq. ft.): 230,000

Const. Contract: 6,126,000 (not incl. 196,000 in C.O.)

Completion Date: Feb. 69

General Descriptors

Structure	concrete	Exterior Skin	brick
No. Floors	7 (no bsmt.)	Interior Partitions	masonry
Air Cond.	central plant	Spl. Equipment	cold storage, sterilizers, etc.

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	1.10	04
Structure	5.60	21
Roofing	.30	01
Atmosphere	4.50	17
Ceiling	.30	01
Int. Partitions	2.40	09
Exterior Skin	2.10	08
Plumbing	2.10	08
Electrical	3.20	12
Int. Finishes	1.60	06
Fixed Equip.	2.90	11
Elevators	.50	02
Total	26.60	

Other Cost Information
- Architects Fee Rate
- Moveable Equipment
- Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		
Architectural Contract	24	07.64
Construction Contract	31	07.66
Occupy		02.69

Sources: Contractor Breakdown Linbeck Const. Corp. U.H. Records.

Building: Chemistry Annex (1-1614)

Location: Texas A&M Univ.

Function: Labs. offices

Area (sq. ft.): 85,000 sq. ft.

Const. Contract: $3,200,400

Completion Date: July 72 (est.)

General Descriptors

Structure	concrete	Exterior Skin	brick & pre. cast concrete
No. Floors	5 (+ part. bsmt.)	Interior Partitions	masonry & dry wall
Air Cond.	cent. plant	Spl. Equipment	Lab. builtins

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	1.90	05
Structure	4.90	13
Roofing	40	01
Atmosphere	7.20	19
Ceiling		
Int. Partitions	2.60	07
Exterior Skin	3.00	08
Plumbing	5.70	15
Electrical	4.20	11
Int. Finishes	.70	02
Fixed Equip.	5.70	15
Elevators	1.50	04
Total	37.80	

Other Cost Information
- Architects Fee Rate 4 1/2% + misc. $149,300
- Moveable Equipment
- Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		
Architectural Contract	32	02.68
Construction Contract	21 (est.)	10.70
Occupy		07.72 (est.)

Sources: Contractor Cost Breakdown (B.F.W. Const. Co. Inc.) and University records.

Building: Oceanography & Meteorology (1-1691)

Area (sq. ft.): 178,918 (net 69%)

Location: Texas A&M University

Const. Contract: $6,774,000

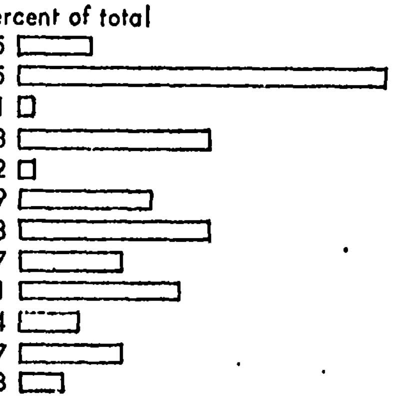
Function: C.R. Labs, offices

Completion Date: July 72 est.

General Descriptors

Structure	Steel	Exterior Skin	brick
No. Floors	15	Interior Partitions	masonry (some dry)
Air Cond.	cent. plant	Spl. Equipment	many builtins

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	1.90	5
Structure	9.50	25
Roofing	.40	1
Atmosphere	4.90	13
Ceiling	.80	2
Int. Partitions	3.40	9
Exterior Skin	4.90	13
Plumbing	2.60	7
Electrical	4.20	11
Int. Finishes	1.50	4
Fixed Equip.	2.60	7
Elevators	1.10	3
Total	37.80	



Other Cost Information

Architects Fee Rate
Moveable Equipment
Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		
Architectural Contract	22	09.68
Construction Contract	24	07.70
Occupy		07.72

Sources: Contractor Cost Breakdown (Manhattan Const. Co.) + TAMU records

Building: Biological Sciences (1-1190)

Area (sq. ft.): 96,000 sq. ft. (net 68%)

Location: Texas A&M University

Const. Contract: $2,357,991

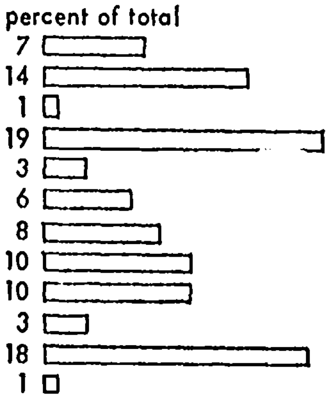
Function: Laboratories, offices

Completion Date: June 67

General Descriptors

Structure	Concrete	Exterior Skin	brick
No. Floors	4 + basement	Interior Partitions	masonry
Air Cond.	Cent. plant	Spl. Equipment	lab. builtins, cold rms.

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	1.70	7
Structure	3.50	14
Roofing	.20	1
Atmosphere	4.70	19
Ceiling	.70	3
Int. Partitions	1.50	6
Exterior Skin	2.00	8
Plumbing	2.50	10
Electrical	2.50	10
Int. Finishes	.70	3
Fixed Equip.	4.40	18
Elevators	.20	1
Total	24.60	



Other Cost Information

Architects Fee Rate — System architect
Moveable Equipment — $323,500
Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		
Architectural Contract	35 (approvals & HEW= delay)	12.62
Construction Contract	19	11.65
Occupy		06.67

Sources: Contractor Breakdown (Stokes Const. Co.) and University records

Building: Veterinary Science | Area (sq. ft.): 96,700 (15,670 unfinished)

Location: Texas A&M University | Const. Contract: $1,343,206

Function: C.R., labs, library, etc. | Completion Date: Apr. 69

General Descriptors

Structure	Steel	Exterior Skin	brick
No. Floors	3 (+bsmt.)	Interior Partitions	masonry
Air Cond.	package unit	Spl. Equipment	no

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	1.10	8
Structure	2.90	21
Roofing	.30	2
Atmosphere	1.40	10
Ceiling	.30	2
Int. Partitions	2.10	15
Exterior Skin	1.10	8
Plumbing	1.40	10
Electrical	1.80	13
Int. Finishes	.70	5
Fixed Equip.	.50	4
Elevators	.30	2
Total	13.90	

Other Cost Information

Architects Fee Rate	
Moveable Equipment	$197,500 furnish.
Labor/Materials Breakdown	51/49

Time Information

	no. months	date
Preliminary Study		
Architectural Contract	16	12.65
Construction Contract	24	04.67
Occupy		04.69

Sources: Contractor cost breakdown (Wm. Matero) and University records.

Building: Dormitories (1-1262) | Area (sq. ft.): 155,000 (933 students)

Location: Prairie View A&M | Const. Contract: 2,040,990

Function: residence | Completion Date: Sept. 65

General Descriptors

Structure	concrete	Exterior Skin	brick
No. Floors	4	Interior Partitions	dry wall
Air Cond.	central plant	Spl. Equipment	built ins

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.		
Structure	2.50	19
Roofing		
Atmosphere	1.60	12
Ceiling		
Int. Partitions		
Exterior Skin		
Plumbing	1.20	09
Electrical	.90	07
Int. Finishes		
Fixed Equip.		
Elevators		
Total	13.20	

Other Cost Information

Architects Fee Rate	4%
Moveable Equipment	
Labor/Materials Breakdown	29%/71% (contractor)

Time Information

	no. months	date
Preliminary Study		
Architectural Contract	8	12.63
Construction Contract	14	07.64
Occupy		09.65

Sources: Architects Cost Estimate (Golemon & Roth) and Contractor (Scheffe Const. Co.) bid documents: Note: no schedule of prices

Building: Dormitory addition (3-1520) — Area (sq. ft.): 35,772

Location: Tarleton — Const. Contract: $747,000

Function: Womens' residence (105 rms.) — Completion Date: Nov. 68

General Descriptors

Structure	reinf. conc.	Exterior Skin	brick
No. Floors	3	Interior Partitions	dry wall
Air Cond.	own unit	Spl. Equipment	built in furnish.

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	1.90	09
Structure	2.90	14
Roofing	.40	02
Atmosphere	2.90	14
Ceiling	.40	02
Int. Partitions	1.70	08
Exterior Skin	1.20	06
Plumbing	2.70	13
Electrical	2.50	12
Int. Finishes	1.90	09
Fixed Equip.	2.30	11
Elevators		-
Total	20.80	

Other Cost Information

Architects Fee Rate	
Moveable Equipment	$18,012
Labor/Materials Breakdown	

Time Information	no. months	date
Preliminary Study		
Architectural Contract	17	01.66
Construction Contract	17	06.67
Occupy		11.68

Sources: Contractor cost breakdown (Marvin Connell Const.) and TAMU records.

Building: Dormitory (4-1726) — Area (sq. ft.): 137,486 (net 62%)

Location: Prarie View A&M — Const. Contract: $2,490,000.

Function: Mens residence (255 students) — Completion Date: Apr. 72 (est.)

General Descriptors

Structure	Concrete	Exterior Skin	brick
No. Floors	4	Interior Partitions	masonry
Air Cond.	cent. plant	Spl. Equipment	built in furnishings

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	1.40	08
Structure	4.40	24
Roofing	20	01
Atmosphere	1.60	09
Ceiling		-
Int. Partitions	2.30	13
Exterior Skin	2.30	13
Plumbing	1.60	09
Electrical	1.40	08
Int. Finishes	1.40	08
Fixed Equip.	1.20	06
Elevators	20	01
Total	18.10	

Other Cost Information

Architects Fee Rate	4 1/2%
Moveable Equipment	
Labor/Materials Breakdown	

Time Information	no. months	date
Preliminary Study		
Architectural Contract	26	08.68
Construction Contract	18 (est.)	10.70
Occupy		04.72

Sources: Contractor cost breakdown (H.A. Lott Inc.) and University records

Building: Dormitory (4-1726) — Area (sq. ft.): 129,660 (net 68%)

Location: Prairie View A&M — Const. Contract: $2,860,000

Function: Womens residence — Completion Date: Apr. 72 (est.)

General Descriptors

Structure	Concrete	Exterior Skin	brick
No. Floors	4	Interior Partitions	masonry
Air Cond.	Cent. plant	Spl. Equipment	built in furnish.

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	2.20	10
Structure	4.00	18
Roofing	40	02
Atmosphere	2.20	10
Ceiling	40	02
Int. Partitions	2.90	13
Exterior Skin	2.70	12
Plumbing	2.20	10
Electrical	1.80	08
Int. Finishes	1.50	07
Fixed Equip.	1.50	07
Elevators	20	01
Total	22.00	

Other Cost Information

Architects Fee Rate — 4 1/2%
Moveable Equipment
Labor/Materials Breakdown

Time Information

	no. months	date
Preliminary Study		
Architectural Contract	26	08.68
Construction Contract	18 (est.)	10.70
Occupy		04.72 (est.)

Sources: Contractor cost breakdown (B.F.W. Const. Co.) and University records.

Building: Dormitories - 960 students (1-1749) — Area (sq. ft.): 276,842 (77% residence)

Location: Texas A&M Univ. — Const. Contract: $7,197,000

Function: Dormitory, dining commons, recreation — Completion Date: Apr. 72 (est.)

General Descriptors

Structure	steel/concrete	Exterior Skin	brick & precast concrete.
No. Floors	4	Interior Partitions	masonry
Air Cond.	cent. plant	Spl. Equipment	complete kitchen

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	1.80	7
Structure	5.70	22
Roofing	.30	1
Atmosphere	2.30	9
Ceiling	.80	3
Int. Partitions	3.40	13
Exterior Skin	2.90	11
Plumbing	2.60	10
Electrical	2.00	8
Int. Finishes	1.80	7
Fixed Equip.	2.30	9
Elevators	-	0
Total	26.00	100

Other Cost Information

Architects Fee Rate — $326,000 (sliding fee scale)
Moveable Equipment
Labor/Materials Breakdown

Time Information

	no. months	date
Preliminary Study		
Architectural Contract	25	06.68
Construction Contract	21 (est.)	07.70
Occupy		04.72 (est.)

Sources: Contractor cost breakdown (Manhattan Const.) and University records.

Building: Conference Center (1-1519)

Location: Texas A&M University

Function: Conference rms, faculty club

Area (sq. ft.): 76,400

Const. Contract: $2,896,046

Completion Date: June 73 (est.)

General Descriptors

Structure	Steel	Exterior Skin	pre cast concrete
No. Floors	11	Interior Partitions	plaster
Air Cond.	cent. plant	Spl. Equipment	kitchen equip.

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	2.30	06
Structure	12.50	33
Roofing	.40	01
Atmosphere	3.40	09
Ceiling	.40	01
Int. Partitions	2.30	06
Exterior Skin	3.80	10
Plumbing	1.50	04
Electrical	4.20	11
Int. Finishes	1.90	05
Fixed Equip.	1.90	05
Elevators	3.40	09
Total	38.00	

Other Cost Information

Architects Fee Rate	6% (note: complex includes auditorium & theater)
Moveable Equipment	
Labor/Materials Breakdown	

Time Information

	no. months	date
Preliminary Study		
Architectural Contract	36	12.67
Construction Contract	30 (est.)	12.70
Occupy		06.73 (est.)

Sources: Contractor cost breakdown (Manhattan Const. Co.) and University records

Building: Classroom (4-1805)

Location: Prairie View A&M

Function: Classrooms (8)

Area (sq. ft.): 8,200

Const. Contract: $129,700

Completion Date: Jan 71 (est)

General Descriptors

Structure	steel (pre-engineered)	Exterior Skin	metal (+ masonry)
No. Floors	1	Interior Partitions	dry wall
Air Cond.	package unit	Spl. Equipment	no

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	3.20	20
Structure	2.70	* 17
Roofing		* -
Atmosphere	1.90	12
Ceiling	.50	03
Int. Partitions	1.70	11
Exterior Skin	1.10	* 07
Plumbing	.90	06
Electrical	2.40	15
Int. Finishes	.90	06
Fixed Equip.	.50	03
Elevators		-
Total	15.80	

Other Cost Information

Architects Fee Rate	System architects
Moveable Equipment	
Labor/Materials Breakdown	

Time Information

	no. months	date
Preliminary Study	10	01.69
Architectural Contract	12 (approvals)	07.69
Construction Contract	5	07.70
Occupy		01.71

* note: pre engineered bldg. costs listed under structure include roof and some exterior skin

Sources: Contractor cost breakdown (Rowe & Mayfield) Houston and University records

Building: Auditorium (1-1519)

Location: Texas A&M Univ.

Function: Auditorium, Theater complex

Area (sq. ft.): Auditorium (2,500), Theaters (500 & 250)

Const. Contract: $5,421,249

Completion Date: June 73 (est.)

General Descriptors

Structure	Steel truss	Exterior Skin	precast concrete
No. Floors	1-3	Interior Partitions	plaster
Air Cond.	cent. plant	Spl. Equipment	Stage, seating etc.

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.		10
Structure		26
Roofing		02
Atmosphere		10
Ceiling		02
Int. Partitions		07
Exterior Skin		11
Plumbing		01
Electrical		13
Int. Finishes		08
Fixed Equip.		10
Elevators		-
Total		

Other Cost Information

Architects Fee Rate	6%
Moveable Equipment	
Labor/Materials Breakdown	

Time Information

	no. months	date
Preliminary Study		
Architectural Contract	36	12.67
Construction Contract	30 (est.)	12.70
Occupy		06.73 (est.)

Sources: Contractor cost breakdown (Manhattan Const. Co.) and University records.

Building: General Services

Location: Univ. of Houston

Function: Offices, Mail, Press, Storage + shops (Metal Bldgs.)

Area (sq. ft.): Bldg. 40,000*
Shop 121,400

Const. Contract: $1,822,000
$1,200,000 for admin. bldg.

Completion Date: Mar. 70

General Descriptors

Structure	Steel	Exterior Skin	brick, stucco
No. Floors	2	Interior Partitions	dry wall
Air Cond.	own source	Spl. Equipment	sprinklers

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	3.00	10
Structure	3.00	10
Roofing	.60	02
Atmosphere	8.70	29
Ceiling	.60	02
Int. Partitions	3.00	10
Exterior Skin	3.30	11
Plumbing	2.70	09
Electrical	3.00	10
Int. Finishes	1.20	04
Fixed Equip.	.60	02
Elevators	.30	01
Total	30.00 *	

Other Cost Information

Architects Fee Rate
Moveable Equipment
Labor/Materials Breakdown

Time Information

	no. months	date
Preliminary Study		
Architectural Contract	20	02.67
Construction Contract	18	10.68
Occupy		03.70

* note: Metal building costs have been deleted from summary sheet. Only the 40,000 sq. ft. administrative building is included in calculations.

Sources: Contractor cost breakdown (Manhattan Const. Co.) and university records.

Building: Law College Library

Area (sq. ft.): 50,000

Location: University of Houston

Const. Contract: $742,700

Function: Library

Completion Date: Feb. 69

General Descriptors

Structure	concrete	Exterior Skin	-
No. Floors	2 (below grade)	Interior Partitions	plaster
Air Cond.	cent. plant	Spl. Equipment	

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	3.00	20
Structure	4.20	28
Roofing	.70	05
Atmosphere	1.80	12
Ceiling		-
Int. Partitions	.70	05
Exterior Skin	.10	01
Plumbing	.10	01
Electrical	1.50	10
Int. Finishes	1.80	12
Fixed Equip.	.90	06
Elevators		-
Total	14.80	

Other Cost Information

Architects Fee Rate
Moveable Equipment
Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		
Architectural Contract	18	09.65
Construction Contract	23	03.67
Occupy		02.69

Sources: Contractor cost breakdowns (W.S. Bellows) and University records.

Building: Library

Area (sq. ft.): 171,500

Location: Texas A&M University

Const. Contract: 2,967,268

Function: main library

Completion Date: May 68

General Descriptors

Structure	Concrete	Exterior Skin	brick, marble, concrete
No. Floors	4 (+ bsmt.)	Interior Partitions	dry wall
Air Cond.	Cent. plant	Spl. Equipment	other contract

Cost Breakdown (construction)	$psf	percent of total
Site & Found.	1.40	08
Structure	4.30	25
Roofing	20	01
Atmosphere	2.20	13
Ceiling	70	04
Int. Partitions	1.50	09
Exterior Skin	1.50	09
Plumbing	50	03
Electrical	2.80	16
Int. Finishes	1.50	09
Fixed Equip.	10	-
Elevators	50	03
Total	17.20	

Other Cost Information

Architects Fee Rate 4 1/2% (plus 1% on furnishings)
Moveable Equipment $311,000
Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		
Architectural Contract	37	11.62
Construction Contract	29	12.65
Occupy		05.68

Sources: Contractor cost breakdown (Temple Associates Inc.) and University records

Building: Gym and Phys. Ed. (3.1589) Area (sq. ft.): 61,350

Location: Tarleton Const. Contract: 1,204,500

Function: Gym + Class rooms Completion Date: Nov. 70

General Descriptors

Structure	Steel Gym, Conc. / other	Exterior Skin	brick
No. Floors	1 at Gym, 2 other	Interior Partitions	masonry
Air Cond.	own unit	Spl. Equipment	bleachers etc.

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	2.70	14
Structure	4.10	21
Roofing	.40	02
Atmosphere	2.70	14
Ceiling	.80	04
Int. Partitions	1.20	06
Exterior Skin	1.60	08
Plumbing	1.60	08
Electrical	2.00	10
Int. Finishes	1.20	06
Fixed Equip.	1.40	07
Elevators		-
Total	19.70	

Other Cost Information

Architects Fee Rate 4 1/2%
Moveable Equipment
Labor/Materials Breakdown

Time Information

	no. months	date
Preliminary Study		
Architectural Contract	31	08.66
Construction Contract	20	03.69
Occupy		11.70

Sources: Contractor Cost Breakdown (Kasch Bros.) and T.A.M.U. records

Building: Dining Hall (4-1678) Area (sq. ft.): 111,000

Location: Prairie View A&M Const. Contract: $3,800,000

Function: Dining & Food Prep. Completion Date: Apr. 72 (est.)

General Descriptors

Structure	Concrete	Exterior Skin	brick
No. Floors	2 (+ bsmt.)	Interior Partitions	masonry
Air Cond.	cent. plant	Spl. Equipment	Food Prep.

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	3.40	10
Structure	7.20	21
Roofing	70	02
Atmosphere	3.10	09
Ceiling		
Int. Partitions	2.70	08
Exterior Skin	3.10	09
Plumbing	1.70	05
Electrical	2.10	06
Int. Finishes	1.70	05
Fixed Equip.	8.20	24
Elevators	30	01
Total	34.20	

Other Cost Information

Architects Fee Rate 4 1/2%
Moveable Equipment
Labor/Materials Breakdown

Time Information

	no. months	date
Preliminary Study	20 (approvals)	08.67
Architectural Contract	17	04.69
Construction Contract	18 (est.)	10.70
Occupy		04.72 (est.)

Sources: Contractor cost breakdown (H.A. Lott Inc.) and University records

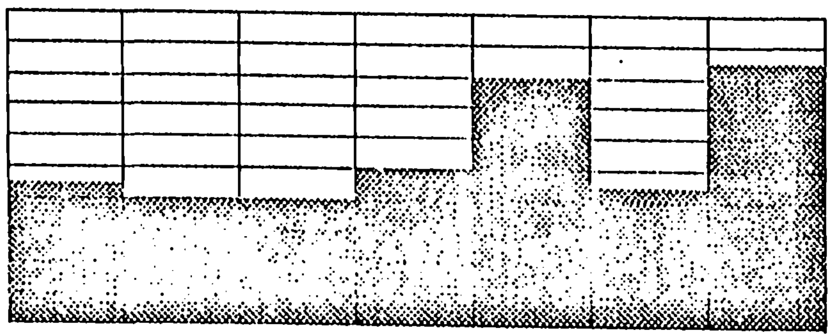
Building System Comparison

● A majority of subsystem work accomplished with system building techniques
○ Part of subsystem work accomplished with system building techniques

Subsystems	CLASP	SCSD	SSP	GSSC	SEF	RAS	ZACHRY
00 Foundation	●						
01 Structure	●	●	●	●	●	●	●
02 Roofing	●	○	○	●	●		○
03 Atmosphere		●	●	●	●	●	●
04 Lighting/Ceiling	○	●	●	●	●	●	●
05 Interior Partitions	●	●	●		●	●	●
06 Exterior Skin	●			●	○		●
07 Plumbing	○				○		●
08 Electrical/Electronic					●	●	●
09 Interior Finishes			○		○		●
10 Furnishings/Equipment	○	○	○		○		●

Systems Cost as a percentage of total building cost

100%



0%

Key

CLASP	Consortium of Local Authorities Special Program, England
SCSD	School Construction System Development, California
SSP	Schoolhouse Systems Project, Florida
GSSC	Georgia Schoolhouse Systems Council, Georgia
SEF	Study of Educational Facilities, Toronto
RAS	Research in Educational Facilities, Montreal
Zachry	H.B. Zachry Co., Texas

CLASP
A building system used for schools and colleges in Britain

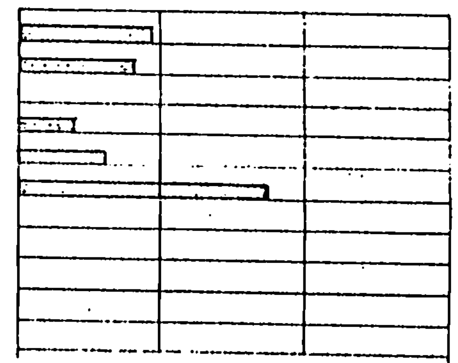
Percentage of total building cost accounted for by system components

Systems 46% Conventional 54%

Cost Breakdown by Subsystem

Subsystem	Cost psf.*
01 Structure	1.29
02 Roofing	1.18
03 Atmosphere	1.60
04 Lighting/Ceiling	.55
05 Interior Partitions	.97
06 Exterior Skin	2.47
07 Plumbing	1.06
08 Electrical/Electronic	.69
09 Interior Finishes	.76
10 Furnishings/Equipment	.78
11 Site Work and Fees	1.93
Total Cost $	13.28
Systems Cost $	6.46

Percentage of Total Construction Cost



9.5%
8.0%
3.8%
6.3%
18.7%

* information source CLASP Standard Information, 1970

System	Name		CLASP/JPD
	Origin		Great Britain
	Used In		1000 Projects @ 90 million pounds (plus). Also 200 projects outside Great Britain.
	Building Types		Schools, office buildings, fire stations, homes for elderly.
	$ Volume/year		68/69 - $32 million 69/70 - $39 million (146 jobs)
	Developer		Consortium of local authorities special program Clerk of County Council County Hall, West Bridgford, Nottingham
	Sponsor		Same
	Manufacturer		Nomination of any firm is only agreed after careful investigation of suitable firms and discussions with senior management and is subject to achieving a satisfactory result in terms of price, quality, and service.
		Patent/License	CLASP fee to users 1/4 of one percent of construction cost.
	Organization	Planning	Selected Architect
		Production	Combination of selected manufacturers under the direction of Brockhouse, Limited (structural supplier).
		Erection	Local contractors
	Development		The system was developed in an evolutionary process beginning in the late 1940's in Great Britain. Currently system built schools account for 40% of Britain's total school construction.
Technical	Planning Module		Planning grid is 1' x 1'. Structural grid is 3' x 3'. (CLASP will go to the metric standard with its Mark 5 model in 1970).

Expandability		Three dimensional (up to four stories)
Site Factory		Not required
Transport Limits		Not applicable
Foundations		Reinforced concrete slab (consists of a series of precast base pads surrounded by an in-situ concrete floor slats. (Both settings on a sand sub-base). Foundations designed to accommodate subsidence.
Structure		Light skeletal frame system of steel hollow tube columns (pin jointed at base), light steel fabricated beams and ties, and timber joist construction. A new set of components CLASP/JDP utilizes concrete floor decks.
	Span Limits	Up to 30 feet in general use areas. Up to 60 feet maximum for gymnasiums.
	Max. floors	Four (up to 6 with newest components)
Exterior walls		A variety of Cladding units including concrete slab, wooden planking, face brick, enamel, sheet metal, etc., may be used.
	Insul. value	Insulating barriers in all external walls are formed from 1" mineral fibre or glass fibre quilts with building paper backing. a) 1/2" mineral fibre/glass fibre quilt $u = 0.216$ b) 1" mineral fibre/glass fibre quilt $u = 0.147$
Interior walls		Options include double plaster board sandwich, melamine plastic faced chipboard, and metal partitions. The components are available in varying heights and widths and the component range includes internal/external corners, stop ends, etc., to fulfill all living conditions normally generated in the system.
	Acoustic Insul.	Average sound reduction index figure for the range 100-3150 cps is 43.4 dB.

	Relocatability	A fixed position seems to be the intent of the system.
Flooring		Rubber flooring
	Above Grade	Timber joists span 6' or 3' between steel floor beams. These joists support either prefabricated floor decks or in-situ cross battens and boarding;
Ceiling		The ceiling support grid is 3' 0" x 3' 0" on plan normally centered on the strucutral grid. Panels are of the "lay-in" type normally 3' 0" square and 5/8" thick. The ceiling is designed to provide fire protection to the steel in the floor or roof zone, and thermal resistence in the latter.
	Acoustic	Average sound reduction for the range 100-3140 cps. is 40.3 dB.
Roofing		Plywood decks Siporex panels Gravel stucco Plastic Roof construction consists of prefabricated decks (6', 9', and 12' lengths) surfaced with 2 layers rag base felt, 1 layer asbestos base felt and 3/4" chipping.
	Insul. value	Insulating barriers in all roofs are of 1" mineral fibre or glass fibre quilts laid above the 5/8" mineral fibre ceiling panels,using 1" mineral fibre/glass fibre quilt. u = 0.13
Vertical Circulation		The staircase is designed to suit the floor to floor heights of the system and may be arranged to give varying conditions of access to landings. Total or partial enclosure of the well is possible.
Climate Control	Heating	Heating system is by circulating hot water normally Andrews-Weatherfoil Controlled Static Head, and may be oil, gas, or solid fuel fired from a central boiler house.
	Cooling	None provided

		Distribution	The heat exchange medium is hot water at 180° F carried by distribution mains located in the ceiling plenum.
	Electrical		Detailed to job requirements by an Electrical Sub-contractor. Not included in CLASP work.
	Lighting		Same as above
		Illumination	Not included as CLASP subsystem.
	Plumbing		Hot and cold water services are detailed to job requirements for supply by the contractor. Sanitary fittings and accessories are available, primarily for school use, in either vitreous china or fireclay.
	Interchangeability of System Components		Variety of subsystem suppliers provide choice in building materials and appearance. Design improvements are competitively bid on a regular basis.
	Fire Resistance		The internal wall provides a one hour protection to steelwork in the partition cavity. It has a flame spread classification Class C and is incombustible throughout. The ceiling subsystem provides one hour protection to steelwork above.
Evaluation	Cost Data		Specific cost data on individual projects is provided in CLASP documents. Comparitive cost information shows that CLASP buildings had an initial 5% cost advantage over conventional construction; currently CLASP costs are nearly equal to conventional work. (The system's increasing cost may be a result of the increasing variety and lesser standardization of components). The British detailed quantity survey estimating method plus annual materials bids have achieved excellent project cost control. An annual market of $48 million is desired to achieve meaningful cost advantages.
	Construction Time Data		Building delivery time is reduced through construction detail standardization (greatly reducing architectural efforts). Guaranteed orders to manufacturers provides good component supply;

and the use of factory produced components reduces field labor time. Documented comparisons of construction time to conventional work are not included in the literature surveyed. (The attempt to obtain orderly continuous production by manufacturers has not been realized - construction peaks continue to cause manufacturing work to be start/stop in nature).

Comments and Conclusions

This voluntary building system, initially developed for poor soil construction has successfully placed a substantial value of buildings since the late 1950's. It offers the initial flexible interior planning potential of conventional construction and is increasing the possible variety of appearance by developing new components. Continual improvement of system components updates the product and offers a high quality finished building faster than conventional methods.

System components do not include integrated mechanical, electrical subsystems so costly in U.S. buildings. Fire code limits appear less rigid than U.S. Periodic updating and the variety of acceptable materials allow for considerable variety of building appearance necessary for a successful large scale building effort.

System dimensioning is being revised to metric standards which should provide a greater European market.

The specific construction materials and code requirements applied to CLASP differ from U.S. standards and the lack of advanced mechanical and electrical subsystems limit the applicability of CLASP to U.S. projects. However the management, market aggregation, and cost control methods used by CLASP coupled with the concept of continual improvement of building components are valid goals for U.S. building system developers.

SCSD
A building system developed for California schools

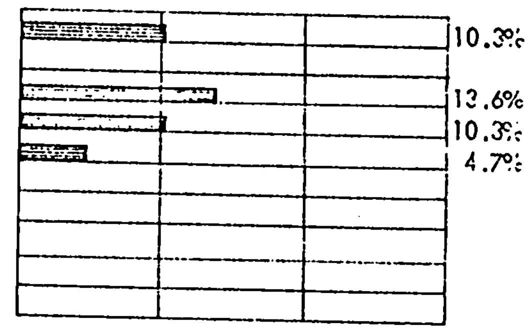
Percentage of total building cost accounted for by system components

Systems 39% Conventional 61%

Cost Breakdown by Subsystem

Subsystem	Cost psf.*
01 Structure	1.91
02 Roofing	
03 Atmosphere	2.47
04 Lighting/Ceiling	1.87
05 Interior Partitions	.85
06 Exterior Skin	
07 Plumbing	
08 Electrical/Electronic	
09 Interior Finishes	
10 Furnishings/Equipment	
Total Cost $	18.17
Systems Cost $	7.15

Percentage of Total Construction Cost



* Information source SCSD: <u>the Project and the Schools</u>, 1967

System	Name		SCSD (School Construction Systems Development)
	Origin		California
	Used In		13 schools initially (65-66). Components developed by project have been used in many additional school projects.
	Building Types		Schools, office buildings
	$ Volume/year		$9.5 million /year (65-66)
	Developer		Stanford University School Planning Laboratory Stanford University, California (E.F.L. Western Regional Center)
	Sponsor		Educational Facilities Laboratories
	Manufacturer		Structural - Inland Steel Company Air Conditioning - Lenrox Industries Lighting/ceiling - Inland Steel Company Interior Partitions - E.F. Hauserman
		Patent/License	Individual Manufacturers
	Organization	Planning	Selected Architect (by school district)
		Production	Selected Manufacturers (see above)
		Erection	Selected Contractor
	Development	Cost	Approximately $650,000
		Time	Feasibility Study began December 1961, Prototype complete November 1964. First school complete September 1966.
		Staff	10-12 professional employees plus many consultants.
Technical	Planning Module		5' x 5' horizontal 2' vertical Partitions can be located on any 4" grid line in planning modules.

Expandability		Three dimensional (height limited to two stories)
Site Factory		Not required
Transport Limits		Not applicable
Foundations		Conventional concrete
Structure		A load bearing skeletal frame on a five foot grid consists of: •Hollow metal cruciform columns •Conventional trusses as primary beams •Metal truss deck •Tension braces The structure is a horizontal "sandwich" supported by the columns with no load bearing walls. The sandwich is a standard 36" for academic areas and 60" for gymnasiums.
	Span limits	110 feet maximum
	Max. floors	Two (single floor plans most used due to easy HVAC installation on roof)
Exterior walls		SCSD does not include exterior finishes. These are designed by the project Architect.
	Insul. value	Not applicable
Interior walls		•40 inch wide panels of steel covered gypsum board snap into a metal grid. •Variety of colors and finishes including floor to ceiling chalk board. •Operable accordian and panel type walls are also available.
	Acoustic Insul.	Average sound transmission loss for all subsystems is 28 decibels.
	Relocatability	All interior wall subsystems are relocatable (degree differs).
Flooring		Conventional finishes

Ceiling		•Based on five foot grid •Suspended from structure •Flat or/ Lighting coffer
	Acoustic	•Perforated steel pans may be backed with mineral wool •Room to room transmission loss is 28 dB
Roofing		•Conventional methods (20 year bonded construction)
	Insul. value	Varies with insulation selected
Vertical Circulation		Not included in this system
Climate Control		•Single, self-contained, roof top unit •Serves 3600 sq.ft. •With individual control to each 450 sq.ft. area
	Heating	Gas fired heater
	Cooling	Direct expansion refrigeration
	Distribution	•Air is carried from mixing box to each central zone by fixed fiber glass ducts. •Flexible ducts then carry air to movable strip diffusers in the ceiling.
Electrical		Conventional methods
Lighting		•Based on 5 foot square ceiling grid. •Suspended from structure. •Flush luminous, or recessed coffer with direct or indirect bulb arrangement.
	Illumination	•70 foot candles typical at work plane. Range is 35 to 210 ft. candles.
Plumbing		Conventional
Interchangeability of System Components		•Closed system, only selected manufacturers provide subsystems after bidding. •However, other manufacturers are entering the new market to compete with the original bid winners.

	Fire Resistance	•Type IV one hour buildings. •Structure and lighting/ceiling - 1 hour. •Interior Partitions - 1 hour (excluding operable partitions).
	Maintenance Considerations	•The HVAC manufacturer must furnish a long term maintenance contract extendable to a total of 20 years. •This includes periodic inspection and replacement of parts or failure and as necessary on a preventive basis.
Evaluation	Cost Data	By 1968 SCSD completed the initial 13 school projects at a total cost of about $28,000,000 (1,600,000 square feet). The following subsystem costs were taken from the 1967 EFL project report: Structure: $1.81 psf compared to 3.24 for conventional work. Lighting Ceiling: $1.31 psf compared to 1.67 for conventional work. Climate Control: $2.24 psf including a 5 year maintenance contract (value estimated $0.30 psf). Conventional, heating only, systems cost $1.70 psf. Partition Walls: comparable in cost to conventional practice but SCSD walls are demountable. The total subsystem cost of 6.85 psf was about 18% lower than conventional costs for the same subsystems and represented approximately 40% of the total cost of construction.
	Construction Time Data	The 13 school projects were completed in 2 years and 10 months. Actual construction time for individual projects averaged 1 year.
	Comments and Conclusions	SCSD realized initial cost savings on 13 project schools in comparison to conventional construction. It provided buildings of equal or better quality than conventional practice and offered the users a degree of internal flexibility for changing space requirements. The project developed new subsystem designs which have been included in or modified for over 200 school building projects in 32 states during the last 5 years. In addition manufacturers who

were not selected on the initial bidding updated or redeisgned their products to compete with subsystem producers.

The initial hardware development was time consuming and expensive: such development must be supported by a large number of projects to be self amortizing. The greatest challenge of the project was not designing hardware, but managing, coordinating, controlling, and aggregating a market from different school districts with differing time and cost requirements. The importance of this planning, programming, and management activity cannot be overlooked for without it the success of project applications is doubtful. Control of building layout and appearance by individual school clients is another essential of project success.

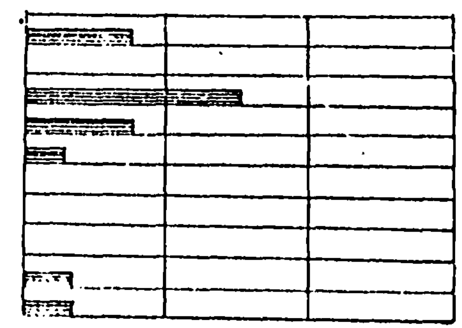
SSP
A building program for Florida schools

Percentage of total building cost accounted for by system components

Systems 41% Conventional 59%

Cost Breakdown by Subsystem

Subsystems	Cost psf.	Percentage of Total Construction Cost
01 Structure	1.16	8.0%
02 Roofing		
03 Atmosphere	2.25	15.3%
04 Lighting/Ceiling	1.14	7.8%
05 Interior Partitions	.42	2.9%
06 Exterior Skin		
07 Plumbing		
08 Electrical/Electronic		
09 Interior Finishes	.52	3.5%
10 Furnishings/Equipment	.51	3.5%



Total Cost $ 14.65
Systems Cost $ 6.00

*Information source Florida SSP report July 1970; and BSIC Newsletter, Spring, 1969

System	Name		SSP (Schoolhouse Systems Project)
	Origin		Florida
	Used In		24 Schools (three programs)
	Building Types		46 Schools since 1967 (25% of States School Construction during the period)
	$ Volume/year		7 programs completed since 1967: total value of construction $30 million. Estimated value of subsystems $12 million since 1967. Volume per year approximately $10 million.
	Sponsor/Developer		State of Florida Department of Education and Educational Facilities Laboratory.
	Manufacturer		Based on Program No. 3 Selections • Structure - Romac Steel • HVAC - Hill-York (ITT) • Lighting/Ceiling - Acoustic Engineering • Interior Partitions - Demountable - Mills Company Operable panel - Hough Mfg. Operable Accordian - Hough Mfg. • Cabinets - Educators, Mfg. • Carpeting - Sears, Roebuck Note: Manufacturers vary based on competitive bids for each program.
		Patent/Licence	Held by individual manufacturers.
	Organization	Planning	A voluntary program available to interested State school districts.
		Production	By selected subsystem manufacturers
		Erection	Local contractors
	Development	Cost	Approximately $270,000 over 2 1/2 years.
		Time	1 year from first funding to first bidding.
		Staff	3; plus consultants.

Technical	Planning Module		Horizontal - 5' x 5' note: technical information based on program no. 3 results.
	Expandability		Up to 2 stories (SCSD) 1 story usual
	Site Factory		None required
	Foundations		Conventional
	Structure		Romac steel's MODULAC structural system is a steel joist on a five-foot horizontal module capable of framing into either the MODULAC column or a bearing wall. (Program 3)
		Span limits	60' common larger spans to 110'
		Max. floors	2 (single floor most usual) due to
	Exterior walls		Not included in this system
		Insul. value	(See above)
	Interior walls		3 options, demountable wall system by Mills Company; operable panel or accordian type by Hough Mfgr. Co. (Program 3)
		Acoustic Insul.	
		Relocatability	All types can be relocated with minimal material loses.
	Flooring		Conventional materials and methods. Carpet frequently used.
	Ceiling		Armstrong C-60 lighting ceiling subsystem.
		Acoustic	STC 35.
	Roofing		Conventional materials and methods. note: roofing was prebid in 1968 program without success (no bidder interest).
		Insul value	Not applicable

	Vertical Circulation	Conventional
	Climate Control	Hill York (ITT) HVAC units for Program 3
	Electrical	Conventional
	Lighting	Included in ceiling subsystem - 2 watts psf (UPI index of visual performance used in selecting light/ceiling systems).
	Illumination	70 fc typical at work surface. 3 levels of illumination specified for differing functions.
	Plumbing	Conventional
	Interchangeability of System Components	Components vary based on competitive bids in annual building programs therefore components are not necessarily interchangeable from year to year.
	Fire Resistance	1 hour capability possible as in SCSD.
Evaluation	Cost Data	Average building costs for the 3 SSP programs have shown that systems buildings cost no more conventional new facilities, yet offer better quality in the form of a carpeted, fully air conditioned, well lighted educational environment. In fact recent systems schools have been built for 10% less than comparable conventional facilities and the costs of system components has shown a strong resistance to the cost escallation typical of the recent construction market. (A graphical summary of cost experienced to date is attached.)

	A second tentative finding, based on 6 similar system school projects is that as the percentage of systems components used increased the total project cost decreases. This finding reflects the reduction of field labor accomplished utilizing industrially produced components.
	The large cost savings (20%) realized in Programs 2 and 3 component purchasing were not evident in the finished building costs. It appears Architects and Clients working to support an educational program opted for more and better facilities instead of less cost. Costs for conventional construction have escallated as much as 40% during the programs but major SSP subsystem costs have not increased during the program.
Construction Time Data	Construction time for system schools was significantly less than for comparable conventional schools. Comparing elementary school projects 26 conventional schools averaged 37 days (14%) longer under construction than 14 similar systems schools. Considering secondary schools 8 conventional projects took an average of 170 days (60%) longer than 8 similar system schools.
	Reductions in project delivery time for systems projects are attributed to pre bidding of system components. Further time savings are considered possible with accelerated project scheduling.
Comments and Conclusions	SSP is unique in that it has utilized the technology developed by other programs and manufacturers thereby avoiding a long and expensive design development effort. The State Commission of Education has employed bulk bidding and performance specifications with success in that program building costs have escallated much less than a comparative conventional building projects. The voluntary aspects of SSP permit smaller school districts to utilize and benefit from subsystems obtained in a large construction program.
	Since 1967 25% of all Florida's new schools have been built using System techniques. Volume bidding has been successful in projects exceeding

500,000 sq. ft. and significant reductions in construction time have been realized.

As a result of the 3 sponsored programs additional local programs are being undertaken with advisory assistance provided by the State Department of Education. In addition a project is now underway to develop a building system for Junior College and University buildings.

Research Trip Report

On February 22, 1971, Messrs. Trost and Sweeney met with James Bruce project architect for Florida Schoolhouse System Program. Discussions covered development of the program and cost-time experience on system school projects.

Background

Dr. Harold L. Cramer and James Y. Bruce of the SSP group:

- 1964 – Contact made with SCSD group by Floridians interested in school systems.
- Dec. '65 – Miami Seminar on building systems at which nationally recognized leaders in the field participated.
- School Plant Planning organized as result and continued interest in systems.
  - Recommended that school system development be handled by state department of Education.
  - Recommended that a feasibility study be made.
- Oct. '66 – July '67 – Feasibility study made – supported by EFL and state funds approximately $70,000 total.
  - First Phase Report on Florida Schoolhouse Systems Project.
  - Sought better schools cheaper and faster.
  - Recommended use of building systems and volume purchasing for school construction.

Program 1

- Oct. '67 – began 2 year legislative funding with EFL matching funds, total of $100,000/year.
  - $15 million worth of work voluntarily committed by various school districts across state.
  - Sought to use and improve on SCSD components.
  - Statewide teacher's strike and new governor (1st Republican since reconstruction days) drew school districts' interests to more immediate political situation.
  - Only 6 schools ($3.6 million) remained of the original group.
  - Program 1 bid on basis of modifying SCSD components instead of developing new ones.
  - Six schools built in Program 1 at average cost approximately $1.35 over that of non-systems schools (285,000 sq. ft.).

Subsequent Programs

- Program 2 – 500,000 sq. ft. approximately.
- Program 3 – 500,000 sq. ft. approximately.

- Program 4 not needed for current Florida needs.
- State depends on modifying SCSD developed components to suit its needs (different climate, no earthquake problems, hurricanes, . . .).
- Average cost per square foot now about $2.00 less than conventional.
- July 1, 1968 - June 30, 1969 - 56 completely new schools built in Florida:
  - Of the 40 elementary schools, 26 were conventional and 14 were systems schools. Construction time was 303 days and 266 days respectively; systems schools were built in 12% less time.
  - Of the 16 secondary schools, 8 were conventional and 8 systems. Construction times average 451 and 281 respectively with systems schools being 38% faster to build.

Significance

- Oct. '67 - Oct. '70 - 46 systems schools either in design, construction, or use. This represents about 25% of all new school construction in the state for that period.

- Leon County School District (includes Tallahassee, state capitol) bid 6 schools in a systems package on the same day. These schools and related costs, etc., are comparable because the bidding climate was the same for all, the owner requirements were the same for all, and the construction sequence was the same for all.
  - Comparing the cost per square foot against the percentage of cost in systems components shows that for these 6 schools: the greater percentage of total cost attributable to systems components, the less the cost per square foot.
  - Several factors account for these cost savings and those experienced by other systems schools.
  - Time - the systems schools are realized faster due to overlap scheduling in programming, bidding, designing, construction, etc., and prefabrication.

Market Aggregation

Volume bidding (incorporating pre-bidding) resulted in as much as 20% savings for the components involved on programs of 500,000 sq. ft. total construction. The cost of selling components is reduced when volume bidding is utilized because

it occurs at the corporate instead of local or regional levels (fewer middle men).

Labor

- Labor costs are substantially reduced through components prefabrication.
  Field labor - average $8.00 per hour, 30% efficiency rate, and a low quality control level.
  Factory labor - average $4.00 per hour, 80% - efficiency rate, and a high level of quality control.

A great portion of the savings realized in systems schools construction are attributable to the labor differential.

Colleges

- The First Florida Technological University Building System for the College of Humanities and Fine Arts, Orlando, Florida -- represents the first application of systems building to higher education facilities in Florida. Being done by Rowe-Paras and Associates Architects, Inc., Tampa, Florida with considerable support from Florida Schoolhouse Systems Project personnel. Project delivery time is scheduled for 17 1/2 months as compared to the 36 months it would require conventionally. Overlap scheduling is being employed throughout (programming, designing, bidding, construction).

Opposition

- Mr. Bruce indicated that the Association of General Contractors and the concrete industry were two of the most vocal opponents to the use of systems building techniques.

Architects

- Architectural firms involved in systems building typically finds a vast increase in administration time, Bruce said. Also, he said that more of the principal's time was required in these operations to coordinate the work.

Contract Procedures

Completed projects used a great variety of contractural relationships in specific school building projects. A general contractor was always employed to coordinate the total project.
- Frequently sub contractors for system work were assigned to the General Contractor.
- On occasion the General Contract was awarded after the structural work was completed.
- On several projects the local board of education purchased construction materials and then assigned

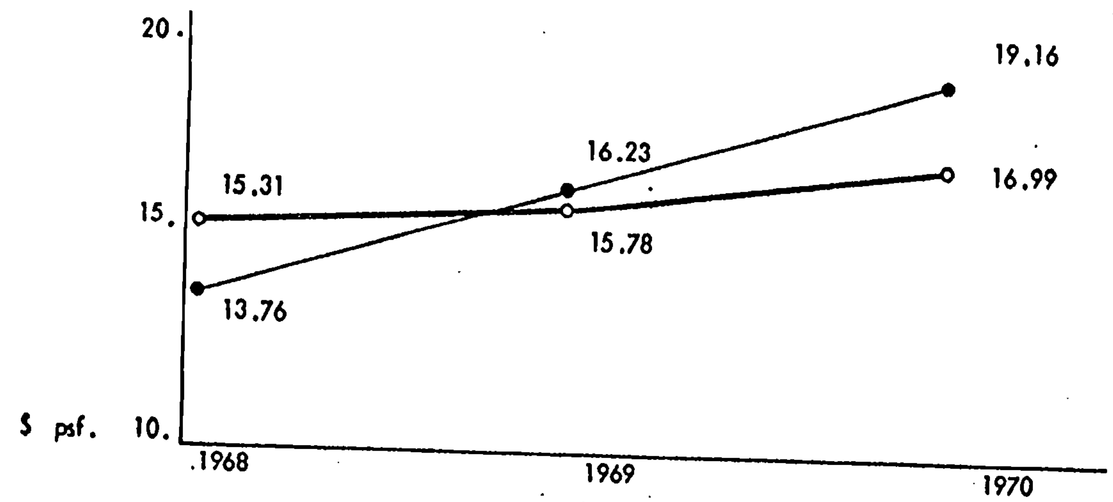
them to the general contractor to eliminate sales tax.

- Multiple contract arrangements and non traditional contractural relationships caused some difficulty and dissatisfaction.
- In later projects subsystem contractors were assigned to the General Contractor to reduce such frictions.
- Meeting conditions necessary for sales tax exemption caused some problems.

Future

Success of program projects have led to increasing use of systems building techniques by individual architects in Florida. The State Department of Education supports interested architects and communities by providing and updating performance specification; assisting in market aggregation, and scheduling.

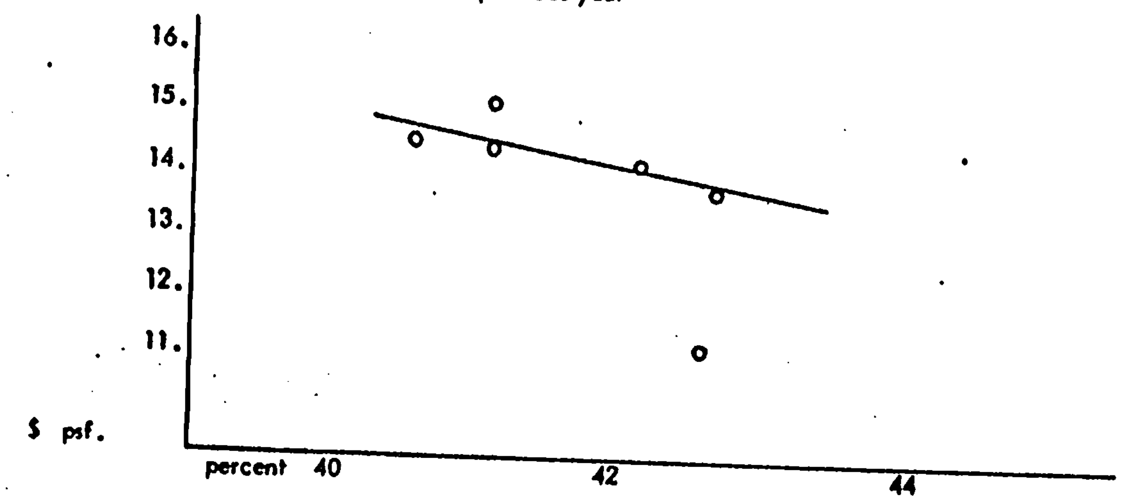
Florida SSP Program



Cost Comparison Systems vs Conventional Schools

Systems
Conventional

cost quoted are average construction costs for Florida elementary and secondary schools awarded in the previous year



Building Cost compared to % system in building cost
based on 6 similar school project bid at the same time in the same locality

note: information based on SSP project architect tabulations as of February 1971

Florida SSP Program

Construction Time Comparison

Conventional ●——●
System ○——○

26 elementary schools	● average 303 days ●
14 elementary schools	○ average 266 days ○
8 secondary schools	● average 451 days ●
8 secondary schools	○ average 281 days ○

Total Project Delivery Time

26 elementary schools	● average 478 days ●
14 elementary schools	○ average 550 days ○
8 secondary schools	● average 774 days ●
8 secondary schools	○ average 535 days ○

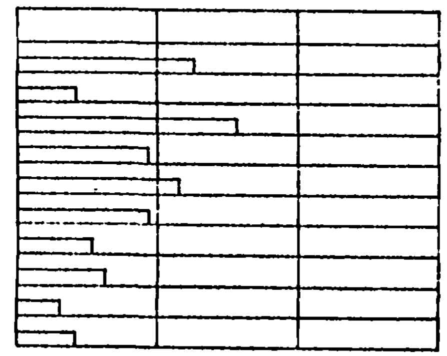
SEF
A school building system developed for Metropolitan Toronto

Percentage of total building cost accounted for by system components

Systems 78% Conventional 22%

Cost Breakdown by Subsystem

Subsystem	Cost psf. *	Percentage of Total Construction Cost
01 Site & Found.		
02 Structure	2.27	12%
03 Roofing	.72	4%
04 Atmosphere	2.92	15%
05 Lighting/Ceiling	1.67	9%
06 Interior Partitions	2.09	11%
07 Exterior Skin	1.83	9%
08 Plumbing	.98	5%
09 Electrical/Electronic	1.15	6%
10 Interior Finishes	.61	3%
11 Furnishings/Equipment	.87	4%
Total Cost of Systems	15.11	
Non System	4.27	
	19.38	



SEF Averaged Costs for 4 nominated schools (see also summary page for Roden School)

System	Name	SEF Study of Educational Facilities
	Origin	Toronto, Canada
	Used In	•Proposed for 26 schools in Canada. •10 schools to be completed by August 1971. •Interest indicated by other school boards in Canada and U.S. •11 schools completed in September 1970.
	Building Types	Schools (K through 13 level)
	$ Volume/year	Proposed by 1970, 1.4 million square feet, 26 projects (1968 cost range $22 - $24 psf and fees).
	Developer	SEF Metropolitan Toronto School Board Study of Educational Facilities 155 College St. Toronto 28, Canada
	Sponsors	•Metropolitan Toronto School Board •Educational Facilities Laboratory •Ontario Department of Education
	Manufacturers	11 subsystems: current information indicates 3 to 5 qualified bidders for each subsystem. Designated suppliers based on February 1969 authorizations by the school board are: •Structure: Anthes Steel Products, Limited, $2.10 psf. •Atmosphere: Canadian Electrical Company, Limited and ITT, $2.72 psf. •Lighting Ceiling: Johns-Manville Company, Canada, $1.55 psf. •Interior Space Division: Westeel-Rosco, Limited, $1.94 psf. •Exterior Skin: Beer-Precast-Precon Murray, Limited, $1.69 psf. •Plumbing: H. Griffiths Company, Limited, $0.91 psf. •Electrical: Industrial Electrical Contractors, $1.07 psf. •Roofing: Dean-Chandler Company, $0.66 psf.

			•Carpet: Perfection Rug Company, Limited, $0.41 psf. •Casework: Cameron McIndo Ltd.
		Patent/License	Individual Suppliers
	Organization	Planning	Selected architect (designs with known subsystems to suit specific program needs).
		Production	Selected subcontractors provide and install their subsystem to meet bid time and cost obligations.
		Erection	Selected Contractor (management of construction) will manage the work of subsystem contractors and coordinate non-system building elements.
	Development	Cost	$2.2 million (50% technical 50% educational)
		Time	Initial Study Funding 1966; first 11 buildings complete September 1970.
		Staff	24,plus consultants (now 10 on staff)
Technical	Planning Module		5' - 0" square horizontal planning grid. 10', 14', 18', and 24' clear ceiling heights.
	Expandability		3 directions (up to 5 floors)
	Site Factory		Not required
	Transport Limits		Subsystems transportable with conventional equipment.
	Foundations		Conventional to suit site conditions.
	Structure		(Note: the following technical information is based on SEF performance specifications and will be updated as more specific information becomes available) •Steel frame •Primary spans 10' to 30' @ 5' increments •Secondary plans 5' to 65' @ 5' increments •Ceiling to finished floor sandwich 4' - 0" thick. •Loadings, finishes, etc., set by performance specification.

	Span limits	Primary 30'; secondary 65'; greater spans custom fabricated in 5' - 0" thick floor sandwich.
	Max. floors	3 for first building series (capable of 5 floors by design).
Exterior walls		Concrete panels
	Insul. value	Heat (u) max. / Sound (STC) min. panels 0.15 / 27 doors 0.56 / 20 windows 0.58
Interior walls		Demountable, non load bearing, system of panels, doors and accessaries plus an operable partition unit. panel type 10', 14', 18', and 24' high accordion type 10' and 14' high
	Acoustic Insul.	STC 35 (STC 30 with door) also unrated, includes above ceiling sound stops.
	Relocatability	Caretaker relocation of 28' wall (length) in 64 man hours (rated) 32 man hours (unrated) other limits set by specification.
Flooring		Carpet selected by competitive bid.
	On Grade	Conve tional construction (concrete)
	Above Grade	System structural-mechanical sandwich
Ceiling		Hung ceiling system on 5' - 0" grid including light fixtures, and supply points for HVAC if required.
	Acoustic	35 STC room to room. 2 options on absorption: (1). 5 to .7 sabins psf @ 500 cps; (2) .15 to .35 sabins psf @ 500 cps.
Roofing		Flat surface design with drain points to limit ponding to 1" depth. All flashing and weather connection to vertical skin included.
	Insul. value	u=0.15 from underside of deck to top of roof surface

Vertical Circulation		Non System
Climate Control		System sized to 4000 sq.ft. plan area. Able to supply or return at each 5' square grid section. Heating and ventilating loads determined by occupancy and use of space.
	Heating	Annual owning cost (purchase and operate system) basis of selection.
	Cooling	To be an optional add on capability for selected unit (criteria for cooling given).
	Distribution	Preference indicated for ceiling distribution by flexibility requirements. Distribution in partition walls possible in certain locations.
Electrical		Ceiling distribution prefered for relocatability - floor distribution permitted. Quantity and relocatability specified for power outlets. Power Column proposed. Fire Alarm, clock, intercom, TV, and P.A. included.
Lighting		Included in ceiling system
	Illumination	5 use areas defined - lighting levels and maintenance factors specified, i.e. 50 fc gym, 30 fc corridors, etc.
Plumbing		Essentially conventional except proposals requested for incremental washrooms and showers to fit planning grid and be expandable.
Interchangeability of System Components		"Closed - open" system, i.e. (open competitive bidding for individual building subsystems are closed for the identified group of projects.)
Fire Resistance		Bidders to provide a variety of fire ratings for their subsystems: in general · Columns and floors - 1 and 2 hour · Partitions unrated (except hazardous locations) · Exterior Skin unrated (except hazardous locations) · 2 hour ratings required, labs and kitchens, etc. Ceiling may be part of rated assembly.

Maintenance Considerations

Owning cost a basis of selection for atmosphere subsystem. Relocatability performance a basis of partition selection criteria. Maintenance data required for many subsystems to be weighed in bid evaluations.

Evaluation

Cost Data

Anticipated cost savings based on initial bid prices were not realized in the first phase of SEF construction. The completed SEF schools are fully air conditioned, carpeted, high quality buildings that can change internally to meet changing educational requirements. Costs for the first 11 schools were essentially equal to the projected costs of lower quality conventionally constructed schools. Costs for 10 SEF schools now under construction are within budget targets and should provide lower initial costs than can be obtained with conventional construction.

Construction Time Data

Construction time for the 11 completed SEF schools averaged 10 months as compared to 15 to 18 months experience with conventional construction. The current 10 school program allows 8 months for construction.

Comments and Conclusions

The project is a serious commitment in excess of $30 million construction value which permits industry to participate in design and development of building subsystems on a competitive cost/performance basis. Emphasis on flexibility in both design and renovation recognizes the likelihood of substantial changes in educational program requirements over a building's useful life span.

The initial 26 projects shrunk to 21 by September 1970 emphasizing the challenges and difficulties of maintaining a complexbut necessary aggregated market. Quality of the SEF buildings is excellent; system components are now being used for projects in Detroit and Boston where cost and quality advantages are projected.

In the long term SEF hopes to assemble an open system where components of different manufacturer may be used interchangeability on building pro-

jects. In addition the SEF will be evaluating completed projects seeking improved components when appropriate.

Discussion with Mr. Peter Tirion, Technical Director SEF project Toronto.

Mr. Tirion noted that the 11 completed SEF Schools were more expensive than similar conventional projects. He cited the fact that SEF suppliers were paid more for their products due to a contract cost inflation escallator. At the same time the conventional construction market was squeezed by high interest rates and cancelled projects resulting in a very competitive conventional construction bid market.

Documentation of the finished project costs and verification of our summary information was obtained. Messrs Trost and Sweeney then visited completed SEF schools and phase 2 projects now under construction.

General Comments:

- EBS not related to SEF it is a consortium of some manufacturers and an architect.
- All SEF subsystems available in U.S. as demonstrated by Boston and Detroit projects.
- Development costs for SEF were approximately $2.2 million which was equally divided between educational and technical work.
- The claimed 20-25% extra value in SEF schools is documented as follows:

	cost psf.
Flexibility	
long span	.75
air cond. & control	1.00
electrical	.75
case work	.10
light ceil.	.20
General	
Plumbing	.20
Gym Flooring	.10
Gym ceiling	.25
Quality (workmanship hardware)	.25

Non System extras	
Site plumb)	
Site util)	.40
Coordination)	
	4.00
Escallation, dev. costs	1.00
	5.00
5.00/20.00 =	25%

The schools visited which were in use showed considerable exploitation of system features. SEF case work especially was used in many ingenious configurations.

All schools visited were "open plan" in accordance with findings and suggestions of SEF educational program investigations. Users of the facilities seemed enthusiastic -- the children especially immersed in learning experiences made more poignant by the quality of the facilities and programs.

Building: SEF Roden School

Location: Toronto

Function: Public school

Area (sq. ft.): 80,597

Const. Contract: $1,508,043

Completion Date: Sept. 1970

General Descriptors

Structure	Steel
No. Floors	3
Air Cond.	own source
Exterior Skin	pre cast concrete
Interior Partitions	moveable
Spl. Equipment	moveable furnishings

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	1.90	10
Structure	2.50	13
Roofing	.50	3
Atmosphere	2.80	15
Ceiling	1.70	9
Int. Partitions	2.80	15
Exterior Skin	1.70	9
Plumbing	1.10	6
Electrical	1.10	6
Int. Finishes	1.30	7
Fixed Equip.	1.30	7
Elevators		
Total	18.70*	

Total – systems 80%

Other Cost Information

Architects Fee Rate	SEF staff
Moveable Equipment	Included
Labor/Materials Breakdown	

Time Information

	no. months	date
Preliminary Study		
Architectural Contract		
Construction Contract		
Occupy		

* note: Total cost does not include cost escallation of 8.5% which applied to this school. Costs for non system work are estimated.

Sources: SEF project cost summary and pre construction cost projection.

RAS
A building system developed by the Catholic School Commission, Montreal, Canada

Percentage of total building cost accounted for by system components

Systems 40% Conventional 60%

Cost Breakdown by Subsystem

Subsystem	Bid Price*	Percentage of Total Construction Cost
01 Structure	8.6	21.3%
02 Roofing		
03 Atmosphere	2.7	
04 Lighting/Ceiling	1.5	6.7%
05 Interior Partitions	1.7	3.8%
06 Exterior Skin		4.2%
07 Plumbing		
08 Electrical/Electronic	1.6	
09 Interior Finishes		4.0%
10 Furnishings/Equipment		
Total Cost million $	40.0	
System Cost million $	16.1	

* information source BSIC Newsletter, Spring 1969

System	Name		RAS (Research in Educational Facilities)
	Origin		Montreal, Canada
	Used In		8 School projects (1,500,000 sq. ft. and $30 million) are to be completed by 1976. A potential of 75 schools in the next decade are anticipated. To date a prototype has been completed and bids taken on a pilot school.
	Building Types		Schools
	$ Volume/year		$7 - 8 million planned
	Developer		IRNES, Inc. (M. Gaetan J. Cote, IRNES, Inc., Quebec.)
	Sponsor		Montreal Catholic School Commission Educational Facilities Laboratories
	Manufacturer		Structural - Francan, Ltd. HVAC - Lennox Ind. of Canada Ceiling/Lighting - Electrolier Internal Space Subdivision - B.K. Johl Electric Distribution System - Bedard-Givard
		Patent/License	Held by individual manufacturers
	Organization	Planning	Selected Architect
		Production	Selected Manufacturers
		Erection	Selected Contractor
	Development	Cost	Research contract for development work approximately $1 million
		Time	Program undertaken January 1967. Mock up completed Spring 1970. Pilot school to begin construction Spring 1971.
		Staff	12 with IRNES, plus outside consultants.
Technical	Planning Module		Horizontal 22'

Expandability		Three dimensional (max. vert. to 3)
Site Factory		Not req'd.
Transport Limits		
Foundations		Conventional
Structure		• A precast concrete subsystem based on an assembly of two elements. • A precast portal frame, one story in height with a span of 20 or 10 feet. • Horizontal spanning elements, precast double double or single tees, frames into these portals • Adjacent assemblies share a common portal frame to insure structural continuity. • Maximum clear height is 30'8". • Service sandwich thickness is 48".
	Span limits	10' or 20' portal frames Right angles spans of 60' are possible using long span concrete tees.
	Max. floors	Three
Exterior walls		Not included in the system components
	Insul. value	See above
Interior walls		• A 1 hour rated steel faced partition; • Face to face thickness 2 1/4". • Various finishes available including floor to ceiling chalkboard. • Window and door panels interchangeable with solid panels.
	Acoustic Insul.	STC 40
	Relocatability	Either face may be removed and replaced without taking down the wall.
Flooring		Conventional

Ceiling

The Electrolier system is a suspended ceiling of five foot flourescent fixtures special units are provided for use with the electrical distribution column, and a 40" by 60" lighting unit is also available for special conditions.

Acoustic

Roofing

Conventional

Insul. value

Not applicable

Vertical Circulation

Not included

Climate Control

- Air treatment units are housed in pairs. Each pair occupying a mechanical room 20'0" x 20'0".
- Each room with its two units serves approximately 16,000 sq. ft.
- In a multi-story building, these rooms will be placed one above the other.
- Each ventilation unit, controls included, is assembled in the plant.
- The central unit is shipped in one piece, the humidifier and return fan are shipped separately.

Distribution

The distribution of treated air to the zones is through a multi-zone mixing box arrangement similar to the unit used in the SCSD program. The treated air is supplied to the zones in ducts which lie on a 10 foot grid. At the ceiling grid line intersections a junction box is connected to the duct by an 8" or 10" diameter connector. Each supply diffuser consists of three metal pieces which are fitted into the slot between adjacent lighting/ceiling units. Four diffuser units extend in a cross pattern about two feet along each slot from the junction box. Return air is through the space above the ceiling, collectors are fitted between the lighting/ceiling units.

Electrical

The Bedard-Givard system is based on an electrical column which is coordinated with the partition subsystem. It may be part of a partition, free standing, or against the face of a partition. To

insure a compatible appearance the column will be finished by the partition contractor. The column is 4" x 20" x 9'-10" and provides the following services:

1. Low voltage switching circuits for lighting
2. 120 volt electrical supply
3. Intercom
4. Synchronized clocks
5. Television distribution
6. Space in which to accommodate future service needs.

Structurally the columns plug into the ceiling runners; electrically they plug into color coded "extension cords" which run through the ceiling sandwich to primary electrical junction boxes. Service to these boxes through traditional wiring in conduits.

Lighting

- Five foot by five foot units containing flourescent fixtures.
- A 40" by 60" unit is available for special conceptions.

Illumination

Plumbing

Conventional

Interchangeability of System Components

After bidding, components are limited to those of selected manufacturers.

Fire Resistance

Montreal Fire Codes specify:

- Four hour column protection.
- Three hour floor (sandwich) protection.
- RAS had to meet these specifications which is the main reason for using concrete. The internal partitions meet 1 hour ratings.

Evaluation — **Cost Data**

Re-negotiation of sub system bids and the single bidding of one school had an unfavorable effect on project costs. The St. Fabien school bids of $17.40 psf. were 11% over estimates. Lower costs are anticipated as more projects are released but costs significantly lower than comparable

conventional construction are not likely. RAS supporters stipulate that their building has more to offer than a conventional one in terms of flexibility, finish quality etc. but lower initial cost is not one of its advantages.

note: Subsystem costs were adjusted by IRNES to reflect owning cost factors for each subsystem. The concrete structural system was selected though it did not have the lowest initial cost, in that it was a part of the lowest integrated bid for all subsystems. Bids taken on the Pilot School project did not reflect anticipated cost savings.

Construction Time Data

Data is not yet available on completed projects. RAS is estimating construction time similar to conventional experience which is 10 to 12 months for construction of an elementary school in Montreal.

Comments and Conclusions

The RAS system is significant in that it included on evaluation method which considered long term owning costs for subsystems. Subsystems were selected on the basis of total unit price; satisfaction of project performance specifications, and the annual costs of owning, operating, and maintenance. Many manufacturers submitted proposals and on paper there were1200 potential manufacturers combinations for building use; however, 11 combinations were found to be "compatible." (note: SEF in Toronto identified 13,000 compatible building subsystems from a possible 184,000 combinations.)

The initial market of 3 million square feet slipped 50% during the project development period illustrating again the difficulty of maintaining and coordinating a market aggregation program during a long development effort. The project timetable also appears to have slipped about 1 year.

Comparison of actual RAS costs to building costs of more usual steel framed construction will be of interest. The new electrical/electronic distribution system is the most innovative concept developed in the study and offers greater opportunity for flexible space use than most previous building system applications.

RAS project progress was reviewed in Montreal with Mr. Henri Branchoud Chairman of the RAS committee. Our study data was revised as appropriate and the following is a brief summary of the general discussion items.

- The initial 3 million square feet of construction planned under RAS has been reduced to 1.5 million square feet (approx. value $28.5 million). The reduction resulted from manufacturer, labor and political pressure which challenged project development decisions frequently. As a result RAS did not execute contracts with selected system suppliers within the bid acceptence period and prices had to be re-negotiated.

- During price negotiation a separate bid for the first RAS school was requested. Costs for the single project were higher than anticipated.

- Failure to meet estimated costs on the initial project has led to increased criticism of the RAS concept in spite of the fact that the project is not based on single project bidding.

- The RAS contract cost escallation clause ("price revision clause') involves the application of an escallotion equation to all factors (labor, materials, taxes, etc.) included in a sub-system supplier's price. Thus suppliers are freed from a lump sum commitment over 4 years, and the client is protected from arbitrary cost escallation based on generalized economic indicators. The price revision formula is sensitive to price fluctuotions in either direction, that is, it is not based on an assumption of continuing inflation.

- Contracts have been awarded for the first RAS school. Construction will begin in May 1971.

- The Montreal Catholic School Commission has been pleased with the results of a program in which they guarantee rental of a school for 3 or 5 years. A developer then builds the school to Commission specifications - to date all leases have been renewed.

- The Commission is considering the possibility of retaining packages builders (i.e. EBS) to design and build future schools.

- The Commission is not thinking about applications of RAS to college facilities until present goals are realized, although they believe it would work for such buildings.

- At the conclusion of our discussions Trost and Sweeney visited the Franson Co. plant and the RAS prototype.

Building: RAS system (1st school)

Location: Montreal Canada

Function: School Building

Area (sq. ft.): 58,815

Const. Contract: 1,022,493

Completion Date: Dec. 71 (est.)

General Descriptors

Structure	concrete	Exterior Skin	masonry
No. Floors	2 (est.)	Interior Partitions	moveable
Air Cond.	own source	Spl. Equipment	-

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	1.20	07
Structure	4.00	23
Roofing	.70	04
Atmosphere	3.00	17
Ceiling	.70	04
Int. Partitions	.50	03
Exterior Skin	1.90	11
Plumbing	.90	05
Electrical	1.90	11
Int. Finishes	2.60	15
Fixed Equip.		
Elevators		
Total	17.40	

Other Cost Information
- Architects Fee Rate
- Moveable Equipment
- Labor/Materials Breakdown

Time Information

	no. months	date
Preliminary Study		
Architectural Contract		
Construction Contract		
Occupy		

Sources: RAS project bids (single school, St. Fabien)

Building: RAS system (typical school)

Location: Montreal Canada

Function: School Buildings

Area (sq. ft.): 62,635

Const. Contract: 973,650 *

Completion Date: varies 72-75

General Descriptors

Structure	concrete	Exterior Skin	masonry
No. Floors	1 - 3.	Interior Partitions	moveable
Air Cond.	own source	Spl. Equipment	-

Cost Breakdown (construction)

	$psf	percent of total
Site & Found.	1.10	07
Structure	3.70	24
Roofing	.30	02
Atmosphere	2.80	18
Ceiling	.60	04
Int. Partitions	.50	03
Exterior Skin	1.60	10
Plumbing	.90	06
Electrical	1.85	12
Int. Finishes	2.20	14
Fixed Equip.		
Elevators		
Total	15.55	

Other Cost Information
- Architects Fee Rate
- Moveable Equipment
- Labor/Materials Breakdown

Time Information

	no. months	date
Preliminary Study		
Architectural Contract		
Construction Contract		
Occupy		

Sources: RAS project cost estimate* for anticipated future project.

System	Name		Zachry monolythic box system
	Origin		San Antonio, Texas
	Used In		Palacio Del Rio-Hilton (500 room hotel) Richard Allen Villa (Housing Project)
	Building Types		Motels, Hotels, Apartments, Hospitals, Housing
	$ Volume/year		The Palacio Del Rio was completed in 202 days (approximately $11,000,000 in 1967). Zachry plans to produce and sell 1,000 living units per year including new single family units which will go on sale in January 1971 for approximately $13,000 (including land).
	Developer		H.B. Zachry Corporation San Antonio, Texas
	Sponsor		Same
	Manufacturer		Same
		Patent/License	Potent on forms and process. Available on a royalty basis.
	Organization	Planning	Selected Architect
		Production	H.B. Zachry Corporation
		Erection	H.B. Zachry Corporation
	Development		
Technical	Planning Module		Based on concrete boxes Vertical - 10' Horizontal - 14' x 30' $\pm$
			note: technical evaluation is based on the 1967 hotel construction project unless otherwise noted.
	Expandability		Three dimensional
	Site Factory		Will be necessary in those states where the maximum transport width is less than 14'.

Site Equipment		Crane required minimum 40 - 50 ton capacity
Transport Limits		The corporation claims a transportation radius of up to 300 miles, but actually have only moved the units in San Antonio (up to 7 miles).
Foundations		Conventional for hotels and motels, a precast floor slab will be utilized for their new single family dwellings.
Structure		Consists of stacked concrete boxes, 14' x 30' x 10'. Made of 110 lb./cu. ft. concrete. Concrete thickness 5" typical in walls.
	Span limits	The 14' box width is established by transport requirements not a structural maximum. In project requiring longer clear span areas alternate structural systems are used.
	Max. floors	Building heights of 20 stories or more are possible
Exterior walls		5" concrete. In the new housing units walls will contain insulating cores.
	Insul. value	U factor of .186 in proposed housing units.
Interior walls		In the hotel interior partitions were conventional In the newer housing projects the interior walls are factory cast with the roof and exterior walls.
	Acoustic Insul.	Excellent transmission characteristics
	Relocatability	Walls are not designed for relocation
Flooring		Concrete; finish is wall to wall carpet.
Ceiling		Concrete; finish is a water base textured paint.
	Acoustic	Excellent transmission characteristics.
Roofing		The roof is precast as part of the box. Hotel roofing is conventional. Roofing for housing units are insulated and roofed with conventional materials.
	Insul. value	U Factor of .186 with internal insulation

	Vertical Circulation	Conventional
	Climate Control	A complete heating/cooling unit is installed in each space module at the factory. On large projects such as the hotel conventional methods must be used for hallways, etc.
	Distribution	Forced air from heating AC unit. Conventional for hallways, etc.
	Electrical	All electrical installation is done in the factory. Conduits are placed in the forms prior to pouring the concrete.
	Lighting	Conventionally fixtures installed at the factory.
	Plumbing	A chase space between stacked boxes accommodates plumbing distribution in the hotel. More recent projects use a preplumbed chase within individual boxes.
	Interchangeability of System Components	Permanent Construction Not designed for flexibility
	Fire Resistance	The 5" thick concrete enclasure should satisfy 2 hour fire rating requirements.
	Maintenance Considerations	The concrete enclosure is relatively indestructible.
Evaluation	Cost Data	The Palacio Del Rio-Hilton was constructed for a cost of approximately $11 million in 1967 ($28-$30 psf). The exact allocation of costs to overtime work, equipment write-off and furnishings are difficult to determine. If the projected single family housing unit cost is $13 psf in 1971 is realized it will permit more meaningful cost analysis.
	Construction Time Data	The hotel was constructed in 202 days (however 3 shifts were used making the project in effect a 2 year effort). Real construction time advantages do exist in the factory fabrication and [illegible] demand on order quantity and yard capacity.

Comments and Conclusions	The Zachry process of maximum plant fabrication and finishing results in efficient use of time and labor resources. Production control of labor costs assembly time and quality are real advantages of the system that can lead to time and cost savings for users. The only serious drawback of the Zachry modules is transport limits which set maximum unit size and establish an area of availability.
	The modules appear appropriate for College and University dormitories at the present time. The 14' span in one direction makes them unsuitable for many academic buildings unless the basic box units are used in combination with long span floor and ceiling components.

GSSC
A building program for Georgia schools

Percentage of total building cost accounted for by system components

System 49% | Conventional 51%

Cost Breakdown by Subsystem

Subsystem	Cost psf.*	Percentage of Total Construction Cost
01 Structure	1.29	5.6%
02 Roofing	.83	3.8%
03 Atmosphere	3.44	15.7%
04 Lighting/Ceiling	1.17	5.5%
05 Interior Partitions		
06 Exterior Skin	4.02	18.4%
07 Plumbing		
08 Electrical/Electronic		
09 Interior Finishes		
10 Furnishing/Equipment		

Total Cost $ 21.95
Systems Cost $ 10.75

* information source BSIC Newsletter, June 30, 1970

Building: Merrick N.Y. School Additions (3)
Area (sq. ft.): 24,942

Location: Long Island N.Y.
Const. Contract: $930,231

Function: Elementary School Additions
Completion Date: Nov. 70 (1) Jan. 71 (2)

General Descriptors

Structure Steel
No. Floors 1
Air Cond. own source

Exterior Skin brick
Interior Partitions moveable partitions
Spl. Equipment -

Cost Breakdown (construction)	$psf	percent of total
Site & Found.		
Structure	1.88	07
Roofing	1.06	04
Atmosphere	3.40	12
Ceiling/lighting	1.96	07
Int. Partitions		
Exterior Skin		
Plumbing		
Electrical		
Int. Finishes		
Fixed Equip.		
Elevators		
Total	27.50 *	

Other Cost Information

Architects Fee Rate
Moveable Equipment
Labor/Materials Breakdown

Time Information

	no. months	date
Preliminary Study		
Architectural Contract)		11.69
Construction Contract)	12 & 15	01.70 (pre bid syst.)
Occupy)		11.70 & 01.70

* Total project costs include renovation and site work 27.50 figure represents approx. cost of new construction only.

Sources: Architects records (CRS)

Building: Industrial School
Location: Ohio
Function: Bell & Howell Co. Training Center

Area (sq. ft.): 45,250
Const. Contract: $830,000
Completion Date: Sept. 71 (est.)

General Descriptors

Structure	steel	Exterior Skin	
No. Floors	1	Interior Partitions	moveable partitions
Air Cond.	own unit	Spl. Equipment	

Cost Breakdown (construction)	$psf *	percent of total
Site & Found.		
Structure	1.46	08
Roofing		
Atmosphere	3.87	21
Ceiling	1.73	09
Int. Partitions	.60	03
Exterior Skin		
Plumbing		
Electrical		
Int. Finishes	1.37 (carpet)	05
Fixed Equip.		
Elevators		
Total	18.30	

Other Cost Information
Architects Fee Rate
Moveable Equipment
Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		
Architectural Contract)		01.71
Construction Contract)	9 total	03.71
Occupy)		09.71

* costs are prebids for building subsystems

Sources: Architects records (CRS)

Building: Industrial School
Location: Arizona
Function: Bell & Howell Co. Training Center

Area (sq. ft.): 67,000
Const. Contract: $1,160,000
Completion Date: Sept. 71 (est.)

General Descriptors

Structure	steel	Exterior Skin	
No. Floors	1	Interior Partitions	moveable partitions
Air Cond.	own unit	Spl. Equipment	

Cost Breakdown (construction)	$psf *	percent of total
Site & Found.		
Structure	2.01	12
Roofing		
Atmosphere	2.91	17
Ceiling	1.66	10
Int. Partitions	.68	04
Exterior Skin		
Plumbing		
Electrical		
Int. Finishes	1.13 (carpet)	05
Fixed Equip.		
Elevators		
Total	17.30	

Other Cost Information
Architects Fee Rate
Moveable Equipment
Labor/Materials Breakdown

Time Information	no. months	date
Preliminary Study		
Architectural Contract)		01.71
Construction Contract)	9 total	03.71
Occupy)		09.71

* costs are prebids for building sub systems

Sources: Architects Records (CRS)

Building:	6 Prototype ward buildings	Area (sq. ft.):	133, 440
Location:	Austin State Hospital (4) and Rusk State Hospital (2)	Const. Contract:	May 71 (est.)
Function:	Patient wards - Texas Department of MH/MR	Completion Date:	Mar 72 (est.)

General Descriptors

Structure	Steel	Exterior Skin	brick
No. Floors	1	Interior Partitions	dry wall
Air Cond.	own source	Spl. Equipment	-

Cost Breakdown (construction)	$psf	percent of total *
Site & Found.		
Structure	1.40	8
Roofing		
Atmosphere	3.00	17
Ceiling		
Int. Partitions		
Exterior Skin		
Plumbing		
Electrical		
Int. Finishes		
Fixed Equip.		
Elevators		
Total		

Other Cost Information
- Architects Fee Rate
- Moveable Equipment
- Labor/Materials Breakdown

Time Information

	no. months	date
Preliminary Study	14	02.69
Architectural Contract	13	04.70
Construction Contract	10	04.71
Occupy		

General Comments

Subsystems were bid on a performance specification basis. Competition and costs for the selected subsystems are considered favorable.

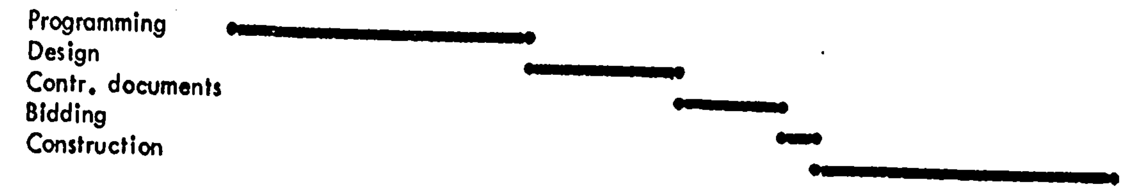
* Percentage of total is estimated.

Sources: MH/MR project records.

Project Scheduling Methods

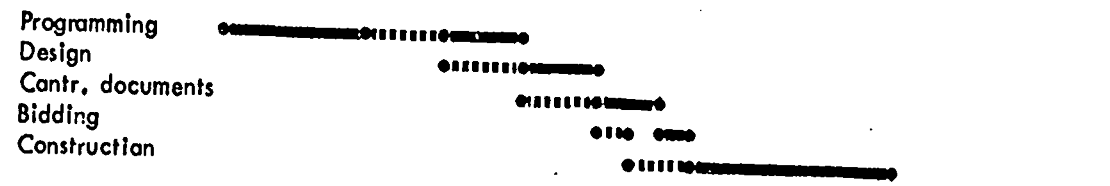
Sequential

A linear schedule typically employed in conventional construction.



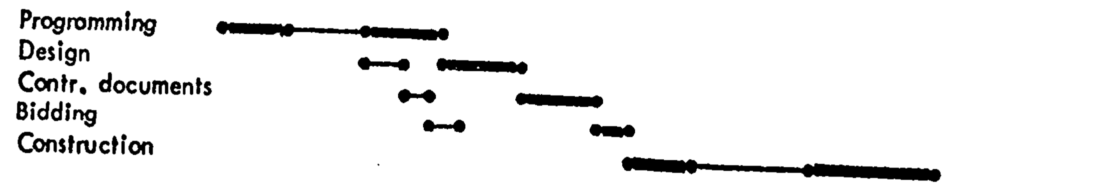
Overlapping

A compressed schedule where design, development, and construction activities are conducted simultaneously to reduce project time.



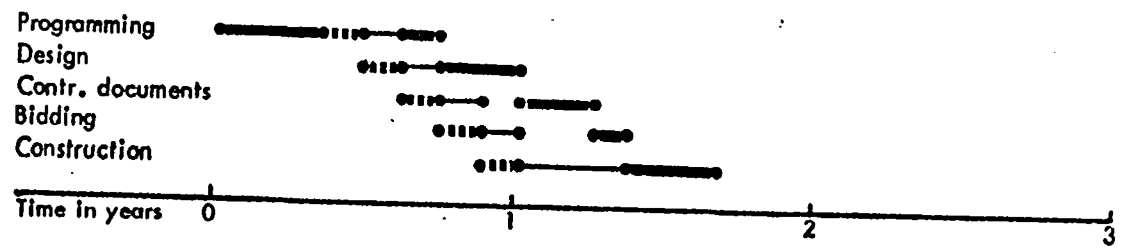
Building Systems

A method employing selected building components to reduce construction time.



Integrated

A method employing simultaneous activities scheduling and building systems to minimize project time.



Key:
- Development, conventional methods
- Development, overlapping activities
- Development, building subsystems

* Information source: Fast Track, C R S, Nov. 1969; BSIC Research Report # 1, Fall 1970

Appendix A-3
Utilization

Population Projections

United States (population and school enrollments in millions)

	Population	Element	H.S.	College
1950	151	21	6.6	2.2
1960	179	32	10.2	3.6
1970	206	36	15.0	7.0
1980e	243	40	15.7	11.1
1985e	264	48	17.3	11.8

United States (population/distribution by age groups in millions)

	Age 5 - 17	Age 18 - 24
1970	53	24
1980e	57	29
1985e	65.5	28

Texas (population and distribution by age groups in millions)

	Population	Age 5 - 13	Age 14 - 17	Age 18 - 24
1970	11.0*	2.1	0.9	1.4
1980	13.1*	2.4	0.9	1.7
1985e	14.1*	2.8	1.0	1.7

Source: U.S. Department of Commerce IB projections P-25-375 1967;
* corrected to reflect 1970 preliminary census figures or actual enrollments where available

Texas Enrollments (in thousands)

	Public	Private	Total
1970	350e	77e	427
1980e	620	88	708
1985e			

(Source: 1969 Coordinating Board Report, Challenge of Excellence)

Headcount Enrollment

Texas Public Junior Colleges

Fall 1968	86,913
Spring 1969	79,905
Summer 1969	44,330

Texas Public Senior Colleges

Fall 1968	212,162
Spring 1969	200,927
Summer 1969	94,215

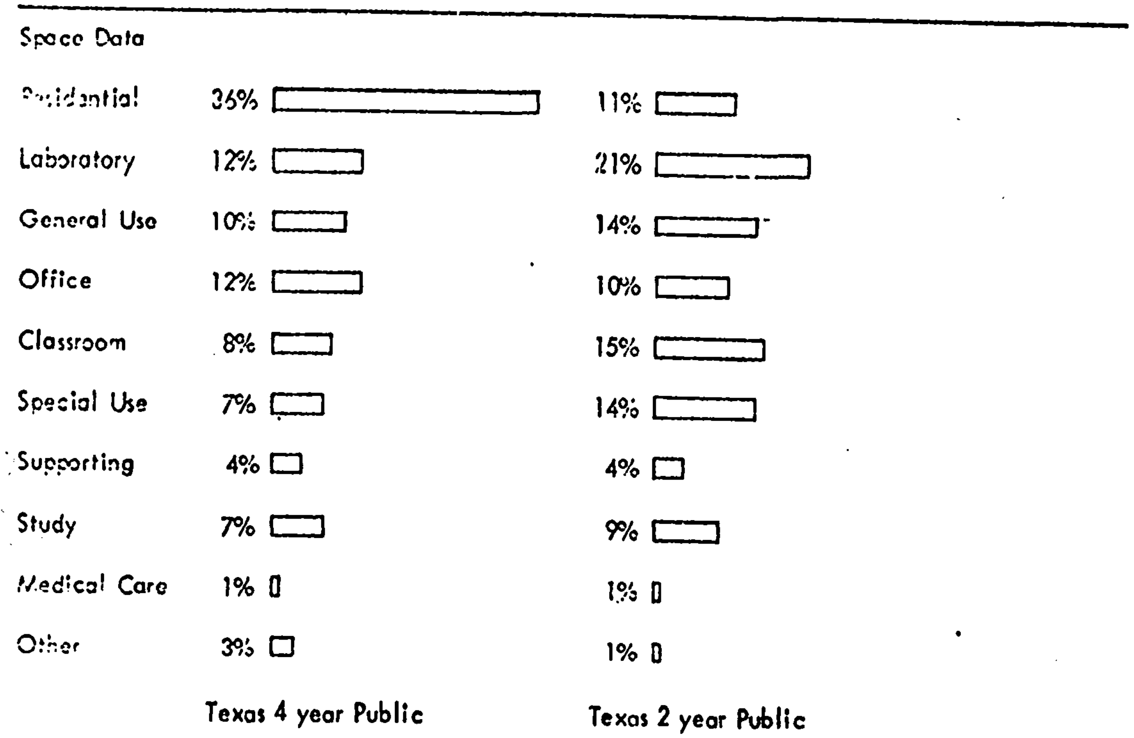
(Source: 1968 – 1969 Coordinating Board Tabulation Sheets)

Campus space analysis by Function

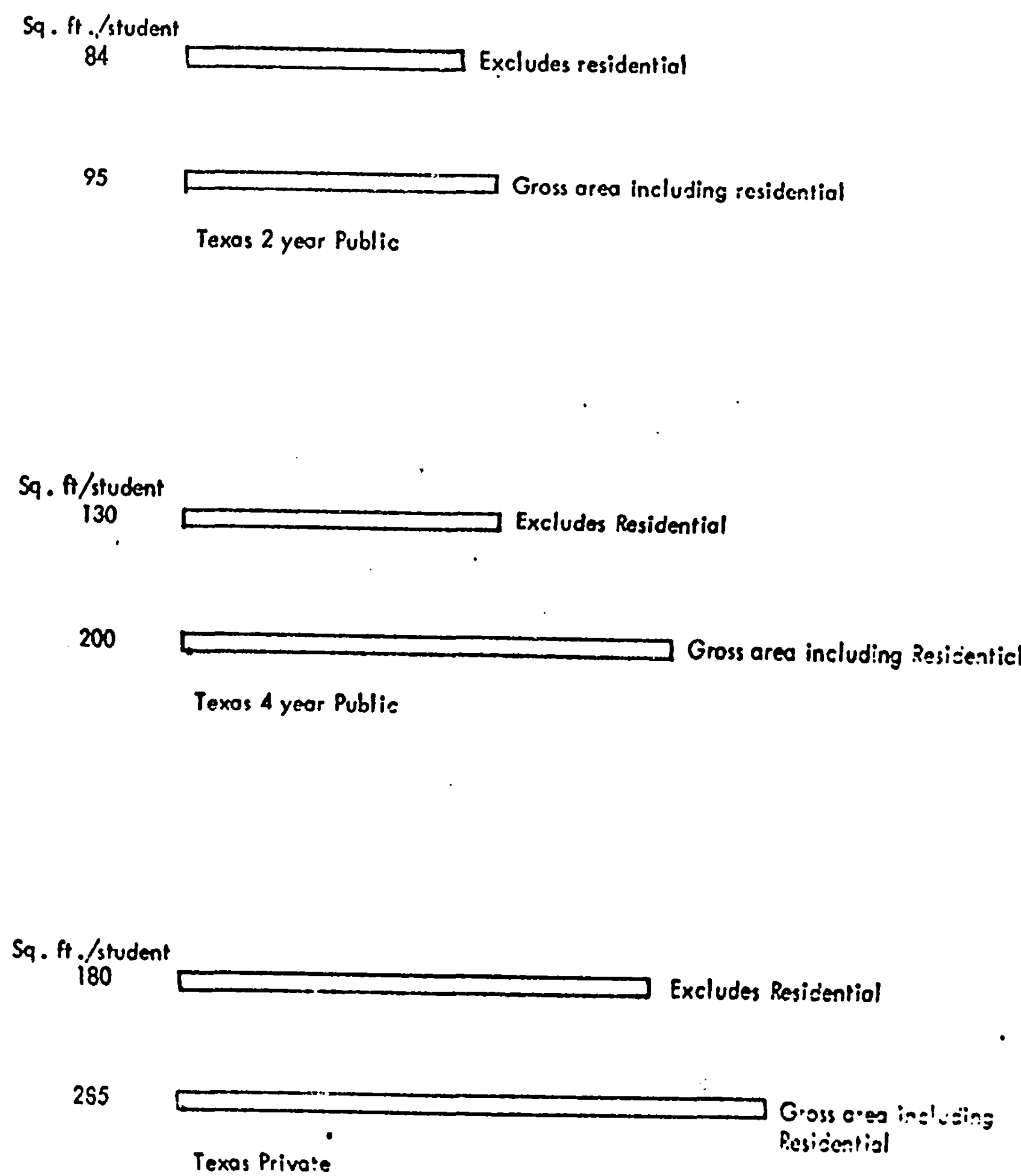
	Texas Public	National Public
Residential	32%	28%
Laboratory	14%	16%
General Use	11%	12%
Office	11%	12%
Classroom	9%	9%
Special Use	8%	9%
Supporting	4%	7%
Study	7%	6%
Medical Care	1%	1%
Other	3%	

	Texas Private	National Private
Residential	37%	34%
Laboratory	9%	10%
General Use	12%	16%
Office	9%	10%
Classroom	8%	9%
Special Use	6%	7%
Supporting	4%	6%
Study	8%	7%
Medical Care		1%
Other	7%	

(Source: Facilities Inventory Summary Report, Fall 1969)



Campus Space Analysis
Area per student
Enrollment date, Fall 1969



Classroom space utilization guidelines

75% of assumed 40 hour week scheduled for use

50% of available student spaces occupied

In total 38% of the available classroom capacity is utilized

Laboratory space utilization sample

50%/week — maximum possible 40 hours/week

60% station utilization — 100% station utilization

30% laboratory capacity is utilized — 100 % efficient

* note: sample may apply to basic lab courses where 40 hours/week scheduling is possible. More advanced laboratory work requiring special equipment and clean up will not be used this intensively.

Source: (Coordinating Board, Guidelines for Planning in colleges and universities by TAMU, July 1968)

Financing Considerations

Decreasing purchasing power of the dollar, and the resultant increasing cost of borrowed money lead to substantially increased construction costs. Studies show that the construction dollar's purchasing power has dropped 32% since 1960 (i.e. the current dollar will buy 0.68 cents value of 1960 construction) and projected increases in labor and material costs indicate the rate of value loss in construction will continue in spite of current governmental attempts to reduce inflation.

Public institutions have traditionally obtained funds for new construction through bond issues. The interest rate on such bonds has been significantly lower than private money market rates due to the tax free treatment of municipal bond income. (The cost of bond funds, of course, also reflects the security of the funded investment based on the ability of the borrowing institution to repay principal and interest). An anticipated decrease in the value of the dollar results in an increase in the cost of money borrowed for future repayment. While the construction dollars' value has dropped 32% over the last 10 years, the cost of borrowed funds has increased 100% in the past 5 years. Municipal bond rates increased only gradually until 1965 when their average rate of return was 3.3%. By 1970 the average municipal bond yield had increased to 6.6%. This increase on a 1 million dollar construction program financed over 10 years would increase the total interest cost to a borrowing institution from $330,000 to $660,000; an increase of 25% for the total project costs.

The interest rates for interim construction funds have also increased rapidly in recent years. The cost of these private funds borrowed by contractors to finance a construction program are of course included in a contractors project bid. Since interum fund rates are frequently double municipal interest costs on institution looses some of the benefits of its ability to borrow money at lower rates.

Sources:
Engineering News Record, 1970, 2nd Cost Summary
Moodys Bond Survey, 1967
DJ. 20 Year Bond Averages
Wall Street Journal Report, 27 October 1970

Note:
Texas College & University fund bonds backed by Permanent University Fund rated A aa; by advelorem tax rated A.

Appendix A-4
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Appendix A-5
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