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ABSTRACT

This report, the third in a series which presents the results of a systems analysis of the problem of providing science and engineering buildings at the university level, is a technical manual for using the Academic Building Systems (ABS) approach in programing, designing, and constructing such facilities. The document presents (1) planning concepts, procedures, and cost/performance control; and (2) one section each on the five ABS subsystems (structure, HVAC, lighting/ceiling, partitions, and utility distribution), their relation to non-ABS subsystems, and the two ABS demonstration projects. Each subsystem description includes performance, design, and construction characteristics. Many diagrams, tables, and figures illustrate the text. Related documents are EA 003 886 and EA 003 888. (Author)

information manual ABS

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procedures
planning concepts
subsystems

EA 003 987

ACADEMIC BUILDING SYSTEMS

A Joint Effort of
Indiana University and the University of California
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States of Indiana and California
and by
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July 1971

PREFACE

Many aspects of building performance are not determined by any one characteristic but depend on a high degree of coordination among building concepts, components and procedures. Hertofore, there has been no concerted appraisal of these factors. Certainly, widespread interest in the concept of building systems is evidence of a clear need for a more rational approach to design and construction. The idea that a building is a collection of systems—a structural system, a mechanical system, an electrical system, and so on—is not new. What has evolved more recently is the conceptualization of the total building process as a system.

Conclusions and design criteria in this manual are the result of detailed analytical studies aimed at providing a comprehensive system for developing economical and adaptable academic facilities. The systems approach—a strategy of problem examination, definition and solution whereby the interaction among elements is analyzed in terms of an immediate problem and its larger content—was used. Traditional methods of independent or ad hoc treatment of various building factors were specifically avoided. Building performance characteristics, costs, user activities, adaptability, development time and interrelated environmental conditions were all important areas for research. A recurrent theme in all stages of ABS research and development was the relationship of building performance to cost.

To determine performance requirements for the ABS system, university faculty, staff and students who occupy existing facilities were interviewed in depth. In addition, a series of background studies explored academic methods for trends that would indicate a different emphasis in the way academic buildings may have to meet the needs of future users. Detailed analyses of major buildings measured existing levels of performance and cost. The main strength of the ABS system lies in the connection between these studies of user requirements and cost/performance characteristics.

Typically, system analysis is effective in problem definition and resolution; however, the traditional skills of design professionals are still needed to respond imaginatively to non-explicit environmental needs. During the analytical phase wherein the ABS system relationships were developed, the major subsystems in academic buildings were "uncoupled," that is, clearly separated from the rest of the building to establish radically simplified interface conditions. With these conditions established, aministrators, design professionals, manufacturers and contractors can deal with manageable increments of the total building problem on their own terms.

The procedures, planning concepts and subsystems presented in this manual should be viewed as an on-going program rather than terminating here. New performance requirements will evolve as the activities within buildings change. Better building products are constantly being developed and marketed by industry. More efficient building techniques will be periodically introduced. An evaluation of ABS in its early stages of use will perhaps reveal unanticipated problems that will need to be eliminated in subsequent applications.

The maximum benefits from ABS lie in the years ahead. From practical feedback on initial installations and from in-place performance evaluations by many people over a series of building projects, refinements and enlargements of the ABS system will evolve. The information in this manual provides a coordinated system for developing academic buildings; it also provides the base for an evolutionary academic building system program on a nationwide basis.

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Section

A. INTRODUCTION TO ABS

A.1 BACKGROUND

Academic buildings for institutions of higher education are becoming increasingly complex and costly to build and maintain. Many facilities attain early obsolescence as technology, teaching methods and subject emphasis, as well as university size and organization, continually change. Conventional scheduling of programming, design and construction requires several years from a building's inception to its occupancy. During this period, new academic programs can be accommodated only by time-consuming plan revisions and costly construction change orders. Problems of obtaining adequate capital funding in the face of diminishing resources are compounded by the continually escalating cost of construction.

When changing programs require building modification, after a building has been occupied, alterations are disruptive, time consuming and expensive. Records show that, over the years, the cost of alterations for the conventional science or engineering building substantially exceeds the initial construction cost of these buildings.

The Academic Building Systems (ABS) program was developed to provide a more economical response to problems in accommodating change than was available through conventional approaches. In the ABS approach, adaptability, to permit changes in less time at lower cost and with minimum disruption to building occupants, is the most critical aspect of building performance.

A.2 ABS SPONSORS AND PARTICIPANTS

A.2.1 The ABS program is a joint effort of the University of California and Indiana University, pioneering the system approach to the construction of academic buildings. Following the initial experimental building system program for student housing (URBS), the University of California commenced the ABS program in 1968. Indiana University's active participation began with funding in 1969.

A.2.2 Financial support came from the States of California and Indiana, Educational Facilities Laboratories, Inc., the Office of Education and the Facilities Engineering and Construction Agency of the U.S. Department of Health, Education, and Welfare.

A.2.3 The two universities engaged the firm of Building Systems Development, Inc., San Francisco, as prime consultant for the ABS program.

A.2.4 Preliminary planning of the first ABS demonstration building commenced in late 1970. This building is the Science-Engineering-Technology (SET) Building for the joint Indiana University/Purdue University campus at Indianapolis. Construction is scheduled for late 1971.

A.2.5 In late 1970, the Illinois Building Authority proposed to use ABS at the University of Southern Illinois and to extend application of the ABS system to library facilities at the University of Illinois. (This effort, however, is postponed because of severe cutbacks in capital appropriations.)

A.2.6 In early 1971, an appraisal of ABS' applicability to the basic and clinical sciences building for the new medical school at the Davis campus was made for the University of California by Architects Stone, Marraccini & Patterson of San Francisco.

A.3 SCOPE OF ABS

A.3.1 ABS is a system of coordinated *planning concepts, procedures and building components*. The system responds to the need of higher educational institutions for academic buildings that permit reduced time between inception and occupancy, are more efficient and effective in use, are far more adaptable to change, and have a substantially lower life cost.

ABS was developed for those spaces required in the sciences and engineering disciplines—the teaching and research laboratories, shops, classrooms, and offices. These space types are typical of many academic buildings. Preliminary investigation indicates ABS' applicability to a wide variety of academic facilities.

A.3.2 ABS is the result of coordinating many factors involved in programming, designing, and constructing academic buildings. All factors are directly related to cost/performance benefits.

A.3.3 The ABS system may be used *in toto*, or parts thereof may be extracted and applied independently as is deemed appropriate for a specific project. However, the maximum cost/performance benefits will be derived from full use of the ABS procedures, planning concepts and subsystems.

A.3.4 In using ABS, the owner and his design professional can decide whether to accept the highest levels of performance within a given budget or given levels of performance at the lowest cost. ABS establishes the cost/performance ranges for such choice. Decisions affecting building performance, quality, and cost are made locally.

A.3.5 ABS is easily adaptable to the local requirements of different climates, geography and preferences. All methods and building materials involved in ABS are non-proprietary and readily available from national markets.

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A.4 ABS PLANNING CONCEPTS

A.4.1 Academic buildings differ tremendously in size, organization and spatial relationships, and requirements for services and program adaptability. ABS responds to these requirements by providing generalized academic spaces permitting a range of choices in initial building configurations and rapid, economical alterations over time. This design concept, adopted by ABS, is that of the *Non-Specific Building.*

A.4.2 The concept of the non-specific building is, as the name implies, to provide generalized space that can accommodate a wide range of activities and functions at any one time, with options for a variety of other configurations as program requirements change.

A.4.3 The concept of the non-specific building divides building elements into *permanent* and *adaptable* elements. The permanent elements form the fixed framework of the building, and usually remain unaltered during the half century or so that the building is used. The adaptable elements are non-permanent items that can be relocated or replaced as time passes. Their initial configuration may be considered simply as the first building alteration.

A.4.4 ABS buildings are composed of large (10,000 sq. ft. ± 25%) blocks of space called *Space Modules.* Each space module is a one story volume, mechanically independent, and sized to permit a wide range of planning choices in internal plan layouts and building configurations. Space modules can be stacked and grouped in many ways to form buildings of any size. The structural frame of the space module is considered a permanent element.

A space module can be pretested for its ability to accommodate a range of activities long prior to detailed room planning for a building. Plan solutions can then be developed according to the program constraints identified for each space module. Further, the space module allows an accurate appraisal of the cost, both initially and for subsequent alterations as required by changes in activities. The space module is, in fact, the foundation of the ABS subsystems and is the basis for the subsystems' interface conditions.

A.4.5 A *Service Tower,* also a permanent element, houses those facilities required to complement the academic activities contained in the space module—elevators, stairs, mechanical and toilet rooms. The mechanical rooms contain the main vertical distribution of services—plumbing, electrical, and HVAC. To minimize the limitations on future adaptability within a space module, the service tower is located outside but contiguous to the space module.

A.4.6 Horizontal distribution of services is from the mechanical room within a service tower to the space module via a service zone above the ceiling in the space module. Depending on the type of access required, this service zone is either *Deep Service Space* with catwalk access, or *Shallow Service Space* with access through the ceiling. The deep service space is particularly desirable above laboratory spaces as it permits maintenance, repair and alterations to be made with minimum disturbances of the occupants. The shallow service space is appropriate in buildings or spaces where changes will be minimal and infrequent.

A.5 ABS PROCEDURES

A.5.1 Although ABS planning concepts and subsystems can be applied using traditional construction procedures, the most significant prospects for reducing initial project costs lie in the use of the following three procedures:

a. Phased Design and Construction
b. Prebidding
c. Construction Management

A.5.2 *Phased Design and Construction.* Different phases of design and construction begin before others are completed. The main objective is to shorten the overall building project time. Use of the ABS planning concepts and subsystems facilitates phased design and construction.

A.5.3 *Prebidding.* Bids for the supply and installation of components are requested prior to bidding for the general construction work, to ensure availability and determine actual cost.

A.5.4 *Construction Management.* A construction manager is selected much earlier in the building process than a general contractor would be. The construction manager becomes a member of a team composed of owner, architect and builder, and contributes cost estimating expertise as well as knowledge of local markets, materials, and construction methods.

A.5.5 These three procedures are particularly compatible with the non-specific building and the ABS space module concepts. Since, for practical reasons, construction time is incompressible after a certain point, it is important to begin construction at the earliest possible time. Phased Design and Construction allows the construction of foundations and structural shell to be started well before programming and design of interiors has been completed. Prebidding permits the owner to take advantage of market conditions and obviates extended delivery time. Construction Management provides optimum cost control and the most effective coordination of the other procedures.

A.6 ABS SUBSYSTEMS

A.6.1 The ABS subsystems are those subsystems which, operating together, would most improve the performance and/or reduce the costs of construction and alteration for academic buildings:

Structure
HVAC
Lighting-Ceiling
Partitions
Utilities Distribution

The first four of the ABS subsystems represent from 40 to 55 percent of the construction cost of an academic building.

A 6 2 Non ABS subsystems are discussed in this manual only to the degree necessary to insure their compatibility with the ABS subsystems.

A 6 3 ABS subsystems are developed to permit appraisal of construction cost relative to levels of performance. A wide range of options is available so that the design professional can select the most appropriate cost/performance alternatives for his specific project.

A 7 SUMMARY

A 7 1 Although the importance of first cost reduction is not underestimated, the main emphasis of the ABS program is on the objectives of adaptability and lower life costs. Hence, the alternatives offered permit development of the highest *continuing* facility response to owner needs within a programmed budget. As successive projects are designed and constructed, the ABS system will provide the following advantages:

a. More accurate prediction of building construction costs.

b. Management tools for administrative use allowing faster and more effective space planning and budgeting of new buildings.

c. Buildings with substantially lower life costs, because alterations will be less disruptive, faster, and more economical.

d. The ability to reduce design time because of basic design and construction decisions inherent in the ABS planning concepts and subsystems.

e. The ability to proceed confidently with design and construction before academic programs are established because of the non-specific nature of the design.

f. The ability to reduce total project time, and cost, because of the design and management tools in the ABS system.

A.7.2 As each subsystem involves non-proprietary components, ABS allows full recognition of local preferences and capabilities and a maximum of competition in bidding.

A.7.3 Final critical decisions as to costs and the best use of available resources rest with the owner and the design professionals using ABS.

B. PLANNING CONCEPTS

B.1 GENERAL

B.1.1 An initial step in creating a system for developing more capable academic buildings was to establish rational planning concepts or standards as a base for effective decision-making.

B.1.2 The ABS planning concepts were not selected arbitrarily but were derived from the systematic analyses of academic building requirements, design, cost and performance. Constraints inherent in the planning concepts, standards, or modules are justified by definite benefits: standardization of planning concepts facilitates programming, provides the base for key planning decisions, aids in effective use of the ABS subsystems, and ensures provision of adaptable spaces in academic buildings.

B.1.3 ABS planning concepts can be used to produce a wide range of design solutions and building configurations; they provide for innumerable alternative arrangements, in both initial and possible future accommodations.

B.1.4 The ABS planning concepts include: the *Non-Specific Building* composed of *permanent* and *adaptable elements;* the *Space Module* with a *Ceiling Grid* and *Mechanical Service Zone;* and the *Service Tower.*

B.1.5 The assurance of fire safety in using the ABS planning concepts is predicated on the incombustible, fire-resistive building of UBC[1] Type 1 (noncombustible fire-resistive) construction and compliance with the National Fire Codes.

B.2 THE NON-SPECIFIC BUILDING

B.2.1 Much of the lack of adaptability in conventional academic buildings stems from an unrealistic assumption that the initial occupants are life-time "owners" and that building components have equal life spans. Conventional planning focusing on the academic programs initially housed in a building is short-sighted; academic buildings should be capable of accommodating a variety of programs over the years.

B.2.2 The concept of a non-specific building recognizes that during the life span of a building its occupants will change. Further, the concept differentiates building components in terms of useful life spans. For example, structure will be useful for more than a half century; but lighting fixtures may be obsolete in a decade.

Thus, in a non-specific building, its elements are identified as either permanent or adaptable.

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[1] International Conference of Building Officials "Uniform Building Code."

B.3 PERMANENT ELEMENTS

B.3.1 Permanent elements remain essentially unaltered throughout the life of the building. Once their arrangement has been determined in the design process, their positions are neither physically nor economically easily changed. Permanent elements are least affected by academic program requirements for space relationships, environmental qualities and services distribution.

B.3.2 Permanent elements include the structure, stairs, elevators, fixed walls, toilet facilities, mechanical rooms and vertical and horizontal mains for all services. These elements are considered separately from, and usually constructed prior to, the adaptable elements.

B.4 ADAPTABLE ELEMENTS

B.4.1 Adaptable building elements respond to the academic requirements for specific space and services. Each adaptable element is non-permanent—that is, individually removable and replaceable with minimum damage. The positions of these elements may be determined after the start of building construction; the initial configuration of the adaptable elements may be considered simply as the first alteration.

B.4.2 Adaptable elements include interior partitions, ceilings, lighting fixtures, academic program equipment, casework and finishes, and the laterals for all services.

B.5 THE SPACE MODULE

B.5.1 The conventional design process commonly uses a room as the "building block." A room, however, must usually be closely interrelated to other rooms, and is not sufficient in size to generate economical structural, mechanical and service subsystems. Groups of rooms afford a more efficient and desirable planning entity, providing large generalized spaces to accommodate academic environments at a scale compatible with the building subsystems. On this premise, ABS uses a large, multi-room module as the major "building block" or space module as a means for dealing more adequately and economically with problems of adaptability, fire safety, structure and services.

B.5.2 Space modules can be coupled, joined, stacked, and arranged in a wide variety of ways to form a building. During planning, the building area can be adjusted by increasing or decreasing the number of space modules. This capability is a particularly useful tool in times of uncertain capital funding. A single building can be enlarged or a complex of buildings can be expanded, by adding one or more space modules.

B.5.3 The space module is a permanent building element providing generalized academic space that may change over time. When an acceptable general building program has been established, schematic building design proceeds by combining appropriate space modules to achieve the desired plan relationships and building mass.

B.5.4 Advantages of the space module concept can be summarized as follows:

a. It provides an administrative tool allowing rapid, accurate programming and cost control. Each space module, prior to planning a specific building, can be pretested for its ability to accommodate a range of academic activities, and its potential for adapting to changes after an initial configuration.

b. It permits an early decision, before programming is completed in detail, on building mass and plan configuration.

c. It circumvents escalating construction costs, as construction can begin before the academic program is detailed.

d. It reduces life costs substantially, as alterations will be much less disruptive, easier and more economical.

B.5.5 Space module restrictions as to maximum length, maximum aspect ratios, and perimeter frame separations are established by structural requirements for resistance of seismic and high wind loadings or thermal expansion required in some geographic locations. Less severe local requirements will permit other alternatives by the design professional.

B.5.6 The space module is contained in a perimeter structural frame. Two space modules may be coupled within a single perimeter frame. Multiple space modules can be connected, provided separation of perimeter frames is maintained.

B.5.7 THE SINGLE SPACE MODULE

B.5.7.1 The single space module is a one story, multi-room space of 7,500 to 12,500 square feet. It may be either of two basic heights depending on the type of access to mechanical services. The space module is internally free of vertical elements except for interior structural columns; it is mechanically independent; each space module is divided horizontally by a ceiling grid. The space above the ceiling grid is reserved for the mechanical service zone and the attending service personnel only. The space below the ceiling grid is reserved for people, academic equipment and horizontal circulation.

B.5.7.2 The space module functions as:

a. A programming and planning module.
b. A heating, ventilating and air conditioning module.
c. A plumbing and electrical service module.
d. A structural module.

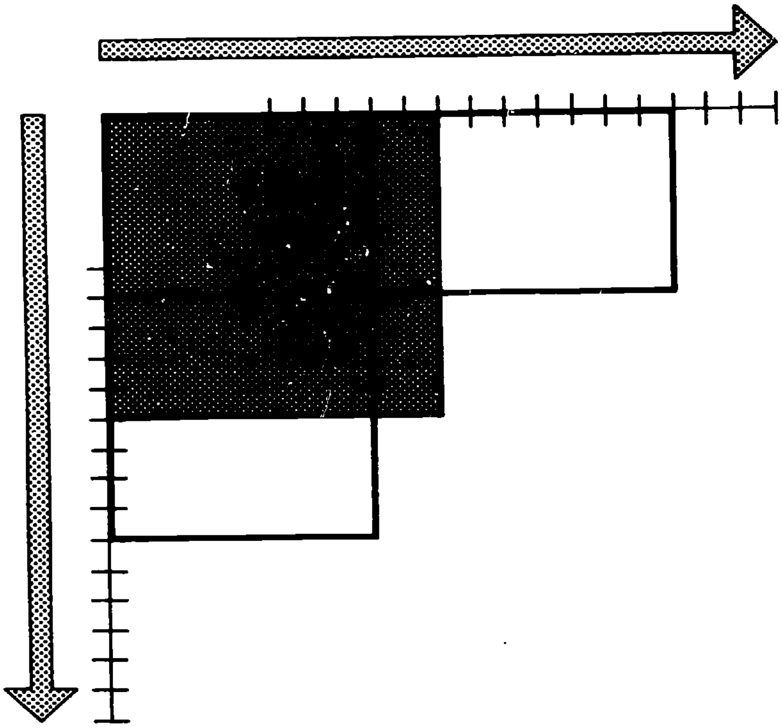
SPACE MODULE

Single story height (14'-7" or 16'-10")
Area: 7,500 to 12,500 square feet

B.5.7.3 Length and Width for a Single Space Module.

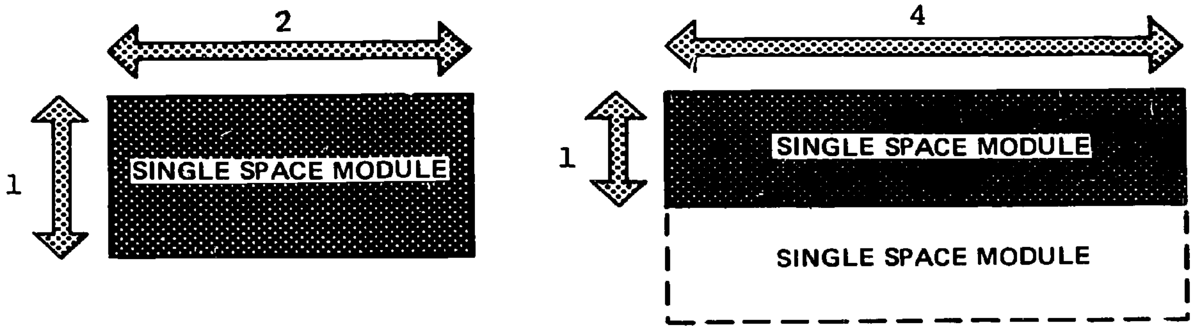
Length:
parallel with interior girders. In 10 feet increments to 200 feet maximum (limited by seismic and thermal expansion).

Width:
parallel with beam. In 10 feet increments to 200 feet maximum (limited by seismic and thermal expansion).



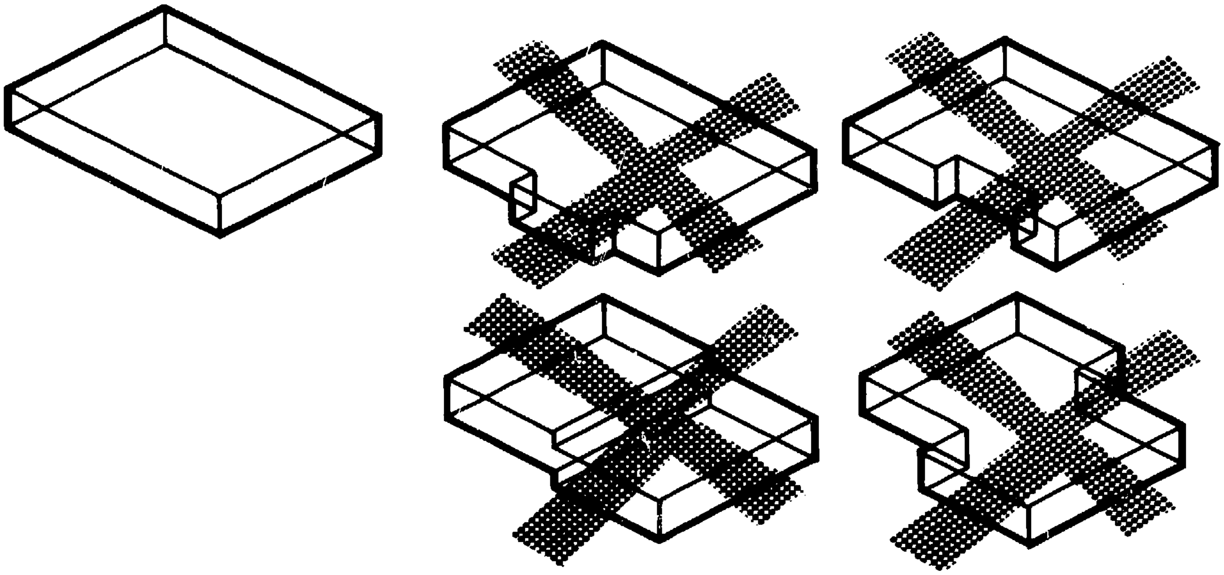
B.5.7.4 Aspect Ratio for a Single Space Module.

The aspect ratio is a maximum of 2:1 for a single space module. It is a maximum of 4:1 when two space modules are coupled within the same perimeter frame.



B.5.7.5 Perimeter Frame for a Single Space Module.

Both the horizontal and vertical envelope perimeters shall be straight and parallel with no indentations, projections or staggering of the perimeter frame.



B.5.8 COUPLED SPACE MODULES

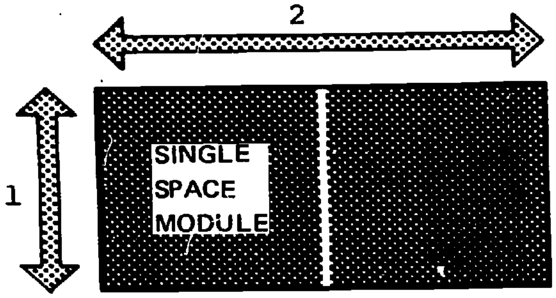
B.5.8.1 Two space modules may be coupled within the same structural perimeter frame. subject to the conditions described herein.

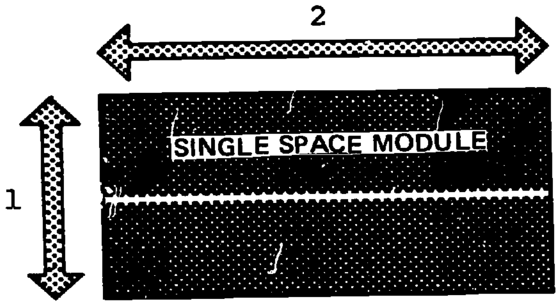
B.5.8.2 Length of Coupled Space Modules

The maximum length of any side of the perimeter frame surrounding coupled space modules shall not exceed 200 feet as limited by sesimic and thermal requirements.

B.5.8.3 Aspect Ratio for Coupled Space Modules

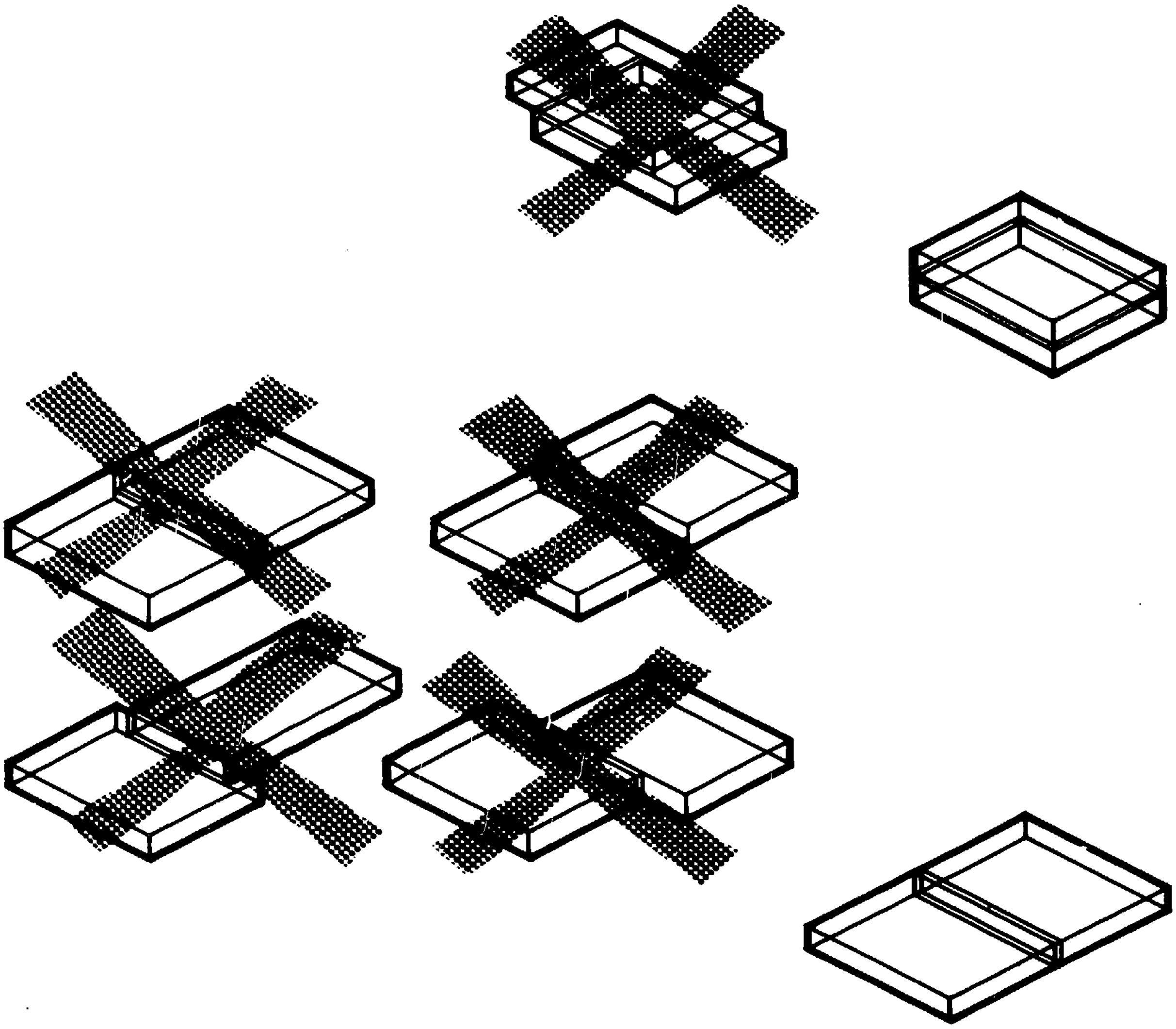
The aspect ratio is variable, with a maximum of 2:1 for the two space modules coupled wihin the same perimeter frame.





B.5.8.4 Perimeter Frame for Coupled Space Modules

Both the horizontal and vertical envelope perimeters of the two space modules shall be straight and parallel, with no indentations, projections or staggering.



B.5.9 SPACE MODULE AREA RANGE

Length: parallel with interior girders

Width parallel with beams

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200 FEET
10																				
20																				
30																				
40																				
50														▲ 7000	▲ 7500	▲ 8000	▲ 8500	▲ 9000	▲ 9500	▲✪ 10000
60												7200	▲ 7800	▲ 8400	▲ 9000	▲ 9600	▲✪ 10200	▲ 11800	▲ 11400	▲ 12000
70										7000	7700	8400	9100	✪ 9800	▲ 10500	▲ 11200	▲ 11900	▲ 12600		
80									7200	8000	8800	✪ 9600	✪ 10400	11200	12000	12800				
90								7200	8100	9000	✪ 9900	10800	11700	12600						
100							7000	8000	9000	✪ 10000	11000	12000	13000							
110							7700	8800	✪ 9900	11000	12100									
120						7200	8400	✪ 9600	10800	12000										
130						▲ 7800	9100	✪ 10400	11700	13000										
140					▲ 7000	▲ 8400	✪ 9800	11200	12600											
150					▲ 7500	▲ 9000	▲✪ 10500	12000												
160					▲ 8000	▲✪ 9600	▲ 11200	12800												
170					▲ 8500	▲✪ 10200	▲ 11900													
180					▲ 9000	▲✪ 10800	▲ 12600													
190					▲✪ 9500	▲ 11400														
200 FEET					▲✪ 10000	▲ 12000														

✪ Space module closest in area to 10,000 square feet.

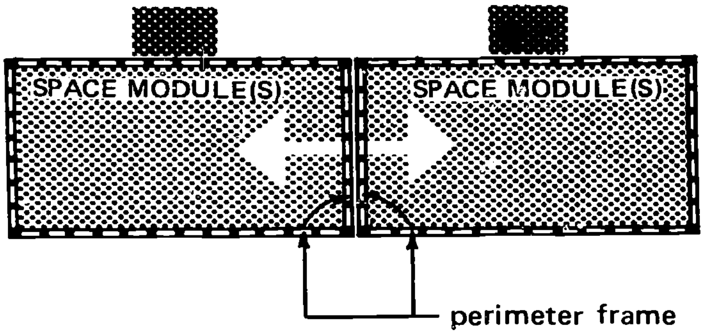
▲ Space module with greater than 2:1 aspect ratio. Use only when coupled with another space module.

The areas indicated are to the inside of the perimeter frame.

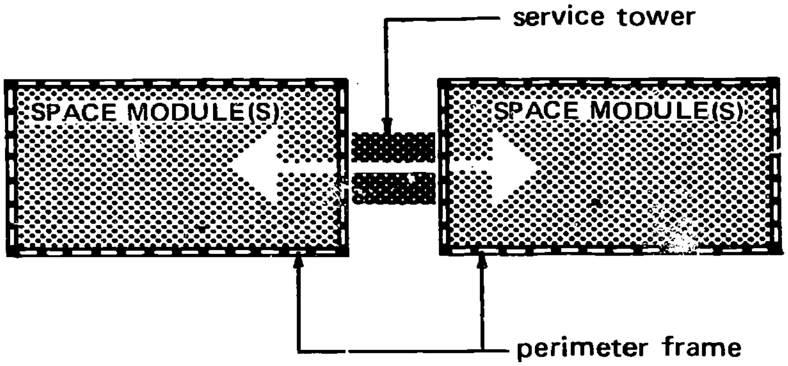
B.5.10 MULTIPLE SPACE MODULES

B.5.10.1 Three or more space modules can be connected, subject to the conditions described herein.

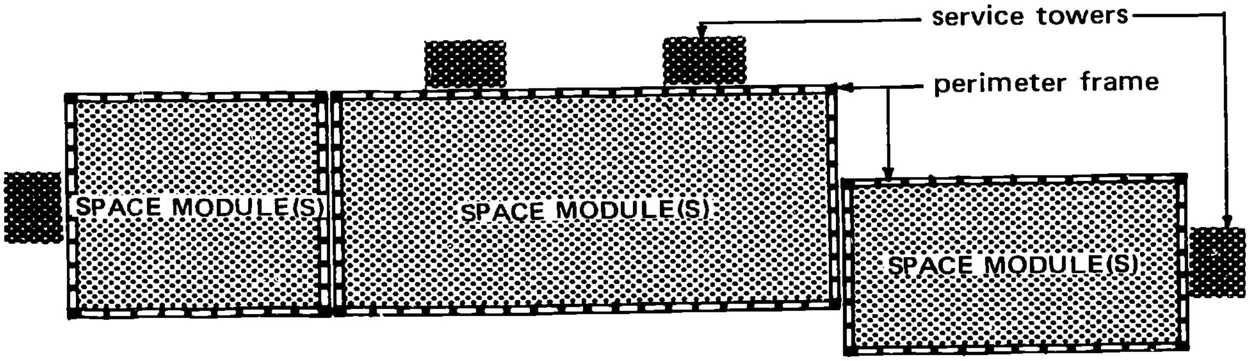
B.5.10.2 An individual space module or coupled space modules can be connected with other space modules if each grouping is separated by perimeter frames.



B.5.10.3 A different means of connecting space modules is via a service tower. Any staircase therein must be organized so as to take care of any required change in floor level.



B.5.10.4 Staggering is possible at the perimeter frame junction and a total *building* length of more than 200 feet is possible, if no individual perimeter frame is longer than 200 feet.

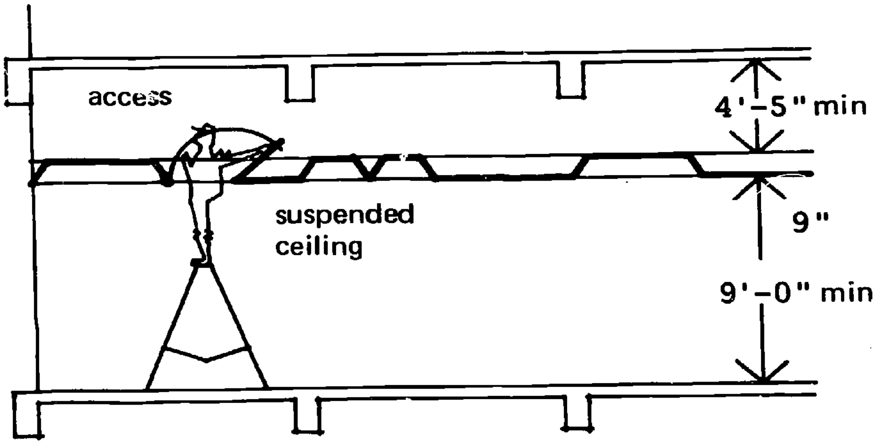


B.6 MECHANICAL SERVICE ZONE

B.6.1 Each space module contains a mechanical service zone—the space above the ceiling grid. The zone contains the plumbing and electrical services, and the HVAC air distribution and returns essential to the proper functioning of the academic spaces below the ceiling grid. It has two basic heights; one is the *Deep Service Space*, the other is the *Shallow Service Space*.

B.7 THE SHALLOW SERVICE SPACE

B.7.1 The shallow service space is accessible from below, through the ceiling.



B.7.2 The advantage of this type of service space is a lower construction cost, in that services can be tightly organized under the structure so that floor-to-floor heights may be minimized.

B.7.3 Disadvantages are:

a. Any access to the services interferes with academic functions in the space below.

b. Spills, dust and debris from maintenance/alteration work can mean that laboratory experiments or other academic work have to be stopped while work is in progress.

c. Some services become inaccessible because they are tightly organized.

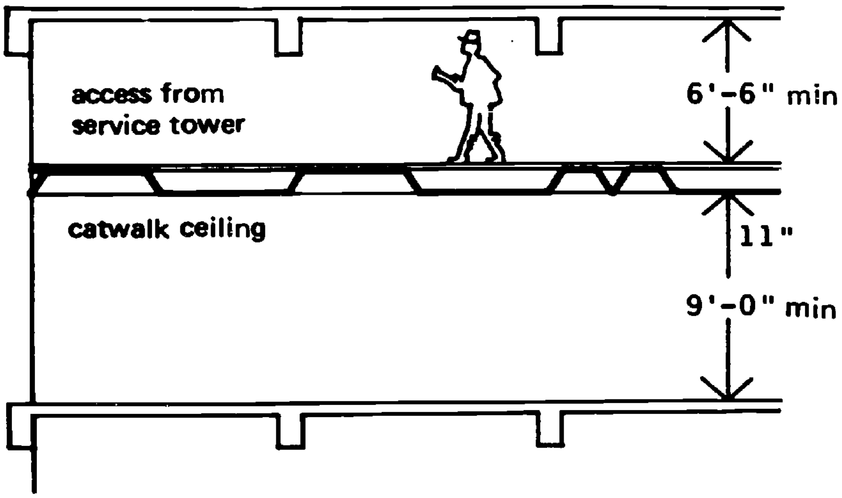
d. Adding new services is difficult and expensive.

e. When making alterations, interference with spaces on other floors is inevitable; e.g., if a waste pipe is put in, the ceiling in the room below has to be opened, and both rooms are disrupted.

B.7.4 The shallow service space is recommended for facilities that will house academic functions with minimal services requirements.

B.8 THE DEEP SERVICE SPACE

B.8.1 The deep service space is accessible by catwalks from the mechanical room in the service tower. The height is sufficient to enable maintenance and repairs to be done above the ceiling.



B.8.2 Advantages are:

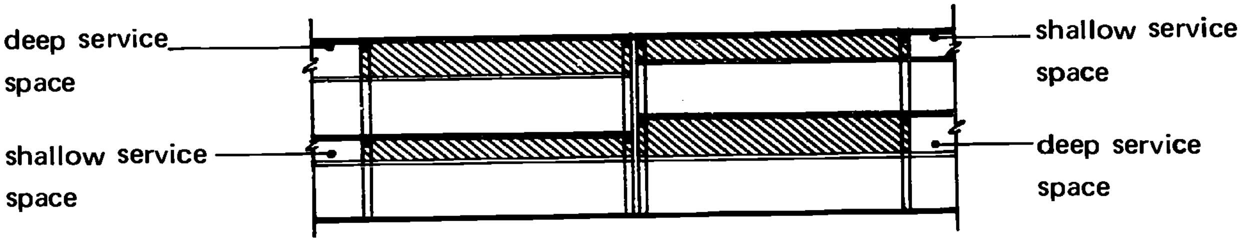
a. The additional space permits better organization of services for easier alterations.
b. Disruption of academic activities is kept to a minimum.

B.8.3 A disadvantage is the added cost of the increase in floor-to-floor height.

B.8.4 The deep service space is recommended for facilities that will house academic activities with initial and/or continuing extensive service requirements.

B.9 COMBINATION OF SERVICE SPACES

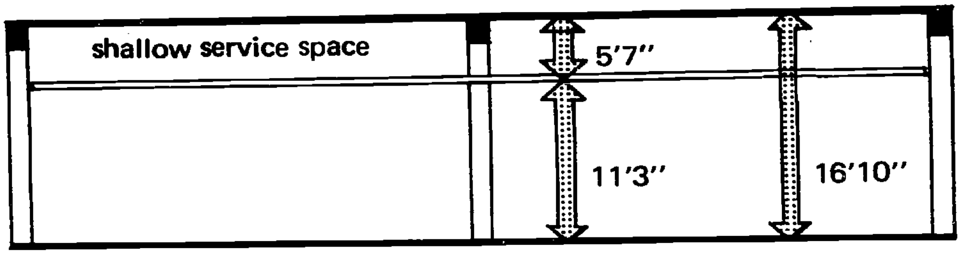
B.9.1 A change from the deep service space to the shallow service space may occur vertically and horizontally, but only at the junction of space modules.

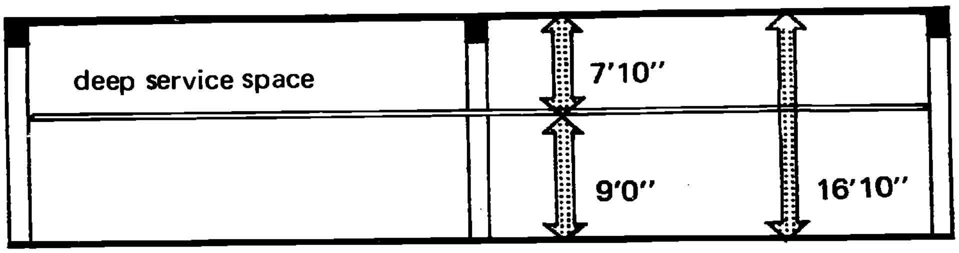


B.9.2 It is not possible to include both service spaces within the same space module.

B.10 VARIATION ON THE SERVICE SPACE

B.10.1 The 16'-10" floor-to-floor height, normally using the deep service space, may also use the shallow service space to give a floor-to-ceiling height of 11'-3". In this case, the service access is through the ceiling only.

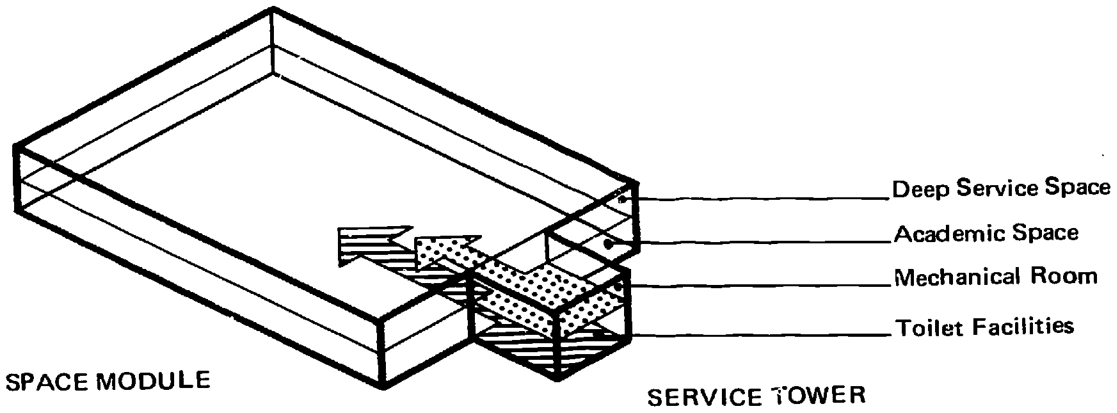




B.11 SERVICE TOWER

B.11.1 The service tower is a permanent element containing the ancillary facilities and services essential to proper functioning of the activities in the space module. Included in the service tower are: elevators, stairs, toilet facilities, janitor rooms, vertical service mains, and a mechanical room for each space module. The service tower is located outside of, but contiguous to the space module, to provide uninterrupted loft space and thereby optimum adaptability within the space module.

B.11.2 The service tower is individually designed for each building, with no restrictions on either its area or its location outside the space module. It is structurally independent of the space module and may be constructed non-ABS. The total height of the service tower will relate to the number of adjacent space modules stacked vertically. Both stacking and grouping of service towers is expected in order to reduce costs. An overall space saving is afforded, when the space module uses the deep service space, by vertical alternate placement of the mechanical room and the toilet facilities, as shown below.



B.11.3 Distribution of services from the service tower to any space module is via the mechanical service zone. Use of the deep service space permits access to the mechanical service zone from the mechanical room in the service tower. The area of each mechanical room will depend upon the many variations of mechanical equipment and positioning required to accommodate local climatic conditions, energy source, exhaust air, difference in floor-to-floor heights, and initial and future building uses.

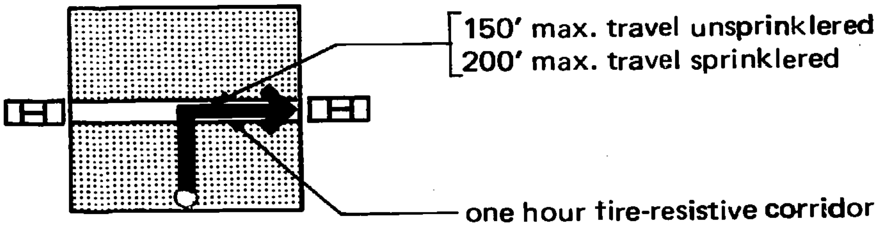
B.11.4 Service towers may serve as connecting circulation links between space modules.

B.11.5 The service tower may be located within the perimeter of the space module, subject to size and position limitations imposed by the structural subsystem. Such location will severely limit future adaptability.

B.12 FIRE SAFETY

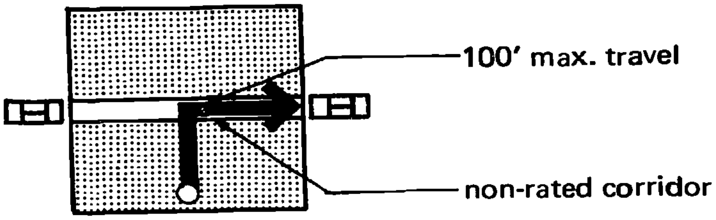
B.12.1 Planning considerations for fire safety, based on requirements for educational occupancies in the National Fire Codes, 1969-70, Volume 4, are:

- a. Travel distance from any point to an exit shall not exceed 150 feet if not sprinklered, or 200 feet if sprinklered.
- b. Provide two exits minimum, as remotely located from each other as possible.
- c. The maximum length of a dead-end corridor shall be 20 feet.
- d. Interior corridors shall be one-hour (minimum) fire-resistive construction.



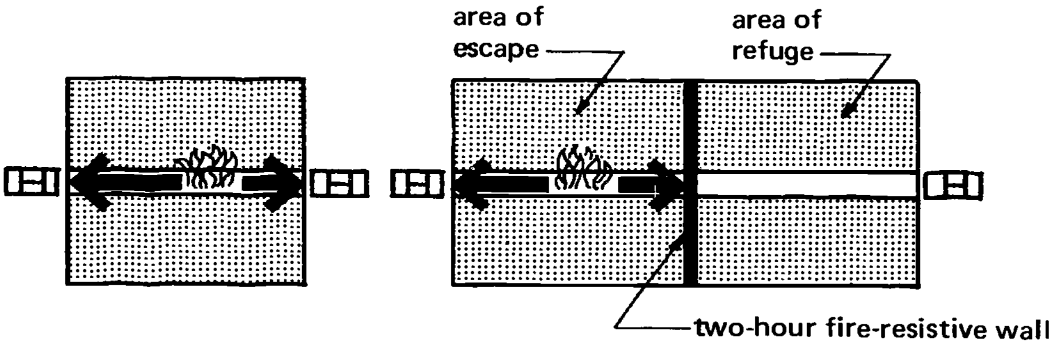
B.12.2 The following special provision applies to any open plan educational building not having the one-hour fire-resistive corridor protection:

- a. The undivided floor area shall not exceed 30,000 square feet.
- b. Provide a smoke stop partition at 300 feet intervals (maximum).
- c. The travel distance from any point to an exit shall not exceed 100 feet.



B.12.3 A partial alternative to the conventional exit requirements is the *area of refuge* concept, to provide fire safety by horizontal routing. Section 5-5, Volume 4, NFC defines horizontal exits as:

B.12.3.1 "A horizontal exit is a way of passage from one building to an *area of refuge* in another building on approximately the same level, or a way of passage through or around a fire wall or fire partition to an *area of refuge* on approximately the same level in the same building, which affords safety from fire or smoke from the *area of escape* and areas communicating therewith."



B.12.3.2 The concept of *area of refuge* may be applied where space modules are horizontally coupled, and where permitted by local fire safety requirements and conventional code requirements. Herein, each refuge area shall be less than the *area of escape.*

B.12.3.3 To contain a fire within a small area, and to prevent migration of smoke and fumes, a two-hour fire-rated smoke-tight wall shall pass through the suspended ceiling to the structure above. This wall separates the *area of escape* from the *area of refuge,* staircase, elevator, mechanical room, and any vertical services chases.

B.12.3.4 The escape route distances to the *area of refuge* shall not be greater than the code requirements for access routing to stairways.

B.12.3.5 Consideration must be given to ease of access to the *area of escape* by fire-fighting personnel and their equipment.

B.12.4 ABS typically will provide a building of UBC Type 1 construction (incombustible, fire-resistive) throughout, with a one-hour fire-rated ceiling suspended beneath the separately rated structure. Herein, one-hour fire-rated partitions, including those defining corridor exit routes, stop at the suspended ceiling, thus allowing the partitions and overhead services to be easily relocated. Normally, the only openings in the ceiling requiring fire dampers are in areas where the ceiling is specifically required to be fire-rated—such as corridors.

C. PROCEDURES

C.1 INTRODUCTION

C.1.1 Coordination of ABS planning concepts and subsystems does not require changes in conventional administrative practices; traditional programming and construction procedures can be used.

C.1.2 The following procedures, although not mandatory, are recommended as highly compatible with ABS planning concepts and subsystems:

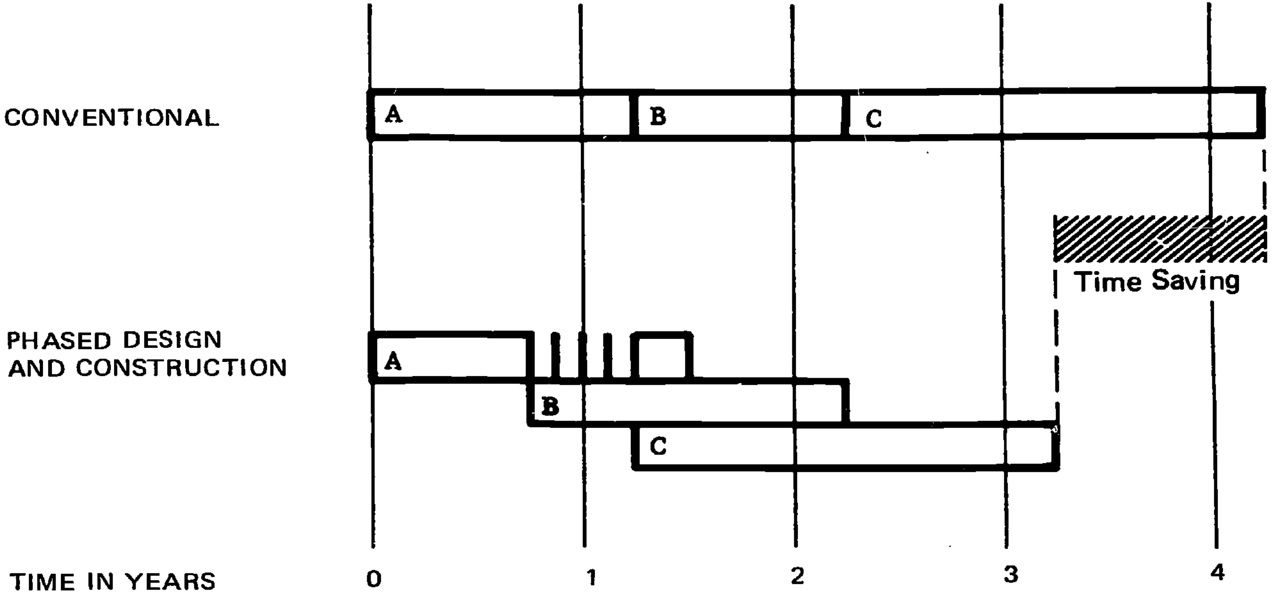
a. Phased Design and Construction
b. Construction Management
c. Prebidding of selected subsystems or components

C.1.3 Some institutions may not be able to incorporate these procedures. Local regulations may not permit Construction Management or Prebidding; capital outlay funding on an incremental fiscal year basis may restrict the use of Phased Design and Construction.

C.2 PHASED DESIGN AND CONSTRUCTION

C.2.1 Phased design and construction is a scheduling procedure that shortens the overall time between building inception and occupancy. Different stages of the programming, design and construction processes are phased so that some commence before others are completed. This overlapping contrasts with conventional procedures which sequentially schedule programming, then design, and finally construction. Use of phased design and construction offers the possibility of considerable variation in the scope of each phase and the extent to which phases overlap. Variations will depend upon the size and nature of the building project, and other local constraints.

C.2.2 The following simplified diagram compares phased design and construction with the conventional scheduling.



LEGEND

A — Programming
B — Design/Working Drawings
C — Construction

C.2.3 Phased design and construction generally divides the building design and construction for the building into three main phases:

a. Foundations and Site Work, including subgrade drainage and utilities.

b. Structural Shell and Exterior Skin, including rough structure, main services[2] distribution and equipment, and ceiling grid.

c. Interiors and Finish, including secondary services[3] distribution and controls, partitions, lighting-ceiling, casework, all remaining finish work, including equipment for the academic programs.

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[2] Services is used in a comprehensive sense to include electrical, plumbing, utility services, and HVAC distribution.

[3] *Ibid.*

C.2.4 Compression of time by phase overlapping depends on predefined interface conditions among the building components and clear delineation of contractual responsibility. The ABS subsystems as packages of compatible components facilitates phased design and construction.

C.2.5 Although under this procedure any one phase may extend over a longer time period, carefully coordinated overlapping of phases can substantially reduce the total time.

C.2.6 Phased design and construction, if combined with Construction Management (hereinafter described) and coordination of the ABS subsystems with the non-ABS subsystems, minimizes the risk of budget overrun by providing more direct control of the total building process.

C.2.7 Steps in the procedure are outlined as follows:

a. Initial programming is sufficient to establish the overall building area and size, and to determine site requirements.

b. Then, schematic design commences, establishing the number and arrangement of space modules, the building configuration and mass.

c. As design development work proceeds, working drawings are begun for the site work and foundations. Because the ABS structure subsystem is well defined, critical decisions affecting structure and foundations can be made prior to completing working drawings for the structural frame.

d. Thus, construction of foundations can proceed prior to completion of structural frame working drawings.

e. Meanwhile, programming, design and working drawings for successive stages—building enclosure and interior finishing—are underway. Detailed programming of interiors need not begin until the building shell is actually under construction. An academician or other occupant is thus enabled to state detailed requirements much nearer to the time of actual building occupancy.

C.2.8 The two charts on succeeding pages compare conventional scheduling methods with phased design and construction. This comparison is for the ABS demonstration building for science and engineering and technology on the Indiana University/Purdue University campus in Indianapolis.

C.2.9 Phased design and construction should be used only to the extent that it produces the best possible building in the minimum time. Rapid and binding decisions are required of the institution's administrator for a given project.

CHART 1

ABS/SET CONVENTIONAL SCHEDULE

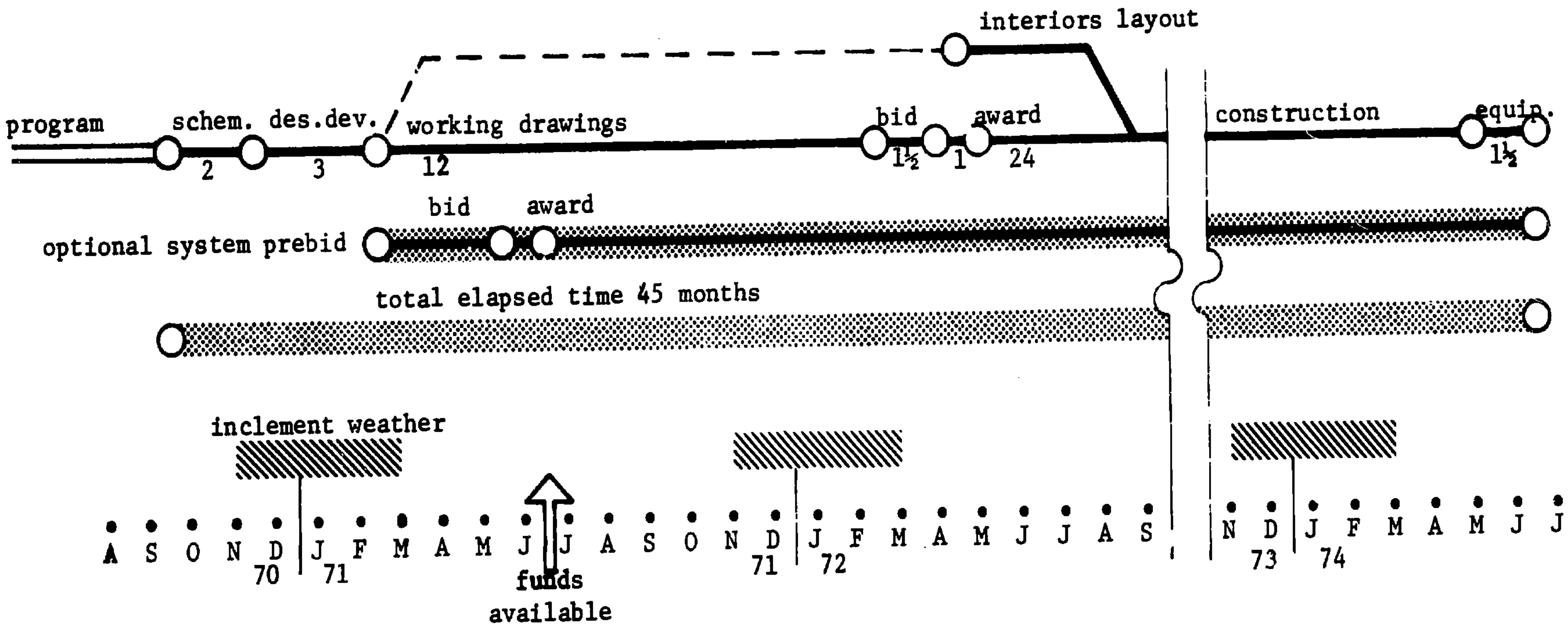
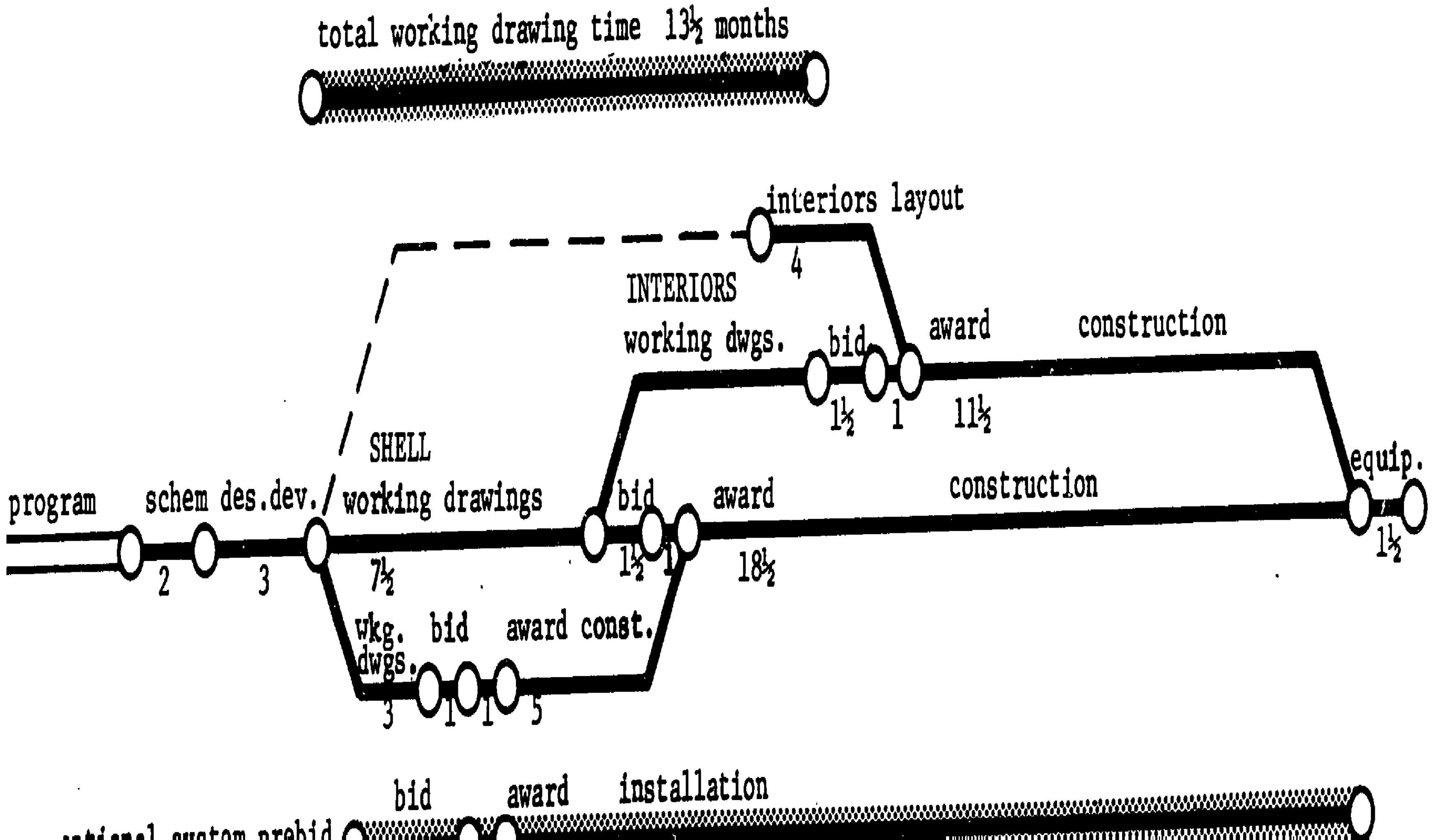
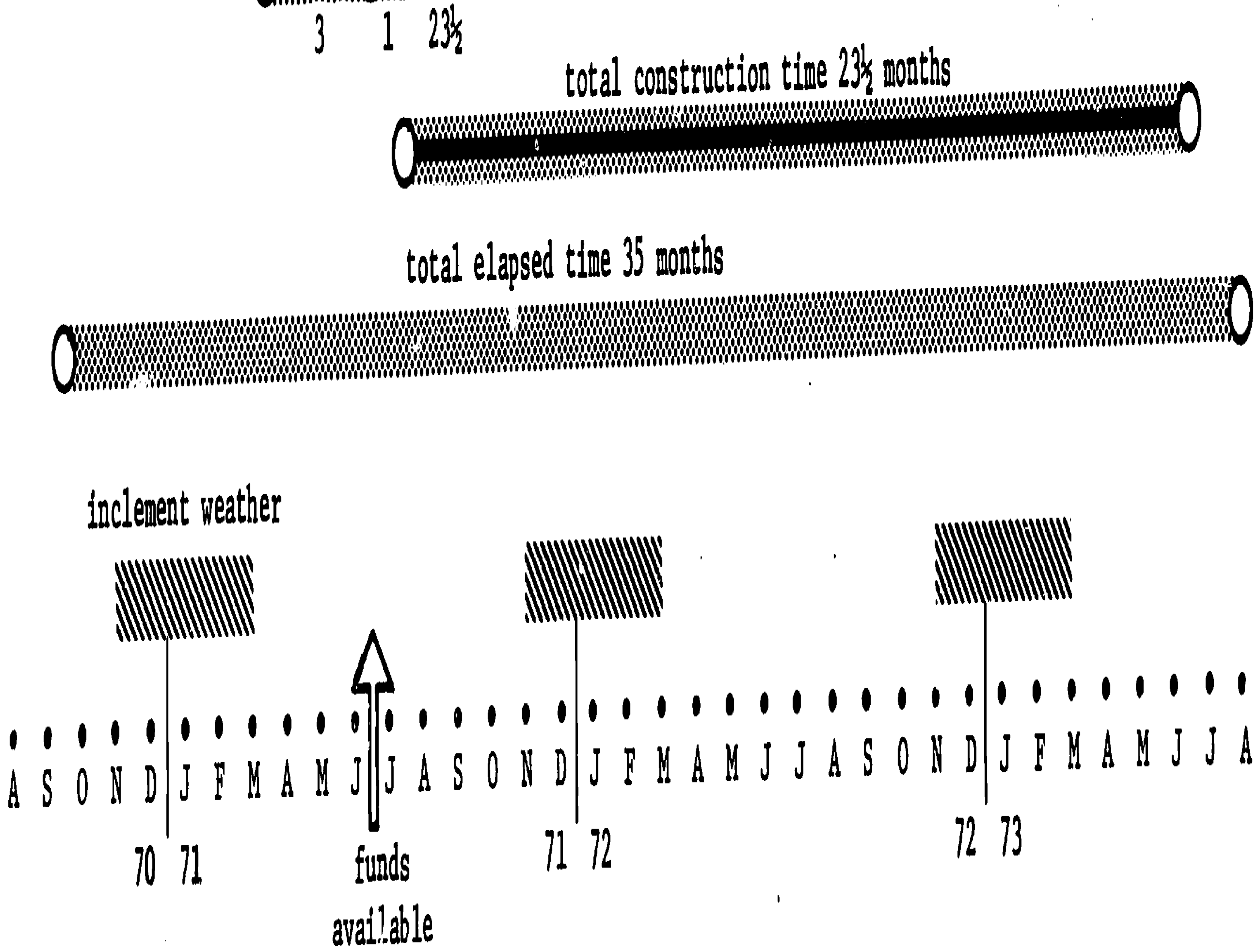


CHART 2

ABS/SET PHASED DESIGN AND CONSTRUCTION




3
1
23½
total construction time 23½ months
total elapsed time 35 months
inclement weather
A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
70 71
funds available
71 72
72 73

C.2.9.1 For maximum time saving to offset escalating construction costs, construction may begin before a firm total building price is available. However, this basic decision should be checked against fiscal or legal policy for an institution. Because the procedure has built-in cost control methods, monetary risk is minimal.

The original cost estimate for a project should include a percentage contingency allowance. As design and working drawings progress, this cost estimate should be continually refined and updated and reasonable contingency allowance should be maintained. Until a final contract price is established, the architect should continue to develop options allowing deductive alternates. These strategies will reasonably assure that a project is within budget even though extraordinary circumstances beyond the control of the owner, architect or contractor may occur.

C.2.9.2 Decisions pertaining to the siting, building configuration, height and mass must be made much *earlier* than in conventional scheduling. These decisions cannot be changed after construction is started.

C.2.9.3 Decisions pertaining to detailed academic program requirements for space division components, services and equipment within the departmental areas can be made much *later* than conventionally. This delay is possible because detailed design of the structural shell does not depend on a detailed program.

C.2.10 Phased design and construction is advantageous in that detailed programming of interior spaces can be postponed. This reduces the possibility of building obsolescence by the time of occupancy.

In large projects, detailed programming can begin after the structural shell of the building is well under construction. Users can appraise their detailed requirements by viewing the actual spaces they will occupy.

C.2.11 This procedure permits selection of the most favorable times for bidding and construction within design and occupancy constraints. Conventional scheduling, because it is inflexible, often conflicts with optimum timing for bidding and with inclement weather for construction. For example, bidding often cannot be undertaken until summer, pending release of construction funds in July. This is not the most economical bid period, nor is there sufficient time to be "out of the ground" before bad weather disrupts the construction process.

Further, this procedure permits splitting the bidding for large projects requiring long construction time into several stages. More accurate prices can be obtained if bidding is closer to the time of supply and installation. Traditionally, bidding many months in advance must allow for escalating costs and uncertain labor charges.

C.2.12 Three optional bidding processes that can be used within phased design and construction are:

a. Select the *general contractor* for the entire project at the time of bids for site and foundation work. This is the least satisfactory way. The difficulty lies in evaluating the bidder's price and competence to do the entire building, because all work is not closely defined at this early stage. Although unit prices for the ABS subsystems can be bid at this stage, difficulties may occur in bidding non-ABS subsystem work.

b. Seek *separate contract* bids for each phase of the project—that is, three separate contractual periods, and potentially, three different general contractors. Although feasible, this process may cause conflicts if one contractor is not finished before another starts. Disputes as to responsibility can be a problem with successive general contractors just as it is between subcontractors in conventional contracts.

c. Utilize the services of a *construction manager*. Phased design and construction can be most fully and effectively administered in this way. The contractor becomes a member of the project process team for the building. Subcontractor bids for subsystems and any portion of the work can be obtained at any time, giving utmost flexibility in phasing. The construction manager will have even greater impact in ensuing ABS contracts as familiarization produces greater efficiency and lower cost.

C.3 PREBIDDING SELECTED SUBSYSTEMS OR COMPONENTS

C.3.1 This procedure is typically used in system building. Bids for the supply and installation of subsystems or components are called for prior to bidding for the general work.

C.3.2 The intent is two-fold: first, to establish costs of major portions of the work in advance, thereby assisting in cost control during detailed design work; second, to designate early the subsystem suppliers and installers who can then assist in material ordering and scheduling to reduce construction time.

C.3.3 If need be, prebidding can be done prior to the selection of the contractor. In this event, the owner awards the prebid contracts and subsequently assigns them to the contractor.

C.3.4 When a long lead time is not required, the contractor should be selected before soliciting the subsystem and component bid proposals, thus avoiding the assignment process.

C.3.5 Prebidding can include mutual responsibility for performance. For example, an acoustical performance characteristic can be established which must be met mutually by the Structure, HVAC and Partitions subsystem contractors.

C.4 CONSTRUCTION MANAGEMENT (See Exhibit H for terminology)

C.4.1 Conventionally, the owner and the architect constitute the project process team. The general contractor, selected by competitive bidding, does not become involved at all until after the working drawings for the building are completed. Thus, he has neither incentive nor opportunity to participate in achieving the owner's objective of the best building performance for the least cost.

C.4.2 In contrast, the *Construction Manager* becomes an effective member of the team at the completion of the schematic design work. He contributes in the areas of cost estimating, materials evaluation and selection, and construction methods during the finalization of building design and working drawing preparation.

C.4.3 The inclusion of the construction manager on the project process team benefits the owner in that a new and important relationship is created between architect and contractor. Whether or not so titled, the construction manager becomes a consultant with the architect. The two parties must have mutual respect and work well together, or most of the benefit to the owner will be lost. Fortunately, architects involved in large scale commercial work have been accustomed to construction managers for many years and, in general, greatly prefer to work this way. So there should be minimum problems as this procedure is introduced to college and university work.

C.4.4 The Construction Management procedure separates the management of construction from the actual construction activities. Although a specific profession of construction managers is developing, typically the construction manager is an individual engaged in general contracting.

Some general contractors may object to the Construction Management contracting procedure, claiming that this reduces their freedom of action. They may also resent revealing their fees and other administrative costs to competitors. The possible impact of this must be evaluated carefully in each local situation.

C.4.5 The services of a construction manager are almost obligatory if the phased design and construction procedure is used. Otherwise, the flexibility of subcontract bidding, cost control, and the continuous, competent coordination needed cannot be effectively achieved without a serious burden on the owner's staff.

C.4.6 Services rendered by the construction manager may include:

a. Cost control by estimates during prebid design work; guaranteed prices after subcontract bids; and exact costs with known minimum markup for contemplated change orders during construction.

b. Consultation on construction materials, methods and timing.

c. Management of the separate subcontracts for all construction.

d. Application of value engineering throughout the project process.

e. Possible participation in construction activities using his own forces. The owner, however, may prefer that the construction manager only control the work of others and perform no construction work himself.

C.4.7 Advantages offered by the Construction Management procedure are:

a. The owner is assured protection from budget overruns during design and construction.

b. The overall time required for the project process is reduced.

c. Possibility of errors and/or omissions by the design professionals is reduced.

d. Value engineering provides cost/benefit analysis during both design and construction.

e. The owner is assured of the lowest net cost for: fees to the construction manager and all subcontractors; cost of bonds, Workmen's Compensation Insurance, and the contractor's indirect job labor burden.

f. As the unknown risks for the contractor are minimized, the owner receives a more rapid, less expensive and higher quality job.

g. The number of extras to the contract is reduced. The markup is a minimum known fee for the few that may be required.

h. Bids for subcontract work can be obtained at the most favorable time.

i. The construction manager may be appointed or selected by competitive bid. If the latter must determine his selection, approved[4] prequalification eliminates all unqualified parties.

C.4.8 The approved prequalification for selecting the construction manager by competitive bid includes:

C.4.8.1 The architect must complete the schematic design for the project. His drawings, along with outline specifications, are to give the site location, scope and general building configuration and mass, indication of the structure and the materials, the estimated construction cost range, and the expected time of building completion.

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[4] Both the Facilities Engineering and Construction Agency (FECA) of the U.S. Department of Health, Education, and Welfare and the U.S. Department of Housing and Urban Development have approved the use of the Construction Management procedure.

C.4.8.2 A Notice To Contractors, as a legal advertisement, invites submission of specific financial, surety, and insurance information from each prospective bidder as follows:

a. A complete, audited financial statement not over 90 days old.

b. An open letter of credit stating dollar amount available from bidder's bank, and relating his borrowing experience over the previous five years.

c. The name of the bidder's current surety company and broker, together with number of times the surety had to complete any part of a project during the previous five years.

d. A listing of the other surety companies used in the previous five years.

e. The name of the bidder's current insurance companies and the broker for each. If more than one company, bidder is to state the reasons.

f. A listing of the bidder's insurance losses in dollars, together with number of workmen's accidental deaths during the previous five years.

The Notice To Contractors must include the statement:

> "Final evaluation and contract award will be made on the basis of the proposal most advantageous to the owner, considering probable total cost of bid items, the bidder's financial resources, his surety and insurance experience, his personnel, equipment, workload and client relationships. The owner reserves the right to reject any or all bids and to waive any irregularities in any bid received. Award may be made to other than the low bidder."

C.4.8.3 The bid submissions are not public records and are not open to public inspection. Each submission is to be objectively evaluated by the owner, solely on the data submitted. (See Exhibit A.) A bidder becomes prequalified if the evaluation scores thirty or more points out of a possible thirty-eight points. Those bidders receiving less than thirty points are disqualified. For details, see Exhibit B.

C.4.8.4 Another legal advertisement, the Advertisement For Bids, requests bid proposals from the prequalified bidders. The schematic design information, the Information for Bidders, and the bid form are released to intending bidders. The Advertisement For Bids must carry the same statement as did the Notice to Contractors. (See C.4.8.2).

C.4.8.5 The Information for Bidders should include the statements shown on Exhibit C.

Prior to preparing the information, the owner must decide whether the construction manager will participate in construction activities using his own forces, or whether he will control the work of others and perform no construction work himself.

Certain areas of work may be made available to the construction manager; his selection for that work would be based on a sealed bid submitted in competition with other subcontractors. The construction manager may advantageously perform work, such as site work or foundation work, traditionally done by a general contractor. Normally, work performed by a construction manager's own forces is under 10 percent of the total.

Under these circumstances, the coordination advantages are far more significant than the chances of the owner suffering because of the construction manager's "privileged position" vis-a-vis the other subcontractors.

C.4.8.6 The bid proposal requires cost information on those highly competitive items involved in the bidder's cost of doing business. The items are shown on Exhibit D.

C.4.8.7 The sealed bid proposals from the prequalified bidders are publicly opened and read aloud. The owner then evaluates each proposal by converting the bid percentages to a dollar value, to determine the successful bidder. His bid evaluation will show the lowest net cost to the owner. (See Exhibit E.)

C.4.8.8 If, after evaluating the bid proposals, there is some question as to the low bidder's ability to perform, a second evaluation by the owner can be applied. This is also rated on a point system. Sixty-five points out of a possible eigty-three points are considered acceptable. (See Exhibit F.) The form of contract is shown in Exhibit G.

C.4.9 Use of the Construction Management Procedure.

C.4.9.1 The construction manager, the architect and the owner in conference appraise the schematic design information to determine if the project can be constructed within the original price estimate. If the project is agreed to be solvent, the architect can proceed with final design work, the working drawings and specifications.

C.4.9.2 The construction manager, when and as determined by the owner, contributes cost estimating, materials evaluation and selection, and construction methods and timing expertise. At this time, value engineering is achieved by mutual agreement and the construction manager prepares his prebid price. This price is based on quantity take-offs by the construction manager and potential subcontractors. The quantity take-offs are priced according to the competitive market. This is an informal operation with the construction manager taking subcontract prices from a few selected subcontractors on whom he can depend.

C.4.9.3 A review by the three team members follows, to ascertain that the prebid price is within the budget. If the prebid price is acceptable, the architect completes his working drawings, specifications and contract documents for bidding purposes. If the price is not acceptable, design adjustments are made.

C.4.9.4 When the market is favorable, the construction manager, in concurrence with the owner, obtains competitive bids, as would be done for a lump sum bid job. He also obtains competitive bids on those materials to be installed by his own forces, if any. Thus, with the exception of the labor employed for his own work, all required labor and materials are competitively bid.

Conventionally, the owner receives a sealed lump sum bid only from the general contractors, with each general contractor listing his major subcontractors. The general contractor obtains most of his subbids by telephone, later to be confirmed in writing. Herein occurs the major portion of bid shopping.

Under Construction Management procedure, *sealed* bids are required from all subcontractors. Bids remain sealed until delivered to the owner, and are then opened in the presence of the construction manager, the architect and the owner. This procedure eliminates subcontract bid shopping because each bid is unknown until the time all are opened.

C.4.9.5 The construction manager then prepares a final or guaranteed outside price (GOP) based on the price of his work plus the prices from the successful subcontractors. The final price remains guaranteed until altered by change order.

The GOP is increased or decreased only by the change orders. Time extensions and liquidated and ascertained damages apply as in a conventional lump sum contract.

C.4.9.6 The construction manager's contract *may* require that: if the actual completed cost exceed the GOP, the owner pays only the GOP; if the final price is less than the GOP plus change orders, the construction manager and the owner share the savings in the predetermined ratio.

C.4.9.7 After the GOP is established and accepted by the owner, construction of the project proceeds.

C.4.10 The following construction schedule compares Construction Management with the general contractor method. (See Exhibit I, page 65.)

C.5 THE USE OF PROCEDURES

C.5.1 GENERAL

C.5.1.1 ABS, in its present form, is a body of information that can be applied in a variety of ways—ranging from conventional to innovative. The potential of ABS can best be exploited by applying the concepts and procedures previously discussed to the fullest extent possible. Thus, the optimum ABS project would ally phased design and construction with construction management, and employ subsystem prebidding to assure delivery and the early development of essential cost information.

The program-design-construction process can be considered as a set of phases. Although the designation and sequence originate in the conventional process, they are equally applicable in the use of ABS.

These phases are:

a. Programming
b. Schematic Design
c. Design Development
d. Working Drawings and Specifications
e. Bidding
f. Contract Award
g. Construction
h. Alteration

The recommended application of the procedures on a project would have the following impact on each of the above phases.

C.5.2 PROGRAMMING

C.5.2.1 ABS assists programming by providing three types of criteria: budget development costs, user requirements, and cost/performance comparisons. The data already accumulated is a significant resource for academic facility programming, and can measurably improve the decision processes.

C.5.2.2 Budget development costs are provided in the form of functional area costs. These are the synthesis of cost analyses of existing academic buildings, and provide functional area costs. Their application provides a more realistic budget than does the conventional method based on typical building costs. Both the programmer and the user can better negotiate a responsible and yet responsive budget.

For example, the faculty member is immediately aware of the impact from his request for more laboratory space at $52.93/sq.ft., as opposed to the librarian's request for space at $40.63/sq.ft.

The functional area costs are developed in ABS Publication 2, *Cost/Performance Study: Six Science and Engineering Buildings.*

To become an even more effective budgeting tool, the functional area costs need to be expanded for many more university buildings, and continuously updated. In the use of ABS, these costs should be automatically derived for new buildings. When the cost estimates for each ABS building are structured in the appropriate form, comparisons can quickly be made.

C.5.2.3 User requirements originate in the needs of the various users and must be met by the new academic building. The concern is with the general requirements—those basic to the nature of learning, teaching and research, and to the environmental needs of the individual. These are in contrast to those specific requirements that must be stated in the building program, wherein the specific requirements for a particular group of users are given.

Thus, the development of ABS has emphasized activities and their requirements, rather than building types and academic disciplines. Future buildings need to be structures capable of accommodating a changing variety of space types and disciplines. Academic departments must become accustomed to being tenants rather than owners of buildings. The single function building, whether for laboratories, classrooms, or a single discipline, is no longer appropriate to the pace of change on the campus.

The user requirements statements by ABS presents the various kinds of users and their activities, and a study of building environment and character in which the activities are performed. The focus is on the common attributes; whether the users are students, staff or faculty; in the sciences or the humanities; and whether in Indiana, California, or elsewhere. The needs of different kinds of users are discussed, and significant differences are pointed out.

The user requirements are developed in ABS Publication 1, *Environmental Study: Six Science and Engineering Buildings*.

C.5.2.4 Cost/performance comparisons are provided in the ABS Publication 2. Performance characteristics and costs for the building's components are shown. This data provides a basis for determining the cost of a requirement, and thus to evaluate its priority.

For example, the cost relationship between additional HVAC capacity versus higher lighting levels can be clearly seen.

C.5.2.5 Phased design and construction scheduling commences after establishment of gross building area. The major impact is: once the gross area is decided, it sets the design and construction process in motion. After approval, initial gross areas decisions cannot be reversed. The detailed areas for program activities will be studied for a longer time period, however, and decisions can be made much later than in the conventional process.

C.5.2.6 Neither construction management nor prebidding will have specific impact on the programming phase.

C.5.3 SCHEMATIC DESIGN

C.5.3.1 The ABS planning concepts provide a discipline that must be understood and accepted by the design professionals involved. The space module concept is the basic tool. The critical decision involves the use of either the deep or shallow service space. Premature changes in the concepts will result in ineffective testing of the system, and the institution will be unable to derive the expected benefits from ABS.

C.5.3.2 Phased design and construction scheduling requires the schematic design to be a critical decision point. Once approved, decisions made herein are irreversible.

C.5.3.3 Construction management will have no specific impact on the schematic design phase, unless the construction manager is selected soon enough to be a member of the team. Typically, this will not be the case, as information about the schematic design may be important in deciding the basis for choosing the construction manager.

C.5.3.4 Prebidding will have impact on the schematic design phase only if the drawings are to become contract documents, as discussed under "Bidding" (C.5.6).

C.5.4 DESIGN DEVELOPMENT

C.5.4.1 This phase has less significance in an ABS project, for the design will be essentially completed in the preceding schematic design phase. This materially benefits the schedule time for the design phase.

C.5.4.2 Phased design and construction scheduling may require two or more design development efforts, spaced in time. Sufficient information is provided to define the construction of the permanent elements of the building. However, detailed space definition need not be provided until shortly before installation of the required subsystems. Obviously, some of the decisions normally made in the conventional design development process are either postponed or are reversible—either can be a decided advantage to the building and its prospective occupants.

The final layout of interiors can be delayed until just prior to construction. Thus, the arrangement of partitions (openings, texture, color), the services distribution (secondary, terminals, controls), the HVAC distribution (terminals, controls) and the casework and exterior wall (types, openings, materials, colors) can be finally defined just prior to installation.

The advantage is that the design development is brought into conformance with the latest program and budgetary requirements, then finalized. This contrasts with the conventional method, wherein the program and budget are necessarily fixed at a much earlier date.

C.5.4.3 Construction Management. It is desirable to have the construction manager appointed early enough to be a member of the team at this stage. His participation in non-system selection and systems and non-systems applications are particularly valuable.

C.5.4.4 **Prebidding,** if done, will produce known subsystem suppliers and installers with details and costs for assistance during this stage of design development. Alternatively, design development information may form part of the drawings and specifications for the prebidding process.

C.5.5 WORKING DRAWINGS AND SPECIFICATIONS

C.5.5.1 ABS simplifies this phase by providing the subsystems and basic design interfacing for a major portion of the building. The design professional will have completed design calculations for Structure and for HVAC—commenced during the Design Development Phase. That information provides the data necessary to complete the detailing of the subsystems.

Contracts for the Partitions and the Lighting-Ceiling subsystems can be based primarily on performance specifications, and will need minimal detailing.

The greatest demand on the design professional will be the conventionally required detailing of non-systems work, and the definition of interfaces between the ABS subsystems and the non-systems work.

C.5.5.2 Phased design and construction scheduling will materially change both the scope and scheduling of working drawings. Precise definition of subsystem contract scope is critical if redundancy in bidding and confusion during construction is to be avoided.

C.5.5.3 Construction Management. If the full value of this procedure is to be received, the construction manager must have been previously appointed so that he is a full member of the team at the commencement of this phase.

C.5.5.4 Prebidding will materially affect the scope and scheduling of working drawings. The nature of this is next discussed.

C.5.6 BIDDING

C.5.6.1 ABS subsystems do not necessarily affect the bidding phase. However, the whole bidding process is transformed through the use of phased design and construction, construction management and prebidding.

C.5.6.2 Both design and construction and construction management tranform the bidding phase, as discussed in Section C, "Procedures."

C.5.6.3 Prebidding of subsystems for ABS projects is desirable, to build reliable cost information on the subsystems involved. Bidding on the subsystems by requiring unit prices is the most effective means of doing this.

The terms used for description of a subsystem in prebidding documents will vary from one subsystem to another. Structure involves no proprietary or manufactured system, and should be bid relatively conventionally—using conventional working drawings and specifications. The same is true for HVAC. Lighting-Ceiling and Partitions may use available proprietary systems, and thus can be bid using documents based on performance requirements, design descriptions, and schematic design drawings for the building to establish parameters of location, type and quantity.

The bid proposal for each prebid subsystem should request the appropriate unit cost information.

C.5.7 CONTRACT AWARD

C.5.7.1 The conventional general contract award will not occur under the ABS procedures. Phased design and construction changes the times at which subcontract awards are made. Construction management changes the mechanism of subcontract awards. Prebidding changes the time and scope of subcontract awards.

C.5.8 CONSTRUCTION

C.5.8.1 There are no necessary changes in the construction, since ABS uses readily available materials and methods. However, the use of phased design and construction and construction management will create changes in the management and scheduling.

C.5.8.2 The ABS planning concepts create opportunities for closer relationships among the ABS subsystems than is conventionally developed. This is because the interference is minimized among the ABS subsystems and, to some degree, within the non-ABS subsystems. Cut and fit modifications in the field are substantially reduced.

C.5.8.3 The ABS Structure subsystem is cleanly formed, with no horizontal penetrations for random services. The mechanical distribution is in straight lines, with few "dog-legs" to avoid unplanned obstructions. The partitions have no services penetration other than an occasional electrical or HVAC control. This minimization of interference requires less on-site special work, with obvious reductions in installation time and cost.

C.5.8.4 The concentration of the vertical services in service towers enables construction in the service space above the space module's ceiling to be carried on independently. Conversely, the time-consuming installations in mechanical and toilet rooms can proceed independently.

C.5.8.5 A further separation of craft effort, permitting overlapping installation schedules, is due to the concentration of services and HVAC distribution in an accessible area above the ceiling plane. The catwalk ceiling is installed as soon as structural formwork is removed and the concrete surfaces cleaned. Installation of services and HVAC distribution can proceed without floor-supported scaffolding, permitting earlier interior finishing preparations. Lighting and HVAC terminal installation takes place independtly of partitions installation. A high percentage of secondary services and HVAC distribution also takes place independently of finishing work.

C.5.9 ALTERATIONS

C.5.9.1 The deep service space with catwalk ceiling should be used in those building housing laboratories and shops—where frequent major changes in services distribution will be required in the academic facilities. The deep service space, because of its direct access to services, permits rapid alterations or additions. Disruption affects only the space being altered.

The shallow service space with access ceiling should be used in those buildings housing classrooms or offices where minimal services distribution modification will be required.

C.5.9.2 Major mechanical alterations or addition of new utility mains involve disruption of that service only in the space module, since all mains should have valve tees in vertical risers at points of main horizontal extension, and capped tees at points of proposed secondary distribution extension. HVAC alterations will require disruption of the space module only during changeover from existing to altered conditions. Additional ductwork and controls are installed to a convenient "break-in" point from the new terminal or space location. The obsolete distribution and controls are disconnected and closed as the new are connected.

C.5.9.3 Electrical alterations and extensions are similarly treated, with main control in each space module and zone controls with spare breakers in appropriate subdivisions of the space module. Lighting modifications involve setting new fixtures and plugging-in the lead to existing receptacles or junction boxes. Obsolete fixtures are unplugged, removed or relocated, and the vacant space filled with ceiling panels.

C.5.9.4 Partitions alterations and additions require a simple dismantle and reinstallation, with disruption of only those spaces defined by the partitions; 95% reuse of materials is expected. New partition locations involve noise disruption of other spaces in the space module if explosive-driven floor fasteners are used.

C.5.9.5 The user can relocate secondary service terminals and casework if the distribution within the room is of the hose/extension cord type. If code or other regulations will not permit this, then the institution's craftsmen or outside contractors must be used.

C.5.9.6 Phased design and construction, construction management, and prebidding procedures normally relate only to initial construction and do not affect building use or alteration. The exception would be when alterations are of such magnitude as to justify repeating their application.

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FACTORS INVOLVED IN PREQUALIFICATION OF BIDDERS*

It should be remembered that money in the bank and ability to make bond does not solely make the bidder responsible. The following areas should be fully explored:

1. **Financial Resources.** The bidder's detailed audited financial statement should be carefully examined. The "quick" assets should be ratioed to the "quick" liabilities and rated. (See Exhibit B, item 1.4.) The bidder's bank should be identified, with the official's name acquainted with the bidder's financial standing. An open letter of credit from the bank should indicate the amount of credit the bank is willing to lend and state the bank's lending experience with the bidder. If there is question as to overall financial picture, the proposed bidder should be discussed with the bank.

2. **Surety.** The bidder's surety coverage should clearly identify the full name of the surety company, its home address, and the name and address of the broker handling the bidder's account. If there is question as to the bidder being able to perform, a call to the broker or the surety's bond manager at the home office may resolve any doubts. Also, if later during construction the contractor cannot be made to perform in a satisfactory manner, a call to the surety's home office bond manager will usually help.

3. **Insurance.** The contractor's insurer and the broker handling the account should be known. If some doubt exists, call the broker or the insurance company.

4. **Construction Ability.** The ability of the bidder to complete the project should be thoroughly investigated. Just because he has successfully built large hotels or wood frame housing does not necessarily mean that he has the ability to build a high-rise science building. His experience record during the past five years should be carefully examined. What he built prior to that means little as methods change and so does the contractor's organization.

5. **Completion Ability.** The ability of the bidder to meet reasonable completion dates successfully, with a minimum of time extensions, should be considered. The assessment of liquidated damages on previous projects should not be overlooked. Does the bidder make good time during the construction of the work with his own forces and then drag during the period his subs are finishing the work? How does he get along with his subs? Does he run the sub in finishing, or do the subs run his job for him?

6. **Personnel.** It is important to know the office and field personnel who will administer and manage the construction. Does the bidder have skilled personnel? Are they available for the project? (This information may not be known prior to bidding but it should be ascertained and considered before contract award.)

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*The prequalification procedure can be applied to any type of bidding. It need not be confined to Construction Management.

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7 **Equipment**. The amount, type, and condition of the bidder's equipment are important qualifications, especially if the contractor is going to do considerable work with his own forces. How much of this equipment is liened? Look at his yard to see if it is well-maintained equipment.

8 **Work Load**. Find out what jobs the bidder has on the books to be built during the period of the project's construction time Is he overcommitted? What portion of the project will he construct with his own forces? Does he intend to sub most of it and act as a broker, or is he a competent builder? (Avoid the "broker" type.)

9 **Client Relationship**. The ability of the bidder's organization to work compatibly with the owner and the architect is most important. Check this with other clients. Does he submit his extra proposals promptly? Do the estimates for these leave a bad taste with either client or architect? Is he cooperative in the field, or is he going to build "his way" without regard to the wishes of owner or architect? Does he follow written instructions faithfully and promptly?

10 **Type of Firm**. The bid will tell whether the firm is an individual, a partnership, a corporation or a joint venture. If it is a joint venture, both venturers should be qualified and it should be known which one will sponsor or run the job.

11 **Safety Record**. The safety record is appraised in the workmen's compensation figure, and in the bidder's acceptance by his bonding company as reflected in his bond rate, and indicates whether he is a preferred risk or run of the mill

EXHIBIT B
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CONSTRUCTION MANAGER PREQUALIFICATION EVALUATION

Name of Bidder: ______________________________ City: ____________________

Owner's Evaluator: ____________________________ Date: ____________________

Evaluation is to be based on detailed information previously requested of the bidder in the Notice to Contractors. If any of this information is not supplied, the evaluation must remain incomplete.

The questionnaires and financial statements, and therefore these evaluations, are not public records and are not open to public inspection.

These evaluations are based on a system of point ratings to be applied objectively to information provided by each bidder. These point ratings are:

Poor	=	1 point	Good	=	3 points
Average	=	2 points	Excellent	=	4 points

The following evaluations must be completed to determine the bidder's prequalification and before contract documents are issued to him for bidding purposes.

	Prequalification Item		Actual Point Rating	Maximum Points Possible
1.0	**Financial Resources:**			
1.1	Financial statement over 90 days old		______	1
1.2	Financial statement less than 90 days old		______	2
1.3	From financial statement submitted, determine:			
1.3.1	Current Assets as follows:			
	a. Cash on hand and in bank	$________		
	b. Notes receivable	________		
	c. Accounts receivable from completed contracts	________		
	d. Sums earned on incomplete contracts	________		
	e. Other accounts receivable	________		
	f. Negotiable securities	________		
	g. Other current assets, list	________		
	h. Total current assets	________		

Prequalification Item — Actual Point Rating — Maxium Points Possible

i. Do not include in above any of the following:
Advances to construction joint ventures
Materials inventoried in stock
Real estate
Construction plant and equipment
Furniture and fixtures
Investments of non-current nature
Value of paid up life insurance
Other non-current assets

1.3.2 Current Liabilities as follows:

a. Current portion of notes payable, exclusive of equipment obligations and real estate encumbrances . . . . $__________

b. Accounts payable, including those to subcontractors . . . . __________

c. Other current liabilities, list . . . . __________

d. Total current liabilities . . . . $__________

e. Do not include in above any of the following:
Real estate encumbrances
Equipment obligations secured by equipment
Other non-current liabilities and non-current notes payable
Reserves
Capital stock paid up

1.4 Determine ratio of current assets to current liabilities by dividing 1.3.1.h by 1.3.2.d above, and rate as follows:

			Actual Point Rating	Maxium Points Possible
Poor	=	1.0 or less	_______	1
Average	=	between 1.0 & 1.5	_______	2
Good	=	between 1.5 & 2.0	_______	3
Excellent	=	over 2.0	_______	4

1.5 Determine working capital by subtracting current liabilities from current assets:

Current assets . . . . $__________
– Current liabilities . . . . __________
= Working capital . . . . __________

Prequalification Item	Actual Point Rating	Maximum Points Possible

1.6 Determine bidder's financial limitation by adding the working capital and bank credit as stated in letter of credit together and then multiplying by 4:

Working capital . . . . $________
\+ Letter of credit . . . . ________
____
x 4 = Limitation . . . . ________

This financial limitation indicates the size of the job the bidder is qualified to bid on. This limitation should be related to the dollar estimate of the owner's project:

			Actual Point Rating	Maximum Points Possible
Poor	=	more than 10% below estimate	______	1
Good	=	equal or above estimate	______	3

1.7 From financial statement, determine ratio of cash available to complete the job:

			Actual Point Rating	Maximum Points Possible
Poor	=	1 to 4% of contract estimate	______	1
Average	=	4 to 7% of contract estimate	______	2
Good	=	7 to 10% of contract estimate	______	3
Excellent	=	over 10% of contract estimate	______	4

1.8 From open letter of credit from bidder's bank, rate credit available for construction of this job:

			Actual Point Rating	Maximum Points Possible
Poor	=	below $500,000	______	1
Average	=	$500,000 to $1,000,000	______	2
Good	=	$1,000,000 to $2,000,000	______	3
Excellent	=	over $2,000,000	______	4

1.9 From letter from bidder's bank, determine contractor's borrowing experience during past five years:

			Actual Point Rating	Maximum Points Possible
Poor	=	continuous loans on hand	______	1
Average	=	substantial loan every year	______	2
Good	=	occasional loan every two years	______	3
Excellent	=	no loans during last five years	______	4

EXHIBIT B

	Prequalification Item	Actual Point Rating	Maximum Points Possible
2.0	Surety: From statement submitted by bidder listing name of surety and name of local broker handling account, determine:		
2.1	Did surety ever have to complete any of bidder's work:		
	Poor = once in last five years	______	1
	Good = never	______	3
2.2	How many different sureties has bidder had in last five years:		
	Poor = more than one	______	1
	Good = only present one	______	3
3.0	Insurance: From statement submitted by bidder listing name of insurance carrier or carriers and name of local brokers handling accounts(s), determine:		
3.1	Is insurance handled by more than one agent or broker:		
	Poor = more than one	______	1
	Good = only present one	______	3
3.2	Has bidder had any workmen's deaths during last five years:		
	Poor = 3 or more	______	1
	Average = 2	______	2
	Good = 1	______	3
	Excellent = none	______	4
3.3	Bidder's insurance losses during last five years:		
	Poor = over $500,000	______	1
	Average = $100,000 to $500,000	______	2
	Good = $50,000 to $100,000	______	3
	Excellent = below $50,000	______	4
4.0	**TOTAL POINT RATING**	______	38

The above point ratings permit a bidder to score a total of 38 points with the best possible evaluations. A rating of 30 points or more will prequalify a bidder to take out contract documents for bidding purposes.

EXHIBIT C
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STATEMENTS TO BE INCLUDED IN THE "INFORMATION FOR BIDDERS"

1.0 GENERAL REQUIREMENTS

1.1 It is the intent of the owner to award a contract for the construction of these facilities based on the Construction Management procedure. In such a procedure, a prime contractor is determined by competitive bidding on the fees and other fixed commitments entering into his cost of doing business. This bidding shall be based on preliminary drawings and outline specifications which indicate in some detail the general scope of the project. The successful contractor is to act as a building consultant by providing construction "know-how" and "value engineering" to the owner and the architect during the development of the working drawings. The contractor will be required to submit periodic current cost estimates of the work for owner's use in determining the project's solvency. Subject to the owner's approval and as the documents are completed for the various trades, the contractor shall obtain competitive subcontract bids allowing such work to proceed. As the drawings near completion, the contractor shall convert his previous cost estimates into a Guaranteed Outside Price based on competitive subcontract bids and which price shall be maintained during the balance of the construction, except as it may be revised by change orders authorized by the owner and representing changes in the scope of the work. If the contractor's final construction cost, including fees, exceeds this GOP, the owner shall make payment only up to the GOP. If this final cost is less than the GOP, the difference is shared in the proportion as bid under Shared Savings.

1.2 In evaluating the fee bids, the owner will apply its own predetermined units of measure to arrive at a total dollar cost of each fee and commitment bid by the contractor, as described herein. For the purpose of this bidding procedure, it is estimated that the cost of construction to be built under this contract will total (amount) and will require (number) calendar days to complete after the Notice to Proceed. Occupancy is contemplated for (date).

1.3 After the GOP has been established, the contractor may, subject to the architect's written approval, suggest changes in construction methods, the substitution of materials and minor design changes which will result in a reduction of construction cost or time. All such savings shall be net without fee mark-up and shall be apportioned to owner and contractor as set forth in the contractor's bid. The GOP shall be adjusted for such approved savings by change order.

2.0 PROPOSALS

Proposals will be received only on the owner's Form of Bid for the complete construction as shown on the bidding plans and as set forth in the bidding specifications and on the basis of the percentage fees for the contractor's services and other commitments as set forth herein and shown on the Form of Bid.

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2.1 The fees and other commitments to be bid in the Proposal and the manner in which these bids will be evaluated by the owner are as follows:

2.1.1 Percentage fee to be applied to cost of construction provided by contractor's own forces, including labor, material, and/or equipment. The owner shall apply to this fee bid an estimated dollar value of the work to be done by the contractor's own forces. The same dollar value shall be applied to each bidder's fee.

2.1.2 Percentage fee to be applied to the total cost of subcontract work. The owner shall apply to this fee bid an estimated dollar value of all subcontract work.

2.1.3 Dollar cost of performance bond for each $100 of contract. All bids will be evaluated by multiplying the dollar cost of bond as bid by (number of 100's in 1.2).

2.1.4 The percentage of contractor's Experience Manual Rate (from 100%) as established by the State Rating Bureau to be used in estimating the cost of Workmen's Compensation Insurance. In evaluating this cost in dollars, the owner will assume each of the bidders will perform the same dollar amount of work with his own forces. The owner will estimate the resulting cost of the contractor's direct labor, and to this will apply a predetermined percentage of insurance cost adjusted to each bidders manual rate as bid.

2.1.5 The percentage to be applied to the estimated contract price representing the total cost of contractor's Indirect Job Labor Burden. This cost shall not include any non-job labor or home office overhead. Dollar evaluation of this bid will be determined by multiplying the percentage bid by the estimated cost.

2.1.6 The percentages to contractor and to owner on any Shared Savings in construction cost that might be later suggested by contractor aand accepted by the owner during construction phase. The owner shall apply a predetermined dollar value of savings estimated to be made during this phase to the percentages as bid.

2.1.7 The per diem charge to be made by Contractor for consulting services authorized by the owner during the final design stage and preparation of the construction documents. The owner will apply a predetermined number of consulting days to the per diem in evaluating this bid.

2.2 After all of the above seven bid items have been evaluated and converted to total dollars, a final evaluation will be made of each bidder based not only on the total dollar amount determined from the bid but also based on the contractor's financial resources, his surety and insurance experience, construction experience, completion ability, personnel available, equipment available, workload, and client relationship. Final evaluation and award will be on the basis of the proposal most advantageous to the owner. The owner reserves the right to reject any or all bids and to waive any irregularities in any bid received. Award may be made to other than the low dollar bidder.

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INFORMATION REQUIRED ON BID PROPOSAL FORM

1. Percentage fee of______% to be applied to the authorized cost of the work performed with the contractor's own forces, including labor, material, and equipment.

2. Percentage fee of______% to be applied to the authorized cost of work performed by any authorized subcontractor, or material supplied by any authorized supplier.

3. Cost of Performance Bond of ______% per $100.00 of total contract amount.

4. Cost of Workmen's Compensation Insurance based on______% of Contractor's Experience Manual Rate as established by State Rating Bureau, and as applied to contractor's base insurance cost.

5. Cost of Indirect Job Labor Burden as______% of total estimated construction cost.

6. We propose to split post-contract savings in the cost of construction (if any) with the owner on a ratio of ______% of such savings to the owner and______% of such savings to the contractor.

7. If awarded a construction contract on the basis proposed above, we further offer our services to the owner as a consultant during the final design stage of the final construction documents, as may be authorized by the owner, at a rate of $__________ per diem per person. It is understood that up to four hours of such consulting time will be considered as one-half per diem, and any time over four hours in one day will be considered a full per diem. If consultation is required with one of our major subcontractors, a charge for such similar consultation will be at a rate of $__________ per diem.

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EVALUATION OF BID
For
(NAME OF PROJECT)

Name of Contractor: ______________________________ City: ______________________

Owner's Evaluator: ______________________________ Date: ______________________

In order to evaluate the fee bids received, the owner will apply the following predetermined units of measure to the fees and commitments as bid to arrive at an equivalent dollar figure:

BID ITEM[a]	Bid Figure	Dollar Evaluation
Fee to be applied to work performed with contractor's own forces as bid: Owner's estimated value of the work: $150,000[b] x ______% =	______%	$______
Fee to be applied to work performed by subcontractors as bid: Owner's estimated value of the work: $1,850,000[b] x ______% =	______%	______
Cost of Performance Bond per $100 of estimated contract price = Owner's estimate = $2,000,000 ÷ $100 x ______¢ = 200,000 x ______¢ =	______	______
Cost of Workmen's Compensation Insurance based on manual rate = Owner's estimate of the cost of this insurance assumes that Contractor's own labor = $75,000 (½ of item 1) and that 8% of this labor cost represents the cost of this insurance, adjusted by the Contractor's manual rate as bid. The adjusted cost of this insurance would = .08 x ______% (manual rate as bid) x $75,000. =	______%	______
Cost of Indirect Labor Burden as bid: Owner's estimate of cost = $2,000,000 x ______% =	______%	______
Sub-total Cost		______
Shared Savings, Owner's share/Contractor's share, as bid: Owner's estimate of savings to be shared = $50,000[b] and owner's portion of savings = deduction of	___/___	______
NET COST TO OWNER		$______
Per diem cost of Contractor's consulting service as bid: Owner's estimate of cost = 30 days[b] @ $ ________ , as bid =	$______	______
Per diem cost of Subcontractor's consulting service as bid: = Owner's estimate of cost = 15 days[b] @ $ ________. as bid	$______	______
Total Cost Consulting Service =		$______

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[a] See following pages for explanation of bid items. The explanation is not part of the documentation furnished to the

[b] These estimated figures (quantity shown for example only) may be given to the bidders for information, but this worksheet is for Owner's use only.

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EXPLANATION OF SEVERAL AREAS OF SAVINGS INCLUDED IN BIDS

1. **Fee on the Base Bid.** The contractor proposes a fixed fee percentage to be added to any job cost, including subcontracts, entailed in completing construction of the project as finally detailed by the architect. This may later be converted to a fixed price.

2. **Fee During Design Phase.** The contractor is retained by the owner as a construction consultant during the working drawing stage, to reduce costs in the detailed design through application of his construction expertise. The method of payment is a per diem charge determined by bid. This applies to prime as well as mechanical, electrical, and other subcontractors.

3. **Cost of Bonds.** Performance bonds are considered necessary. The cost or premium for these bonds varies among contractors. The contractor with the best performance record enjoys a premium rate of, say, $0.55 per $100, against his worst competitor whose rate might be $0.85. Where the owner requires the bonding of certain subcontractors after the prime award, an allowance is set up in the prime's contract to cover the cost of these premiums. Since it is estimated that not over 50% of the subcontractors require bonding, selectivity in this area by the contractor, the architect, and the owner keeps this contract cost to a minimum.

4. **Workmen's Compensation.** This is another competitive area in the contractor's cost. The bidders are required to indicate their manual rate of insurance as set by the State. One contractor's rate may be as low as 65% of manual rate, while another's rate may be 125% or even higher, depending upon his past three years' experience on Workmen's Compensation Insurance. One death on a job can materially affect a contractor's insurance rate on his job labor. This in turn affects the owner's cost. On a competitive basis, the contractor with the lowest rate saves the owner money.

5. **Indirect Job Labor Burden.** The non-productive or indirect job labor used on the job site will vary somewhat depending on the contractor. Some contractors, usually the smaller ones, are tempted to move half their home office force out to the job site, in order that they thereby become a part of job cost for which the owner pays and on which the contractor can collect his base fee. Larger contractors tend to keep this indirect labor burden to a minimum. Thus, this becomes another competitive bid item as it affects each contractor's net cost. Any personnel in this list not priced in the bid is considered part of the home office overhead. His cost is considered included in the base fee structure.

6. **Shared Savings.** After the award of contract a prime contractor may come up with savings in cost by substitution of materials or change in method (with the architect's and owner's approval). Sharing of such savings between the contractor and the owner is include in contract provisions. This split or sharing can run from 50/50 to 75/25 or even 100/0 in favor of the owner. It is another competitive item in the bidding procedure.

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The above items indicate, generally, the enlarged areas of savings in the bidding in the Construction Management type of contract over the lump sum bidding procedure. In the latter procedure all the contractor's unknown risks and costs are lumped into the bid with an increase in the fee to cover the unknown overhead, and a hope for a fair profit. To be successful, the Construction Management documents must define clearly what constitutes job cost, office vs. field overhead, rentals on small tools and large equipment, the GOP or guaranteed outside contract price to be determined before work starts, travel expenses, and other such "general condition" items peculiar to this type of contract. In the end, this approach provides for a quicker, cheaper, and better built job than is possible to obtain otherwise.

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POST BID EVALUATION
(Optional — For Owner's Use Only)

After the bidding, the low contractor is to submit the following before his bid is accepted. Should the low bidder fail, the second low bidder would be evaluated:

1. **Construction Experience:**

   a. Types of construction contractor has specialized in during past five years: ________ pts.

   1 = Poor; housing, wood
   2 = Average; housing, wood and/or concrete and/or masonry
   3 = Good; educational, industrial, commercial concrete and/or masonry up to $2,000,000
   4 = Excellent; ditto over $2,000,000

   b. Percentage of work done with contractor's own forces: ________ pts.

   1 = Poor; 0% (maybe deduct 1 point for this type of "broker")
   2 = Average; 5 to 8%
   3 = Good; 8 to 12%
   4 = Excellent; over 12%

   c. Jobs successfully completed on this campus during past five years: (major jobs) ________ pts.

   1 = Poor; no jobs
   2 = Average; two jobs
   3 = Good; five jobs
   4 = Excellent; over five jobs

2. **Completion Ability:**

   a. Has contractor failed to complete a major job, $50,000 or over, during past five years? ________ pts.

   1 = Poor; one or more jobs
   3 = Good; no jobs

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b. How many major jobs ($1,000,000+) has contractor completed during the past five years within the original contract time schedule without regard to time extensions? ________ pts.

1 = Poor; no jobs
2 = Good; one job
3 = Average; two jobs
4 = Excellent; three jobs

c. If owner's jobs, how many days of LAD have been assessed against contractor during past five years? ________ pts.

1 = Poor; over 50 days
2 = Average; 11 to 50 days
3 = Good; 0 to 10 days
4 = Excellent; none

d. On previous owner's jobs, do finishing trades drag out the job or does contractor push? ________ pts.

1 = Poor; let subs run
2 = Average; sets schedules
3 = Good; sets schedules and regular meetings
4 = Excellent; aggressively pushes subs

e. On previous owner's jobs, does contractor get along well with subs and does he pay them promptly? ________ pts.

1 = Poor; irritation and delays pay
2 = Average; occasional quarrels, no cooperation
3 - Good; maintains cooperation, pays regularly
4 - Excellent; inspires cooperation and pays promptly

f. Contractor's history of stop notices by subs or suppliers during past five years: ________ pts.

1 - Poor, over 100
2 - Average, 25 to 100
3 - Good, 0 to 25
4 - Excellent, none

EXHIBIT F

3. Personnel:

a. Name of person in contractor's office who will administrate contract: ________ pts.

1 = Poor
2 = Average
3 = Good
4 = Excellent

Based on past performance of contractor in areas of promptness and accuracy of submittals, price requests, payment requests, change orders and other correspondence.

b. Name of job superintendent in field who will be in charge of construction: ________ pts.

1 = Poor
2 = Average
3 = Good
4 = Excellent

Based on past performance of individual named with reference to his personal performance considering job atmosphere, coooperation, administration of sub, willingness to negotiate fair values for changes and adherence to schedule requirements.

4. Equipment

a. Review amount, type and condition of contractor's equipment need for job: ________ pts.

1 = Poor; has no equipment of his own
2 = Average; plans to rent or lease 75% of equipment required
3 = Good; plans to rent or lease 50% of equipment required
4 = Excellent; plans to rent or lease 25% of equipment required

b. How much of this equipment is liened? ________ pts.

1 = Poor; 75% or more
2 = Average; 25 to 75%
3 = Good; up to 25%
4 = Excellent; none

c. By observation, is equipment well maintained? ________ pts.

1 = Poor; rusty, poorly maintained
2 = Average; well used, barely serviceable
3 = Good; used but serviceable
4 = Excellent; well maintained and organized, reliably serviceable

5. Work Load:

a. Other jobs contractor has on books to complete. Is he overcommitted for his size? ________ pts.

1 = Poor; is already overcommitted and behind on completion
2 = Average; is straining under overcommitments but is not yet behind schedule
3 = Good; is now working a full capacity and not behind
4 = Excellent; this project will bring contractor to full capacity

b. What other work is he planning to take on if he gets this job? ________ pts.

1 = Poor; plans to add on all additional work he can get
2 = Average; plans to add a large block of additional work
3 = Good; plans to add work selectively
4 = Excellent; plans to add work only as he completed existing commitments

6. Client Relationship:

a. On previous owner's work, does contractor work compatibly with owner's staff and/or architect? ________ pts.

1 = Poor; has always had to be forced to cooperate
2 = Average; reluctantly cooperative
3 = Good; congenial and cooperative
4 = Excellent; very cooperative and frequently assumes initiative in mutual problem solving

b. If new to owner, review his reputation for this with other owners and architects: ________ pts.

1 = Poor; has always had to be forced to cooperate
2 = Average; reluctantly cooperative
3 = Good; congenial and cooperative
4 = Excellent; very cooperative and frequently assumed initiative in mutual problem solving

EXHIBIT F
Page 5 of 5

c. Does he submit extras promptly, in good form without loading or leaving bad taste? ________ pts.

1 = Poor; leaves bad taste
3 = Good; satisfactory

d. Is he cooperative in administration of contract or does he build "his way"? ________ pts.

1 = Poor; "his way"
3 = Good; cooperative

e. Does he follow written instructions or give "lip service"? ________ pts.

1 = Poor; "lip service"
3 = Good; satisfactory

f. Is architect satisfied with past performance? ________ pts.

1 = Poor; no
3 = Good; yes

TOTAL ________ **pts.**

On the above evaluations, a contractor could score a possible 83 points. A contractor scoring 65 or better on the Post Bid Evaluation and possessing the lowest acceptable dollar bid should be awarded the contract.

EXHIBIT G
Page 1 of 2

CONTRACT

THIS AGREEMENT made this______day of__________,1971, by and between____________

____, herein called "Owner," and

____

Strike out applicable terms
(a corporation) (a partnership)
(an individual doing business as ______________________________________

____

of __________ , County of ___________, and State of ___________, hereinafter called "Contractor."

WITNESSETH: That for and in consideration of the payments and agreements hereinafter mentioned, to be made and performed by the OWNER, the CONTRACTOR hereby agrees with the OWNER to commence and complete the construction described as follows:

(NAME AND LOCATION OF PROJECT)

hereinafter called the project, on a fee basis, not to exceed the Guaranteed Outside Price, as specified in Article ______, Compensation, of the General Conditions of the Contract; and to furnish all the materials, supplies, machinery, equipment, tools, superintendence, labor, insurance, and other accessories and services necessary to complete the said project in accordance with the conditions and prices stated in the Form of Bid, the Information to Bidders, The General Conditions of The Contract, the Assignment Agreement, The General Conditions, the Plans, which include all maps, plates, blueprints, and other drawings and printed or written explanatory matter thereof, the Specifications and Contract Documents thereof as prepared by (name and address), herein entitled the Architect, all of which are made a part hereof and collectively evidence and constitute the contract.

The Contractor hereby agrees to commence work under this Contract on or before a date to be specified in a written "Notice to Proceed" by the Owner and to fully complete the project within____ consecutive calendar days thereafter. The Contractor further agrees to pay, as liquidated damages, the sum of $__________ for each consecutive calendar day work remains incomplete as hereinafter provided in Article _____ of The General Conditions.

WNER agrees to pav the CONTRACTOR in current funds for the performance of the contract, t to additions and deductions, as provided in the General Conditions of the Contract, and to payments on account thereof as provided in Section ____, Payment Provisions, of the General tions.

ITNESS WHEREOF, the parties to these presents have executed this contract in ______ (__) erparts, each of which shall be deemed an original, in the year and day first above-mentioned.

ST: ________________________________ (Owner)

________________________________ (Secretary) By ________________________________

________________________________ (Witness) ________________________________ (Title)

________________________________ (Contractor)

________________________________ (Secretary) By ________________________________

________________________________ (Witness) ________________________________ (Title)

________________________________ (Address)

E: Secretary of the Owner should attest. If Contractor is a corporation, Secretary should attest.

CONSTRUCTION MANAGEMENT TERMINOLOGY

ıe present time, terms such as construction manager, construction consultant, and management acting are being freely and loosely used. The following is an attempt to clarify this terminology.

term construction manager has been useo throughout this manual with reference to the basic ›aches discussed, and is used as defined below.

rract

ontract is a voluntary agreement between competent parties to do or abstain from doing some ıl act for a valid consideration." (from *Successful Management for Contractors,* L.C. Miller, raw-Hill Book Co.).

ɪr or Client

Owner is the person or organization identified as such in the Agreement and is referred to ıghout the Contract Documents as if singular in number and masculine in gender. The term Owner s the Owner or his authorized representative. (See *Gordon Forms of Agreement.*) Client may be ituted for Owner, but the latter is preferable.

ractor

Contractor is the person or organization identified as such in the Agreement, and is referred to ıghout the Contract Documents as if singular in number and masculine in gender. The term ractor means the Contractor or his authorized representative. (See *Gordon's Forms of Agreement.*)

ontractor

bcontractor is a person or organization who has a direct contract with a Contractor to perform of the work. Nothing contained in the Contract Documents shall create any contractual relation een the Owner or the Architect and any Subcontractor or Sub-subcontractor. (See *Gordon's ıs of Agreement.)*

ral Contractor, Prime Contractor, Building Contractor

e terms are used loosely to distinguish between the various Contractors.

ıe Owner has one construction contract for an entire project, then the designation is The ractor.

e Owner has agreements with several Contractors, such as Site Contractors, Mechanical Contractors Electrical Contractors, the General Contractor may be given the responsibility of coordinating all vork and may be designated The Prime Contractor or Building Contractor.

/ states also have specific licensing requirements relating to the role of General Contactor.

EXHIBIT H
Page 2 of 2

Construction Consultant
Whether or not the Contractor or other Contractors have consultants is immaterial. The term should be confined to the Owner's prerogative to hire, on a professional basis, such a consultant to advise the Owner and/or the Architect. If he has duties and responsibilities other than consultive, he should be designated as Owner's representative.

Contract Manager
This is a misleading term. The Owner can designate one of his staff as Contract Manager or he can designate a representative (outside his organization) as Contract Manager—with full knowledge of the Contractor. Then, too, the Contractor may have a Contract Manager as distinguished from the Superintendent. The Owner's representative should be referred to as the Owner's Project Manager. Such a manager should be designated, and by name, especially if an outside firm or individual is designated as Owner's representative.

Construction Manager
Other than in this manual, this term has been used synonymously with Contract Manager.

As used in this manual, Construction Manager is the Contractor's man responsible for the construction phases including procurement, expediting and other administrative matters.

The term is applied to the Contractor selected either by negotiation or through competitive bid for a building construction job, for which a final contract price remains to be established after the selection of the Contractor.

This term, as differentiated from General or Prime, is a semantic means to distinguish the method and means of arriving at a total Contract price.

The main differences from Lump Sum Contracts are:

1. The Construction Manager consults with the Owner and the Architect during the preparation of the final design, working drawings and specifications.

2. The Construction Manager assists the Owner and the Architect in modifying the plans, if required, to bring the project within budget.

3. The Construction Manager, the Owner and the Architect together open, review, and award or veto Subcontractor bids.

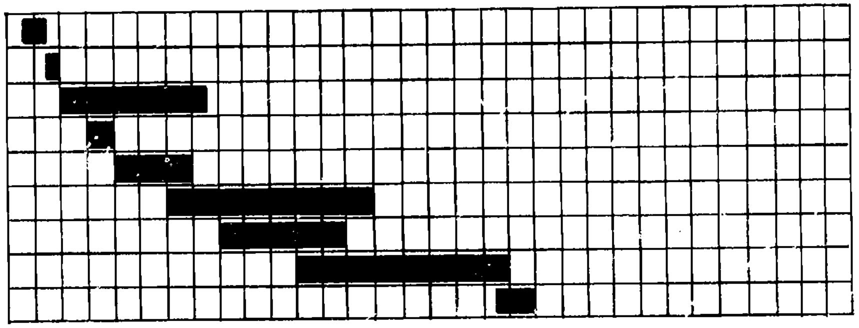
CONSTRUCTION MANAGEMENT COMPARED WITH GENERAL CONTRACTOR METHOD

Project No. CH-Calif-239(D)

CONSTRUCTION SCHEDULE **MONTHLY PROGRESS**

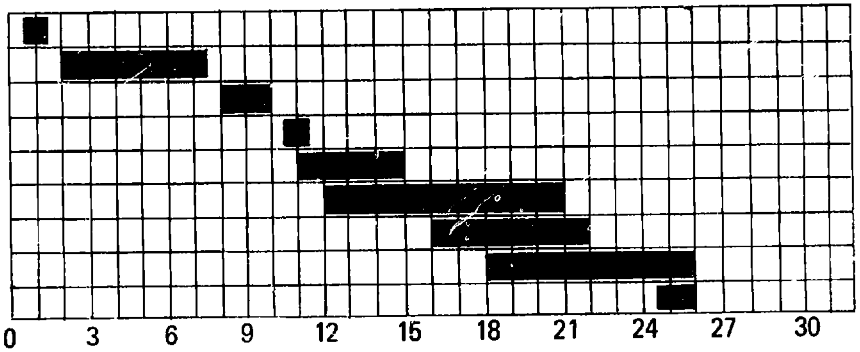
A. CONSTRUCTION MANAGEMENT

SCHEMATIC DESIGN	3 weeks
CONSTRUCTION MANAGEMENT BIDDING	2 weeks
WORKING DRAWINGS	5.5 months
SITE GRADING AND EXCAVATION	1 month
FOUNDATIONS TO GRADE	3 months
STRUCTURAL SUPERSTRUCTURE	8 months
MECHANICAL, HVAC	5 months
FINISHING TRADES	8 months
CLEAN-UP AND MOVE-IN	6 weeks
TOTAL CONSTRUCTION TIME	**17.0 months**
TOTAL ELAPSED TIME	**19.5 months**



B. GENERAL CONTRACTOR METHOD

SCHEMATIC DESIGN	3 weeks
WORKING DRAWINGS	5.5 months
LUMP SUM BIDDING AND AWARD	2 months
SITE GRADING AND EXCAVATION	1 month
FOUNDATIONS TO GRADE	4 months (weather)
STRUCTURAL SUPERSTRUCTURE	9 months (weather)
MEACHANICAL, HVAC	6 months (weather)
FINISHING TRADES	8 months
CLEAN-UP AND MOVE-IN	6 weeks
TOTAL CONSTRUCTION TIME	**15.5 months**
TOTAL ELAPSED TIME	**25.5 months**



The time savings from using Construction Management result primarily from the contractor's ability to start foundation work well bef
completion of working drawings.

D. COST/PERFORMANCE CONTROL

D.1 BACKGROUND

D.1.1 ABS was developed to meet two specific objectives:

a. Improve the performance and adaptability of buildings and their subsystems in response to requirements of the users.

b. Provide the highest levels of performance within a given budget or given levels of performance at the lowest cost.

D.1.2 Conventional levels of performance and cost were determined from detailed analyses of three University of California bioscience buildings and three science and engineering buildings at Indiana University and Purdue University. That effort is reported in the ABS Publication 2, *Cost/Performance Study: Six Science and Engineering Buildings.* Portions are abstracted here for comparing existing buildings with ABS buildings. All costs reflect January 1970 prices in the San Francisco Bay Area (Engineering News-Record Construction Cost Index 1300.) Adjustment of these costs for differences in time and geographical location is required for application to a specific building project.

D.1.3 The control of cost and performance variables is implied in the second objective stated above. ABS criteria offer a variety of options permitting selection of the most advantageous combinations within a programmed budget. Cost/performance checks may be made at successive stages of project development. Different trade-off situations may be applied to individual space modules in the same building. This information provides the owner and design professional with a basis for comparative cost benefit analyses within the framework of the ABS subsystems packages.

D.1.4 The information needs to be tested and expanded to achieve the full potential of ABS. Suggestions for refinements and modifications will be welcomed.

D.2 OVERALL COST CONSIDERATIONS

D.2.1 The control objective is to provide the highest continuing facility response to owner/user needs within a programmed budget. Academic institutions usually express a budget in terms of initial construction cost, with little or no emphasis on continuing cost.

D.2.2 Paradoxically, although reduced funding and competition for available resources places additional emphasis on first cost, the importance of *first* cost in relation to *life* cost is lessening because inflation is substantially increasing the costs of utilities, services and financing.

2.3 The long range financial implications strongly indicates that institutions should redirect the emphasis from first cost to life cost where there is greater opportunity for monetary savings.

3 FIRST COST

3.1 First Cost includes

- a Site acquisition and site clearance
- b Site improvement: landscaping, roads, walks, utilities and services to buildings
- c Building construction
- d Academic program equipment installed in the building
- e Fees: title, surveys, tests, architects, engineers, consultants and inspectors
- f Interim financing of construction

3.2 First cost is affected by length of time required to program, design and construct a building. Construction costs continue to increase month by month. In the last decade, the rate of increase has escalated from 4% to 14% per year. Obviously, a time saving is a cost saving.

3.3 First cost is also affected at time of bidding by seasonal climate and contractor workload.

3.3.1 Winter months involve less construction activity due to inclement weather or completion of work during the preceding fall. As there is time and personnel available, this season provides lower and more thoroughly researched bids. Also, winter bidding permits prefabrication during the inclement weather, for late spring installation.

3.3.2 Construction activity is at its height during the summer months. Many contractors will bid but with higher costs due to the burden of extending their operations.

3.3.3 Early spring bidding enables the contractor to be "out of the ground" by fall, and usually permits work to continue through the winter with nominal down-time.

3.4 The ABS subsystems combined with phased design and construction, construction management, and prebidding of selected components permit lower first cost because of value engineering and reduction in total project time.

D.4 LIFE COST

D.4.1 The total cost of constructing, operating, maintaining and altering a building during its reasonable life period is referred to as life cost. The life cost includes:

a. The first cost

b. Long term financing cost

c. Maintenance and Operations costs: utilities, housekeeping, repairs, and replacement of damaged or worn components to maintain the building in functional condition

d. Building alteration costs necessary to accommodate academic program needs

e. Disruption cost—difficult to assess, but a substantial amount, represents cost of occupants' time lost and academic equipment down time.

D.4.2 Maintenance and operation costs are often given little attention. But conventional emphasis on first cost with its objective to obtain a low bid often results in use of materials and methods adversely affecting the life cost of the building. Inferior quality increases operation and maintenance costs. Nationally, university records indicate that combined operations and maintenance costs incurred each year are from 2% to 5% of the initial cost, and invariably exceed the first cost of the facility in its useful lifetime. For 1970, approximately $1.25/OGSF per annum is the accepted average cost of operations and maintenance for academic buildings. Because of higher use of HVAC and utilities, the cost for science and engineering buildings is considerably greater than this average. A small increment of saving annually in operation and maintenance costs would have a significant effect on life cost.

D.4.3 Alteration or modification can be as minor as changing a door swing, or as major as the internal reorganization of a building. The ability of a building to respond to change influences alteration costs. Records[5] show that within the last forty years alteration costs have been as high as three times first cost. With academic requirements changing at an increasing rate, those facilities unable to accommodate changes economically will impose an inhibiting effect on the users.

D.4.4 Where building alterations and repairs prevent users from effectively working, the disruption cost can be measured in terms of the users' salaries for non-productive time. A conservative estimate indicates the average disruption time cost to be 15% of the alteration cost. Use of the deep service space in the ABS space module would eradicate almost all of this cost.

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[5] Cumulative capitalized costs (book value) of the Life Science Building at the Berkeley campus of the University of California rose from initial construction cost of nearly two million dollars in 1928 to six million dollars in 1968.

D.4.5 The monies involved in life cost for a building are shown below. The tabulation is based on a forty year life, 10,000 square foot building constructed in two years at a cost of $40 per square foot.

	Cost	% of Total
First Cost	$ 400,000	10
Interim financing $200,000 @ 8%	32,000	1
Long term financing @ 4%	640,000	16
Operations and maintenance:		
$1.25/sq.ft. escalating 5%/yr.		
$860,000@ constant dollars	2,000,000	50
Alterations 2 x first cost	800,000	20
Disruption @ 15% of alterations	120,000	3
Life Cost	$3,992,000	100%

The most appreciable cost saving attributable to ABS appears to be in the substantial reduction of alteration and disruption costs.

D.5 ALTERATION COSTS

D.5.1 Adaptability is measured by the cost of making changes relative to first cost. The cost of change depends on several factors—the ease or difficulty of access to the components, the labor skill required, the time required, the disruption to users, the mechanical subsystem "down-time" and the size of the isolation zone involved, and the equipment needed to make the change.

D.5.2 Cost tests of adaptability were made during the ABS development. Since the ABS space module offers two alternative service space types, each having rather different implications for adaptability and cost of change, both were tested under the same conditions as for the six existing buildings. The succeeding model, extending data from the ABS Publication 2, *Cost/Performance Study: Six Science and Engineering Buildings,* is based on a two-stage alteration project consisting of a typical plan segment of four 30' x 30' bays.

D.5.3 The cost tabulations show the components and subsystems most expensive and least expensive to modify, and identify significant cost areas. The cost estimates assume the following factors for the two ABS buildings and the six existing buildings:

a. Alterations A-B and B-C are made five years apart.

b. Floor finish material is not replaced throughout the altered spaces but is repaired as required.

c. ABS partitions will not need general refinishing. A scrap factor of 10% covers needed repairs and replacements.

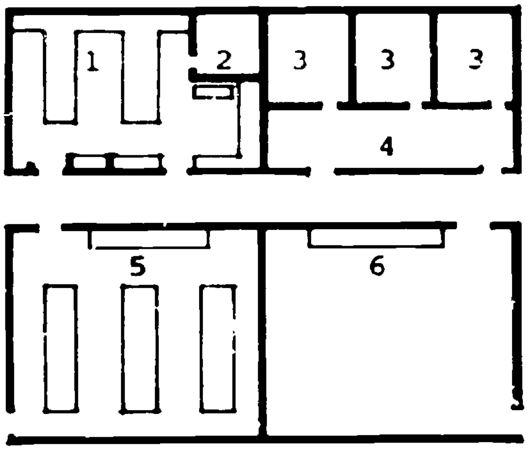
d. Five percent of any suspended ceiling will require replacement.

e. Exposed structural ceilings are repainted in affected rooms.

f. HVAC zone addition costs are identical for double duct or reheat single duct.

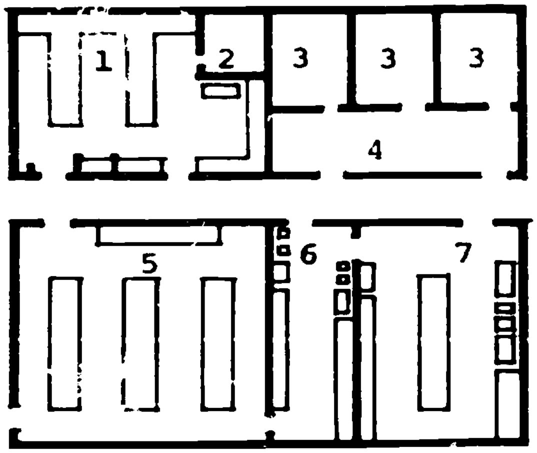
g. As new laboratory casework is the same in all cases, its cost is not included. However, the cost of removing existing laboratory cabinetwork is included.

D.5.4 ALTERATIONS MODEL



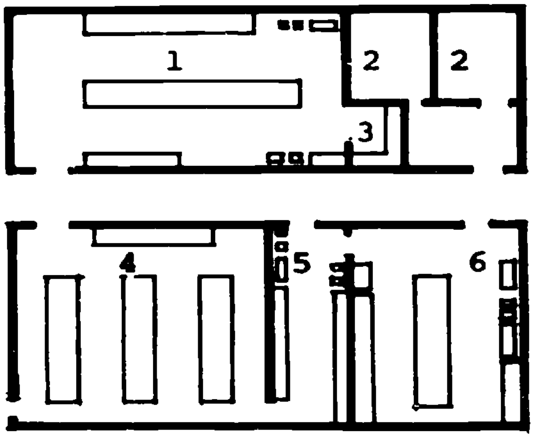
1. chemistry lab
2. office
3. faculty offices
4. typists
5. teaching lab
6. storage

A. INITIAL PLAN



1. chemistry lab
2. office
3. faculty offices
4. typists
5. teaching lab
6. prep room
7. graduate research

B. ALTERATION



1. biology lab
2. TA office
3. dark room
4. teaching lab
5. prep room
6. graduate research

C. ALTERATION

D.5.5 ALTERATIONS COSTS

ALTERATIONS A–B	CALIFORNIA			INDIANA			ABS	
	DAVIS	IRVINE	SANTA BARBARA	BLOOM-INGTON	INDIAN-APOLIS	PURDUE	SHALLOW SERVICE SPACE	DEEP SERVICE SPACE
PAINTING	483	426	474	172	173	172	--	--
CEILING	--	--	--	3,195	3,195	3,195	60	60
PARTITIONS	1,797	1,762	1,871	2,035	1,803	2,030	917	917
FLOORING	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080
PLUMBING	5,360	4,247	4,713	3,956	3,459	3,594	4,237	4,002
ELECTRICAL	474	501	748	628	564	667	432	397
LIGHTING	170	330	490	210	170	290	170	170
HVAC	676	916	802	1,510	1,342	2,170	718	644
MISCELLANEOUS	60	60	60	60	60	60	60	60
GEN. CONTRACTOR	2,121	1,958	2,150	2,698	2,488	2,784	1,612	1,539
TOTALS	12,221	11,280	12,388	15,544	14,334	16,042	9,286	8,869

ALTERATIONS B-C								
PAINTING	545	469	589	231	231	231	--	--
CEILING	150	150	--	2,840	2,840	2,840	90	90
PARTITIONS	1,284	1,286	1,248	1,669	1,546	1,667	900	900
FLOORING	120	120	120	120	120	120	120	120
PLUMBING	1,650	985	786	1,677	1,233	1,309	845	684
ELECTRICAL	355	369	383	369	432	350	369	357
LIGHTING	720	930	620	380	920	920	430	390
HVAC	758	480	558	360	806	210	240	170
MISCELLANEOUS	180	180	180	180	180	180	180	180
GEN. CONTRACTOR	1,210	1,043	942	1,643	1,745	1,644	667	607
TOTALS	6,972	6,012	5,426	9,469	10,053	9,471	3,841	3,498

D.5.6 The succeeding charts indicate several pertinent factors concerning the cost of adaptability both in the existing buildings and in ABS buildings.

D.5.6.1 Alteration A-B changes a Storeroom into a Preparation Room and Graduate Research Laboratory. Both ABS examples were less expensive to alter than any of the existing buildings. In California buildings, by far the most expensive item to change was the plumbing. In Indiana buildings, the ceilings were the most expensive to change because the suspended plaster ceilings had to be ripped out and replaced in the space being remodeled and in the space below. Plumbing costs in Indiana buildings were high for essentially the same reasons as in California buildings. In the two ABS examples, several items were identical in cost because of the service space concept. However, plumbing was the most expensive item to change because of the additional pipe required from the service space down into the rooms below, plus the addition of laboratory table outlets.

D.5.6.2 Alteration B-C converts a Chemistry Laboratory and two Offices into a Biology Laboratory and Darkroom. Again, both ABS examples were less expensive to change than any of the existing buildings, with alteration costs in the Indiana buildings substantially higher than in the California buildings. In California, partitions and plumbing were the most expensive items to change; partitions costs were high because of adding new partitions and removing old ones; and high plumbing costs were again due to adding piping and outlets. In Indiana, the ceiling was again the most costly item to change. In the two ABS examples, as before, several items were identical. The partitions were most costly to change because of the large amount of wall to be relocated or demounted and stored. Plumbing was the second most expensive item.

D.5.7 COMPARISONS: TOTAL COST OF ALTERATIONS.

	Alteration A-B	Alteration B-C
California buildings average cost	$11,963	$ 6,137
Indiana buildings average cost	$15,307	$ 9,664
ABS cost: shallow service space	$ 9,286	$ 3,841
% of California average	78%	63%
% of Indiana average	61%	40%
ABS cost: deep service space	$ 8,869	$ 3,498
% of California average	74%	57%
% of Indiana average	58%	36%

D.5.8 COMPARISONS: ALTERATION ITEMS AS PERCENTAGE OF TOTAL COST.

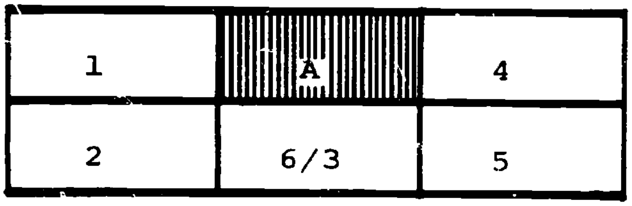
Alteration Item		Average for California Buildings	Average for Indiana Buildings	ABS Buildings	
				Shallow Service Space	Deep Service Space
		%	%	%	%
A-B	Painting	4	1	--	--
	Ceiling	--	20-22	1	1
	Partitions	15	13	10	10
	Flooring	9	7	12	12
	Plumbing	38-44	22-25	46	45
	Electrical	5	4	5	5
	Lighting	3	1	2	2
	HVAC	6-8	9-14	8	7
	Miscellaneous	1	1	1	1
	General Contractor	17	17	17	17
B-C	Painting	9	2	--	--
	Ceiling	2	28-30	2	3
	Partitions	18-23	15-18	23	26
	Flooring	2	1	3	3
	Plumbing	14-24	12-18	22	20
	Electrical	6	4	10	10
	Lighting	10-16	4-10	11	11
	HVAC	8-11	2-8	6	5
	Miscellaneous	3	2	5	5
	General Contractor	17	17	17	17

D.5.9 The foregoing comparisons clearly show that the ABS subsystems provide a positive benefit in terms of cost of adaptability. Coordination of the ABS subsystems and the ABS space module provides an environment that will respond to changing requirements at a reasonable price. Further, the results show the labor saving potential of the ABS building with deep service space for it costs substantially less to alter than the ABS building with shallow service space. In providing accessible service space, workmen can make alterations quickly, without disturbing the occupants below.

D.6 DISRUPTION

D.6.1 Disruption to users is an important factor in evaluating building adaptablility. Disruptions are less quantifiable in terms of cost and therefore infrequently considered in detail. The following study compares the effects of disruption to users during the course of the two stage alteration project (described in Section D.5) for the existing California and Indiana buildings and the two ABS examples.

D.6.2 EFFECTS OF DISRUPTIONS IN THE TWO-STAGE ALTERATION



☐	0 days
▒	1 - 6 days
▓	over 6 days

alteration		Disrupted spaces						
		1	2	3	4	5	6	A
Davis	B	▒		▒				▓
	C			▒				▓
Irvine	B			▒			▒	▓
	C	▒		▒			▒	▓
Santa Barbara	B	▒		▓				▓
	C	▒		▒	▒	▒		▓
Bloomington	B			▓				▓
	C			▓				▓
Indianapolis	B			▓				▓
	C			▓				▓
Purdue	B			▓				▓
	C			▓				▓
ABS shallow service	B			▒				▓
	C			▒				▓
ABS deep service	B							▓
	C							▓

D.6.2.1 In the existing buildings, conventional plumbing was the major expense because plumbing utilities must be brought from another area in use, involving new plumbing connections or rerouting. Because the waste lines were under the floor in the ceiling of the space below, that space was also disrupted. As many as five spaces were disrupted by the alteration in the existing buildings.

D.6.2.2 The ABS shallow service space example, with alterations only disrupting two spaces, is basically similar to the existing buildings with respect to plumbing and other utilities requiring access to the service space above the ceiling. However, its utility components are more readily adaptable since they are mounted on and do not penetrate partitions. The specific rights-of-way in the ABS service space also make the utilities more accessible. Further, the partitions are more readily demounted.

D.6.2.3 Alteration in the ABS deep service space example involved no disruption to adjacent academic spaces.

D.6.3 The disruption time in the two-stage alteration was determined by the tasks performed, the remodeling sequence and field conditions. The cost of the disruption time for university personnel was estimated at $70 per room disturbed per day of disruption.

D.6.3.1 The ABS shallow service space changes disrupted the space below about six days. The space being remodeled required another twenty days to finish, with a total room down-time of twenty-six days. The cost of disruption was $1,820.

D.6.3.2 The ABS deep service space changes did not disrupt the unremodeled spaces below. The changes within the remodeled space required fifteen days. The cost of disruption was $1,050—about half that cost in the conventional buildings.

D.7 ABS COST/PERFORMANCE BASE

D.7.1 Costs and the performance of subsystems in the existing conventional buildings are detailed in ABS Publication 2, *Cost/Performance Study: Six Science and Engineering Buildings.* The data is used here to compare with ABS costs for performance levels equal to or better than in the existing conventional buildings. Thus, the owner and the design professionals may:

a. Compare ABS costs, and ABS subsystems' performance, with that of the six sample buildings.

b. Evaluate ABS cost/performance alternatives.

D.7.2 The performance levels reflect ABS response to user reactions and requirements, as determined by the ABS research.

D.7.3 The cost/performance data relates to four ABS subsystems—Structure, HVAC, Lighting-Ceiling and Partitions—used in a five-story building. Each floor is two space modules, each being 90' x 120'; the area per floor is 21,600 square feet. Each space module has an accompanying mechanical room in an adjacent service tower.

D.7.4 For the cost/performance base this ABS building uses the shallow service space with access through the ceiling. A performance model as comparable as possible to the existing conventional buildings is thus provided.

D.8 ABS PERFORMANCE BASE: COMPARISON WITH SIX EXISTING BUILDINGS

(See table on opposite page.)

D.8.1 In the ABS Structure subsystem, bay sizes are 31% larger than average, an advantage for planning adaptability. Using conventional allowable deflections, the ABS design live load is 100 pounds per square foot, an increase of 8% in load bearing capacity. The number of stories selected for the ABS base model is five; ABS permits eleven. The floor-to-floor height at 14'-7" is higher than the average for the existing buildings, but the structure/services depth at 5'-7" is a gain of 1'-4" over the average for existing buildings. The ceiling height at 9'-0" clear is 9" higher than in the existing buildings. These figures are significant for they show how ABS provides a structure/services depth for greater services capacity without compromising the ceiling height in the occupied space below.

D.8.2 The ABS performance base HVAC subsystem provides an average of 1.75 cfm/sq.ft. throughout the building. This average includes the greater air quantities required in high demand areas—such as laboratories—where 2.0 cfm/sq.ft. is supplied.

D.8.2.1 The ABS performance base exceeds the averages for the existing conventional buildings as follows:

a. A gain of 50% in the average cfm/sq. ft.

b. The ABS ratio of 200 OGSF/ton of refrigeration is 41% lower than the existing average of 338 OGSF/ton; thus cooling capacity is considerably greater.

c. ABS provides 45% filtration throughout non-critical areas, with capability of achieving 90% filtration in laboratory or other spaces requiring high filtration efficiency. This compares with 44% for the existing average.

d. ABS performance base model was prepared on the basis of 1,000 square foot zones, slightly larger than the existing average of 855 square feet. Smaller zones may be provided, at slightly greater cost.

e. Only one of the existing buildings provided any humidity control, and then only in 15% of the building. ABS provides 100% at levels up to 60% relative humidity during summer cooling, and 30% relative humidity during winter heating.

D.8.2.2 ABS PERFORMANCE BASE: COMPARISON WITH SIX EXISTING BUILDINGS

	CALIFORNIA			INDIANA				
SUBSYSTEM	DAVIS	IRVINE	SANTA BARBARA	BLOOM-INGTON	INDIAN-APOLIS	PURDUE	EXISTING BUILDING AVERAGE	ABS
STRUCTURE								
BAY SIZES	600-800	900	900	420-700	600-770	480-680	685	900
LIVE LOAD	50	50	100	40-100	50-100	50-100	93	100
STORIES	6	5	6	5	5	5	5.3	5
FLOOR-TO FLOOR HEIGHT	14'-0"	12'-0"	14'-6"	11'-6"	12'-0"	13'-1"	12'-10"	14'-7"
STRUCTURE/ SERVICES DEPTH	5'-10"	4'-0"	5'-5"	3'-6"	3'-6"	3'-2"	4'-3"	5'-7"
CEILING HEIGHT	8'-2"	8'-0"	9'-1"	8'-0"	8'-6"	9'-11"	8'-3"	9'-0"
HVAC								
CFM/SQ.FT.	1.8	1.14	1.25	.66	1.05	1.1	1.17	1.75
OGSF/TON	240	295	175	450	530	340	338	200
FILTRATION	30%-35%	35%	50%	90%	35%	35%	44%	45%
OGSF/HVAC ZONE	1,000	670	460	1,000	1,000	1,000	855	1,000
HUMIDITY CONTROL (% BUILDING)			15%					100%
MECHANICAL FLOOR AREA (% OGSF)	6.4%	4.5%	11.5%	3.9%	7.6%	9.0%	7.2%	9.1%
LIGHTING-CEILING								
FOOT-CANDLES	not available	not available	not available	not available	not available	not available	not available	70
PARTITIONS								
TYPE	replaceable	replaceable	replaceable + demountable	replaceable + demountable	replaceable	replaceable	replaceable	demountable
STC	35-40	40	35-40	40-48	40-48	44	41	40

Note that the ABS subsystems comparable model offers higher levels of performance than the average for existing university buildings.

D.8.3 The mechanical room area represents an average of 7.2% in the existing buildings. The ABS shallow service space model, used in the foregoing performance base, uses 9.1% whereas the ABS deep service space requires but 8.3%. However, the existing buildings' figure is for HVAC equipment space only; the ABS figure includes all plumbing, electrical utilities, and HVAC. Further, the ABS HVAC subsystem handles nearly 50% more air and the equipment space therefor must be larger to accommodate this higher degree of performance.

D.8.4 The ABS Lighting-Ceiling subsystem performance characteristics are not readily compared with those in existing facilities because detailed information could not be obtained in the early phases of the ABS development. Unquestionably ABS offers improved levels and control of lighting. Moreover, ABS lighting-ceiling is a continuous plane, uninterrupted by partitions, throughout the space module. In the existing facilities, ceilings were usually omitted in laboratories and in some classrooms as well. Ceilings in laboratories respond to users' request for protection of experiments from the dirt which collects on exposed overhead mechanical equipment, ducts and piping. A ceiling also offers the opportunity for acoustical absorption needed in frequently neglected spaces such as teaching laboratories.

D.8.5 ABS Partitions subsystems are designed to provide a Sound Transmission Coefficient of 40, comparable to the average design performance of the existing facilities.

D.8.5.1 Because ABS partitions do not penetrate the ceiling plane, they may be demounted and relocated easily. The intention is that ABS lighting-ceiling and partitions subsystems will provide a much higher degree of internal spatial adaptability than was previously available to users of academic buildings. With the additional provision for adaptable services, ABS buildings will be able to accommodate rapidly changing functional demands with no sacrifice in performance levels.

D.8.5.2 Many of the walls in the existing facilities are non-structural, replaceable, and removable. The remainder, particularly in non-seismic areas, are concrete block or masonry and though technically replaceable, are both difficult and dirty to remove.

D.9 ABS COST BASE: COMPARISON WITH SIX EXISTING BUILDINGS

D.9.1 EXISTING BUILDINGS SUBSYSTEMS COMPARABLE TO ABS SUBSYSTEMS

	Structure	HVAC	Lighting-Ceiling	Partitions	Total Subsystem Costs
California					
Davis	7.29	4.20	1.80	3.39	
Irvine	7.38	3.66	1.40	2.96	
Santa Barbara	7.78	5.83	1.62	2.80	
California Average	7.48	4.56	1.61	3.06	16.71
Indiana					
Bloomington	4.54	4.56	1.61	4.98	
Indianapolis	4.82	4.85	1.43	3.96	
Purdue	5.96	4.17	1.44	5.33	
Indiana Average	5.10	4.53	1.49	4.76	15.88
AVERAGE — 6 Bldgs.	6.29	4.54	1.55	3.91	16.29

All costs are $/OGSF in January 1970 prices for the San Francisco Bay Area (ENR Construction Cost Index 1300).

D.9.1.1 The above figures represent costs for subsystems in the six existing buildings studied comparable in scope to the ABS subsystems. Because ABS was developed for national use, the costs of each subsystem were averaged—both for all six buildings and for the two regional groups (California and Indiana). The total cost for the integrated ABS subsystems was limited to the total cost of the equivalent subsystems in the existing buildings.

D.9.1.2 The basic cost data for the six existisng facilities in California and Indiana was developed by the ABS consultants. The resulting costs were important determinants in the selection of the ABS subsystems. Most of the decisions limiting the range of the ABS subsystems are based entirely on cost considerations.

D.9.1.3 An example was the decision to limit structural spans to 40 feet maximum. Obviously, clear spans up to 80 feet would satisfy all user requirements for adaptability by eliminating columns and providing a deeper structure for the interstitial service space. However, the cost of the longer span would have substantially exceeded the amount allowable for the ABS structure system.

D.9.2 ABS MODELS COST BASE: COMPARISON WITH EXISTING BUILDINGS

	Conventional	ABS Shallow Service Space	ABS Deep Service Space
SYSTEM			
Structure	6.29	4.80	5.15[a]
HVAC	4.54	4.32[b]	4.12[b]
HVAC—campus energy conversion	4.54	.39	.39
Partitions	3.91	2.00	2.00
Lighting-Ceiling	1.55	2.25	3.50
Subtotal	16.29	13.76	15.16
NON-SYSTEM/SYSTEM INFLUENCED			
Electrical	3.05	3.05[c]	2.75[d]
Plumbing	3.90	3.90[c]	3.50[d]
Height (cost penalty)		.34	.56
NON-SYSTEM/COMMON			
Site	2.66	2.66	2.66
HVAC	.54	.54	.54
Partitions	.96	.96	.96
Ceiling	.05	.05	.05
Exterior Skin	3.95	3.95	3.95
Elevators	.63	.63	.63
Other	2.21	2.21	2.21
Subtotal	17.95	18.29	17.81
Total	34.24	32.05	32.97
General Contractor (6.69/ for 6 bldgs. avg.)	2.29	2.14	2.21
TOTAL	36.53	34.19[e]	35.18[f]

[a] Additional height in structure subsystem with ABS deep service space costs $0.35.

[b] HVAC spread of $0.10 each way from $4.22 average HVAC subsystem cost.

[c] Same as conventional.

[d] 10% less than conventional.

[e] 6% less than conventional.

[f] 4% less than conventional.

D.9.2.1 The preceding chart breaks down the total building construction cost, comparing the ABS deep service space and the ABS shallow service space models with the average cost for the six conventional buildings studied. The performance level for the two ABS models is as delineated in subsection D.8.

The costs of non-system work in the ABS models are assumed to be the same as for the conventional buildings, except that plumbing and electrical work for the ABS deep service space model affords a 10% cost reduction because of the ease of installation and the accessibility of utilities.

The cost penalty for the additional floor-to-floor height in ABS buildings is discussed below.

D.9.2.2 Building Height Cost Comparisons.

	COST OF HEIGHT		
ITEM	ABS Shallow Service Space	ABS Deep Service Space	Conventional (Six Building Average)
Columns	a	a	$ 0.04
Elevator	$ 0.03	$ 0.03	0.03
Electrical	0.02	0.02	0.02
Exterior Wall	0.10	0.01	0.10
HVAC	0.01	0.01	0.01
Interior Wall	b	a	0.06
Plumbing	0.02	0.02	0.02
Shear Walls	a	a	0.12
Stairs	0.01	0.01	0.01
Cost/OGSF/ft. of height =	$ 0.19[c]	$ 0.10[d]	$ 0.41

[a] Omitted because included in ABS structure subsystem cost.

[b] Omitted because addition of building height does not affect ABS partition height—partitions are 9′ high, regardless of building height.

[c] The ABS shallow service space floor-to-floor height is 1′-9″ higher than the average for the conventional buildings. The cost of this extra height is: 1.75 x $0.19 = $0.34/OGSF and is applicable to all space modules using the shallow service space.

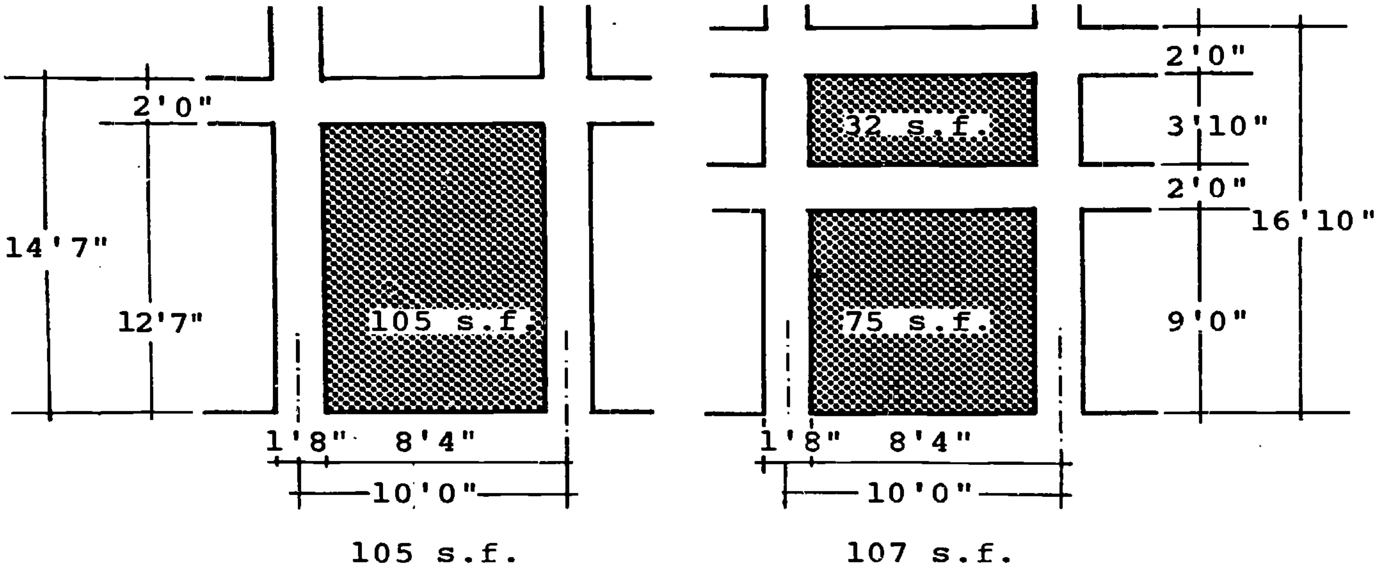
[d] The ABS deep service space floor-to-floor height is 2′-3″ higher than the ABS shallow service space model. The cost of this extra height is: 2.25 x $0.10 = $0.22/OGSF. Also, the ABS deep service space floor-to-floor height is 4′-0″ higher than the average for the conventional buildings. The cost of this extra height is:

$0.22 = deep service space added non-system cost
.34 = shallow service space added non-system cost
$0.56 = non-system cost penalty for deep service space
.35 = added structure cost for deep service space
$0.91 = Total cost penalty/OGSF for deep service space

D.9.2.2.1 The preceding chart and tabulations show that the increased height in the ABS models adds to the initial cost. However, the ABS models offer decided advantages in terms of maintenance, utilities distribution and adaptability.

D.9.2.2.2 The added structure cost of $0.35 for deep service space is the cost of increased column and exterior wall height. The exterior wall cost is also increased $0.01/OGSF/foot of height for additional caulking and the slight increase in exterior wall area over the ABS shallow service space model, as shown on the following diagram:

EXTERIOR WALL COSTS



D.10 ABS COST/PERFORMANCE ALTERNATIVES

Many diverse factors influence cost: building configuration, space module area, construction methods and local differentials, to name a few. All must be recognized in using this material as guidelines for cost/performance control of the ABS subsystems. The cost/performance alternatives are given to assist the owner and the design professional in appraising options for the highest level of performance within a given target cost, or a lesser level of performance at lower cost.

This material will be expanded and refined to reflect the cost experiences in ABS projects.

D.10.1 ABS STRUCTURE COST/PERFORMANCE BASE AND ALTERNATIVES.

D.10.1.1 The ABS Performance Base (described in subsection D.8) and the ABS Cost Base (described in subsection D.9) were derived from a typical project with the following physical description:

Construction Option:	Cast-in-place, post-tensioned light-weight aggregate concrete
Building Height:	Five stories of 16'-10"
Each floor:	120' x 180' = 21,600 sq. ft. (two coupled space modules)
Bay Framing Size:	30' x 30'

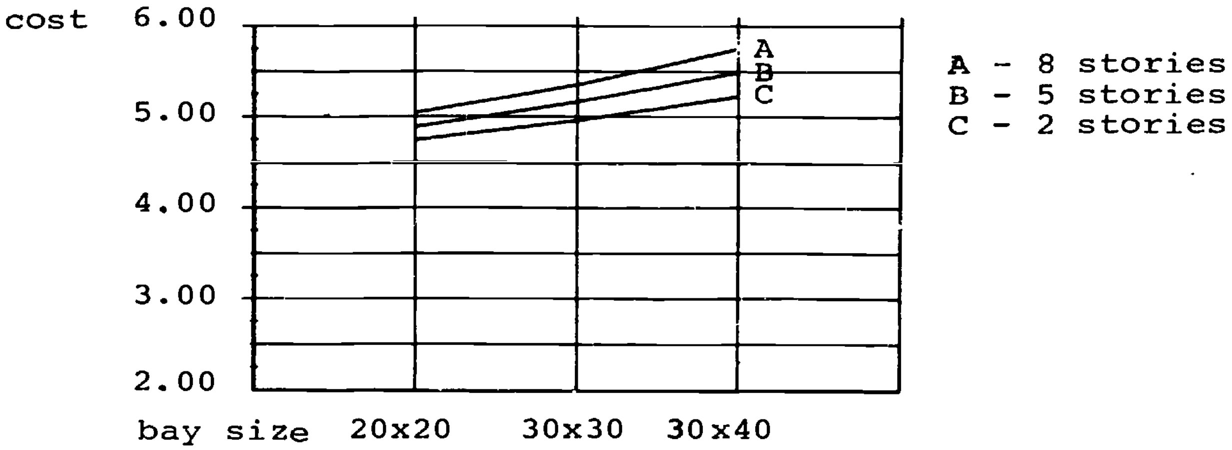
D.10.1.2 The ABS shallow service space cost at $4.80/OGSF, and the ABS deep service space cost at $5.15/OGSF were derived from the following unit prices:

<u>Concrete in Place</u>	
Normal: $30.00 per cubic yard	$30.00 per cubic yard
Lightweight:	$33.00 per cubic yard
Concrete Finishing:	$ 0.15 per square foot
<u>Formwork and Shoring:</u>	
Slabs:	$ 1.00 per square foot
Beam + girders:	$ 1.50 per square foot
Columns:	$ 1.50 per square foot
<u>Reinforcing Steel</u>	
In Place:	$ 0.16 per pound
Prestressing Steel <u>(unbonded type)</u>	
Complete	$ 0.68 per pound

Costs for special treatment and finishes are not included.
Costs do not include markup for contractor's overhead and profit.

The above unit prices were also used in developing the alternative costs shown hereafter. All costs are based on January 1970 prices in the San Francisco Bay Area (Engineering News-Record Construction Cost Index 20—cities Average at 1300.)

D.10.1.3 The ABS Structure Cost/Performance alternatives will vary substantially from project to project. The chart below indicates a general pattern and is intended to serve as a planning aid only. Individual costs for a specific project must be developed, taking into account all factors affecting construction at that location.



D.10.2 **ABS HVAC COST/PERFORMANCE BASE AND ALTERNATIVES.**

D.10.2.1 The ABS Performance Base and the ABS Cost Base in subsections D.8 and D.9, respectively, were derived from the typical project solution described in subsection D.10.1. The ABS shallow service space base cost at $4.32/OGSF, and the ABS deep service space base cost at $4.12/OGSF were based on the following assumptions:

a. 1.75 cfm/sq.ft. average
b. 1,000 sq.ft. average control zone size
c. Filtration 95% efficient throughout
d. Exhaust duct sizes based on 45% OGSF in labs supplied at 2 cfm/sq. ft.
e. Outside summer design temperature 97°F dry bulb and 77°F wet bulb
f. Outside winter design temperature 0°F dry bulbs minimum
g. functional areas (percent of OGSF):

offices and classrooms	15%
laboratories	45%
toilets and janitor closets	1%
circulation and other space	39%

h. Occupancy densities:

offices	one person/100 sq.ft. maximum
classrooms	one person/15 sq.ft. maximum
laboratories	one person/60 sq.t. maximum

i. Electrical heat gains:	
offices and classrooms	40 watts/sq.ft. maxium
laboratories	5.5 watts/sq.ft. maximum
toilets	1.5 watts/sq.ft. maximum
j. Roof heat transfer:	
summer	8.4 BTU/hr./sq.ft. maximum
winter	7.0 BTU/hr./sq.ft. maximum
k. Wall and glass heat transfer:	
summer	377 BTU/hr./lineal foot of wall maximum
winter	345 BTU/hr./lineal foot of wall maximum, including infiltration

D.10.2.2 Control Plant Costs

The following costs for campus energy conversion are additive to the ABS HVAC subsystem base cost:

For campus steam and chilled water, add $0.39/OGSF
For building boiler and 500-ton chiller, add $1.03/OGSF
For building boiler and 1,000-ton chiller, add $1.41/OGSF

D.10.2.3 Double Duct Supply Alternative

The equipment cost for a double duct supply is approximately the same as for the single duct reheat supply used as the base. However, the cost of additional building height to provide equivalent clearance around crossover ductwork is approximately $0.47/OGSF.

In circumstances where the $0.47 first cost disadvantage may not be critical, and total owning cost can be evaluated, the following analysis can be used as a basis for choice:

a. **Operating Cost** analysis has been performed for the Los Angeles climate and the Indianapolis climate.

Assumptions:
Operation 24 hrs/day, 365 days/year
Average cfm/sq.ft. = 1.75
Two space modules per floor at 12,000 sq. ft. each
Normal occupancy 12 hr/day, 5 days/week, 52 weeks/year
Only reheat energy inefficiency needs to be considered to determine the operating cost difference between the two types.

In Los Angeles, the energy cost is $0.24/OGSF/year greater for the reheat system.

In Indianapolis, the energy cost if $0.16/OGSF/year greater for the reheat system.

b. Owning Costs

Assumptions
40 years amortization, 6% interest rate
Only differences need be analyzed

Los Angeles operating cost difference = 24.0 cents/OGSF/yr.
Present worth of 47 cents first cost = 3.1 cents/OGSF/yr.
20.9 cents/OGSF/yr.

Indianapolis operating cost difference = 16.0 cents/OGSF/yr.
3.1
12.9 cents/OGSF/yr.

In both the Los Angeles and the Indianapolis climates, double duct supply although higher in first cost, is advantageous in total owning cost.

D.10.2.4 Total Air Volume Alternatives

The average air supply quantity is 1.75 cfm/sq.ft.:

For 1 cfm/sq.ft. deduct:	$0.95/sq.ft.
For 2 cfm/sq.ft. add:	0.16/sq.ft.
For 3 cfm/sq.ft. add:	1.05/sq.ft.

D.10.2.5 **Separate Exhaust Alternative** allows clean air and contaminated air producing activities to be economically housed within the same space module.

If the building program indicates that some space modules (e.g., an all office, or all classroom floor) will never require a separate exhaust system, the cost of separate exhaust duct mains and branches can be deducted. The HVAC subsystem for that space module will then handle all return air through the service space as a plenum, exhausting part of it at the fan room to compensate for outside air make up.

a. If the space module exhaust ductwork is deleted, deduct $0.75/OGSF for that space module.

b. If all space module exhaust ductwork throughout the building is deleted, including exhaust fans and ductwork on roof, deduct $0.88/OGSF of building.

D.10.2.6 Control Zones Alternatives

The HVAC base cost is based arbitrarily on using twelve control zones per space module. The performance requirements call for 10 to 30 control zones per space module.

The provision of additional control zones will increase the HVAC cost by $500-$600 per zone, including reheat box, ductwork, piping, control material and installation labor.

As an example of the affect on total unit costs:

12 zones/space module		= $4.22/OGSF
20 zones	(+$0.27/OGSF)	= $4.49/OGSF
30 zones	(+$0.54/OGSF)	= $4.76/OGSF

D.10.2.7 Humidity Control Alternative

The omission of humidity control equipment will reduce the cost by approximately $2,500 per module, or $0.17/OGSF.

D.10.2.8 Filtration Alternative

The HVAC subsystem can provide filtration efficiencies from 45% to 95%. The first cost difference between 45% and 95% is approximately $0.03/OGSF.

D.10.3 ABS LIGHTING-CEILING COST/PERFORMANCE BASE AND ALTERNATIVES

Cost analysis of available products meeting the lighting-ceiling subsystem performance base (70 FC; 40 STC; one-hour fire-rating; 2 cfm air delivery) indicates that the lower cost coffered ceilings can be installed for $2.00/OGSF to $2.25/OGSF plus suspension and catwalk costs as described below. The cost base for the lighting-ceiling subsystem is $2.25/OGSF for the shallow service space model, and $3.50/OGSF for the deep service space model having catwalks coverage 30% of the ceiling area.

D.10.3.1 Unit costs used in developing base and alternative costs are:

a. **Ceiling Suspension Rods** also carrying the services components are 5/8" mild steel all thread rod. Rods are required in all space modules. Length and spacing will vary. In the access ceiling, rods are approximately 3' long; in the catwalk ceiling, rods are approximately 5' long.

For access ceiling = $0.20/OGSF
For catwalk ceiling = $0.25/OGSF
(including structural inserts and nuts)

b. **Catwalk** fixed components are the hanger and joists. In space modules where a catwalk is utilized, the supporting framework is installed throughout. Unit prices for these are therefore constant:

5/8" mild steel all thread rods for catwalk ceiling	$ 0.25/OGSF
No. 10 gauge cold formed steel joists 5' o.c.	$ 0.75/OGSF
Total for joists and rods	$ 1.00/OGSF

c. **Catwalk Deck Panels.** Cost of single panels is constant but percent of coverage varies.

3.14 lbs/SF grating, framed in panels 2′ wide		$14.90/panel
Unit prices for percent of area covered:	30%	$ 0.45/OGSF
	50%	$ 0.74/OGSF
	75%	$ 1.20/OGSF
1½″ steel deck in 5′ x 2′ panels		$10.00/panel
Unit prices for percent of area covered:	30%	$ 0.30/OGSF
	50%	$ 0.50/OGSF
	75%	$ 0.76/OGSF

d. **Lighting-Ceiling**

Variation in the cost of lighting fixtures is so wide that only coffered panels are discussed herein. Unit costs relate to the number of fixtures required to provide the rrequired lighting levels. The required air delivery is also a variable factor affecting cost. The combined effect of these two variables on the average cost/OGSF of some lower-cost coffered lighting-ceiling subsystems is:

Air	LIGHTING LEVEL		
Delivery	30 FC	70 FC	100 FC
I CFM	1.55-1.80	1.80-2.05	2.30-2.55
2 CFM	1.75-2.00	2.00-2.25	2.50-2.75
3 CFM	2.05-2.30	2.30-2.55	2.80-3.05
	1/6	1/3	1/2

Ratio Lighting Coffers to Flat Panels

The chart above indicates that the performance requirements of 70 FC, 40 STC, one-hour fire-rated and 2 cfm air delivery of a coffered subsystem is $2.00-$2.25/OGSF.

D.10.3.2 Lighting-Ceiling Cost/Performance Alternatives

Following are examples of the unit cost figures used in a complete subsystem:

			$ Low	$ High
a.	Suspended, coffered access ceiling with average performance level for suspension hangers to carry services	lighting-ceiling	2.00	2.25
		add hangers	0.20	0.20
	COST/OGSF		2.20	2.20
b.	Catwalk ceiling with average levels of performance and 30% steel deck catwalk coverage	hangers	0.25	0.25
		joists	0.75	0.75
		panels	0.30	0.30
		lighting-ceiling	2.00	2.25
	COST/OGSF		3.30	3.55
c.	Catwalk ceiling with 100 FC performance and 75% expanded metal catwalk coverage	hangers	0.25	0.25
		joists	0.75	0.75
		panels	1.20	1.20
		lighting-ceiling	2.50	2.75
	COST/OGSF		4.70	4.95

D.10.4 ABS PARTITIONS COST/PERFORMANCE BASE AND ALTERNATIVES

The base cost of $2.00/OGSF for the Partitions subsystem is the same for both ABS models since all partitions are 9' high. This base cost is a responsible figure representative of a typical partition installation meeting the ABS performance base. The cost variables for finishes, accessories, and partition material are described below:

D.10.4.1 Unit costs used in developing alternative costs are:

Doors	
Doors:	$80-$100 each
Frames:	$60-$ 70 each
Hardware:	$85-$100/door
Panel Finishes	
Vinyl, factor applied:	$ .90/LF-$1.05/LF
Vinyl, field applied:	$1.80/LF-$2.25/LF
Paint, factory applied:	$1.00/LF-$1.20/LF
Paint, field applied:	$ .90/LF-$1.35/LF
Epoxy paint, field applied:	$5.88/LF-$8.64/LF

Partitions Trim Finishes

Clear anodized:	$ .54/LF of finish on std. aluminum head section
Light bronze anodized:	$1.16/LF of finish on std. aluminum head section
Medium bronze anodized:	$1.33/LF of finish on std. aluminum head section

Hanger Strips
(Heavy duty hanger strips to carry utilities, casework and other wall-mounted furnishings, 9' long, integrated into partitions at 30" centers.)

Steel strut-type hanger strip, 5/8" deep:	$2.90/LF of partitions
Aluminum flush hanger strip, 5/8" deep:	$4.00/LF of partitions

D.10.4.2 Cost Range of Partitions

These are combinations of the above unit costs with commercially available partition types meeting the ABS partition subsystem performance base.

a. Nonrated noncombustible gypsum demountable partition, factory applied vinyl, clear anodized aluminum trim.

	Low	High
partition w/base	$14.00/LF	$16.00
vinyl	.90	1.05
anodized trim	.54	.54
doors	7.25	8.70
Total Cost	$22.69/LF	$26.29
	$ 1.71/OGSF	$ 1.98

b. One hour noncombustible progressive demountable partition, field applied vinyl, medium bronze anodized trim, flush hanger strip.

	Low	High
partition w/base	$11.50/LF	$14.50
vinyl	1.80	2.25
anodized trim	1.33	1.33
hanger strip	4.00	4.00
doors	7.25	8.70
Total Cost	$25.88/LF	$30.78
	$ 1.95/OGSF	$ 2.31

c. One hour noncombustible clip-on steelfaced gypsum partition, factory applied paint, strut-type hanger strip.

	Low	High
partition w/base	$25.00/LF	$35.00
paint	1.00	1.20
hanger strip	2.90	2.90
doors	7.25	8.70
Total Cost	$36.15/LF	$47.80
	$ 2.72/OGSF	$ 3.58

d. One hour noncombustible gypsum and steel stud demountable partition, field applied epoxy paint, strut-type hanger strip.

partition w/base	$13.25	$16.00
paint	5.88	8.64
hanger strip	2.90	2.90
doors	7.25	8.70
Total Cost	$29.28/LF	$36.24
	$ 2.20/OGSF	$ 2.72

D.11 ENVIRONMENTAL ISSUES

A series of environmental issues of great concern to users of existing facilities emerged in the ABS research phase. Environmental problems, as yet unsolved, either interfered with the users' activities directly or made activities uncomfortable or unpleasant and therefore more difficult to perform. ABS was developed to solve as many of these problems as possible within the original ABS cost objectives.

D.11.1 VENTILATION

Odor control is an important environmental requirement in laboratory buildings. Odor from a large amount of noxious effluent air may be caused by complex interrelated HVAC design problems, insufficient quantities of fresh air, insufficient air exhaust and/or movement within spaces, poorly planned distribution patterns, insufficient pressure control within each space type, and proximity of air intake to air exhaust locations.

D.11.1.2 The ABS HVAC subsystem supplies an average of 50% more fresh air than the average for the existing facilities, and can exhaust 100% of the air used in the building, i.e., supply 100% fresh air if necessary. The potential for air movement within spaces is from 20-50 fpm in the occupied zone; the higher figure represents the level at which air movement begins to cause discomfort from drafts. ABS subsystem pressure control is by space type in order to isolate, through negative pressure, those building areas causing odor problems. Laboratories and toilets have negative pressure in relation to corridors, offices and classrooms—the most important spaces to be isolated from unpleasant or distracting odors. ABS subsystem air intakes are to the individual mechanical room at the space module floor level served; building exhaust is on the roof. Thus, possibilities for cross-contamination of air supply and exhaust are minimized.

D.11.2 THERMAL ENVIRONMENT

D.11.2.1 Science buildings differ from most buildings in that the environmental requirements for experiments must take precedence over the requirements for human comfort. In the existing buildings, users reported thermal conditions to be frequently unsatisfactory for both experiments and for human comfort. Spaces were often too hot or too cold, and without individual controls.

D.11.2.2 The ABS HVAC subsystem will maintain 75°F in winter and summer, and will provide users with room thermostats to control and maintain individual thermal environments within a tolerance of ± 1½°F.

D.11.3 LIGHTING

D.11.3.1 A well-lighted working environment is an important user requirement for performing tasks ranging from general classroom note-taking to precise, detailed experimental work. User reactions were that modern lighting tends to be too "bright." Users sometimes confuse lighting intensity with brightness; the discomfort sensed may be due to the latter rather than the former. Typical lighting installations try to provide an overall high intensity of light that is, in many instances, too high for activities.

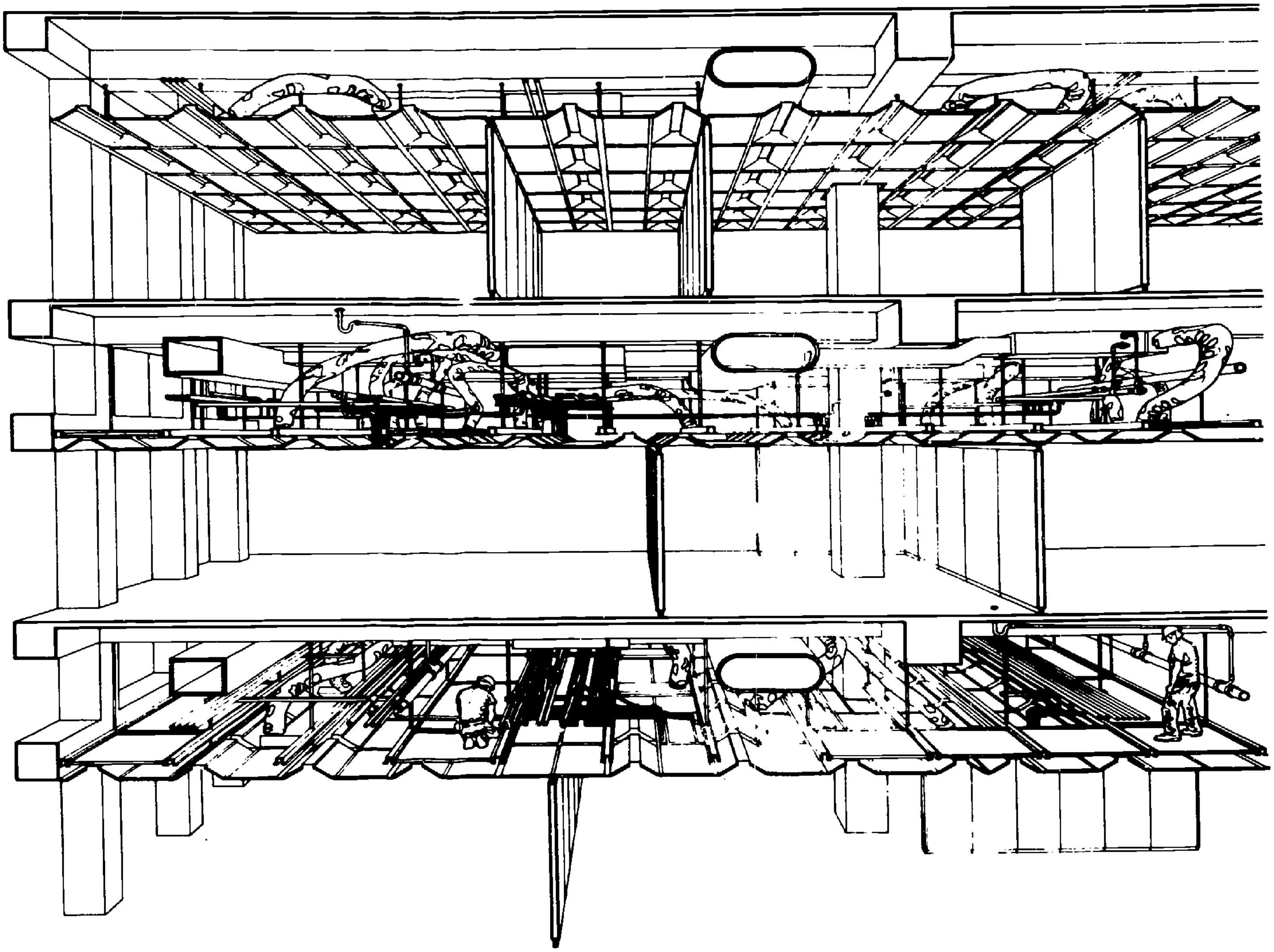
D.11.3.2 ABS provides alternative lighting levels ranging from 30 to 100 footcandles, with dimming capability. Portable lighting can provide the localized, high intensity lighting requested by many users for detailed work. The ABS coffered ceiling offers greater control of brightness and provides a better cut-off of lighting elements from the field of view.

Cost/performance comparisons were based on a level of 70 foot-candles.

D.11.4 ACOUSTICS

D.11.4.1 Acoustical pproblems are of great concern—particularly in spaces where people have to perform quiet and intensely concentrated activities for prolonged periods of time. Noise such as intermittent human speech or intermittent mechanical noises from other spaces is most disruptive to building users.

D.11.4.2 The Sound Transmission Coefficient (STC) of ABS partitions is 40; noises of normal human speech on one side of a wall are inaudible in adjoining spaces. This STC applies not only to the partition panels, but to joints at the partition head and base, and to the ceiling. A .60-.80 Noise Reduction Coefficient of the ceiling panel surface also provides an improved degree of sound absorption in the room where sound is generated.



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E. THE ABS SUBSYSTEMS

E.1 Conventional academic buildings are generally unable to economically accommodate the continuing physical changes required by academic programs. ABS was developed to achieve more adaptable physical space within the constraint of the construction cost for conventional buildings. Those performance/dimensional relationships most effectively improving the quality and/or reducing construction and alterations costs were determined for each of the five ABS subsystems. Selection of the ABS subsystems was based on the following consideration:

a. The subsystems must constitute a high percentage of the construction cost, to afford maximum budget control.

b. They must be related to the construction process critical path, to afford effective scheduling control.

c. They must be commercially available and composed of quality products, so as to result in designs acceptable to both direct and indirect users.

d. The resulting environment must not deteriorate either aesthetically or functionally when changes are made.

e. Component coordination must have the potential to reduce overall costs and/or improve the physical environment.

E.2 Obviously, many aspects of building performance and cost are not determined by the characteristics of any one subsystem but depend on a high degree of coordination among the subsystems and their components. Within the performance/dimensional relationships established, the design professional selects from alternative cost/performance solutions those best accommodating specific conditions of the time and location, and as required for the building's continuing program. Whatever his selection, the desired level under field conditions is assured, in that the interface conditions have been resolved and the control necessary during design and installation has been provided.

E.3 The ABS subsystems currently include:

Structure
HVAC
Lighting-Ceiling
Interior Partitions
Utilities Distribution

E.4 Guidelines are provided to ensure compatability with two non-ABS subsystems. These are Exterior Walls and Casework.

E.5 The architect and his design consultants perform all design work, prepare calculations and details, decide questions of cost, performance and quality, and assume full responsibility therefor—just as for a conventional building.

E.6 The ABS subsystems provide a fire-resistive building up to eleven stories high, whose permanent elements have at least a half century life, in line with current institutional practice, and whose adaptable elements facilitate economical modification. In planning concept, the building is composed of basic units called space modules; each is mechanically independent with main vertical services in an adjacent service tower. No proprietary solutions are involved in ABS; all materials are readily available, and easily applied to the local requirements related to climate, geography and preferences.

F. STRUCTURE

F.1 The information in this section is provided as a guide to the design professional, whose responsibility must include its interpretation and application. Local conditions, preferences, and less stringent code requirements for a specific project may suggest to him economies and variations which he is encouraged to investigate. When the design professional's requirements differ from the defined relationships, careful appraisal of the interface with the other subsystems will be required.

F.2 This ABS subsystem includes all framing elements above the grade level to form a superstructure capable of resisting the vertical and horizontal load requirements imposed by building codes. It was found that wide structural spans are not critical for adaptability, and need not be over an economical 40 feet. This permits a simple slab and beam structure, supported by girders on columns—a conventional framing that allows maximum application nationwide. Performance/dimensional relationships established herein define the structural configuration, maximum member sizes, and general variations. These relationships respond to the stated loading criteria and to the various national building codes and ensure optimum interface with the other ABS subsystems. The numerious variations of both bay and lateral size provide a wide range of choice.

F.3 The ABS superstructure may be concrete, steel, or a combination thereof. Any of three construction options may be used. These are:

a. Concrete, cast in place[6]
b. Concrete, precast composite
c. Concrete and structural steel composite

F.4 The ABS structure subsystem includes:

a. Floor and roof slabs
b. Beams
c. Interior girders
d. Interior columns
e. Lateral force resisting perimeter frame

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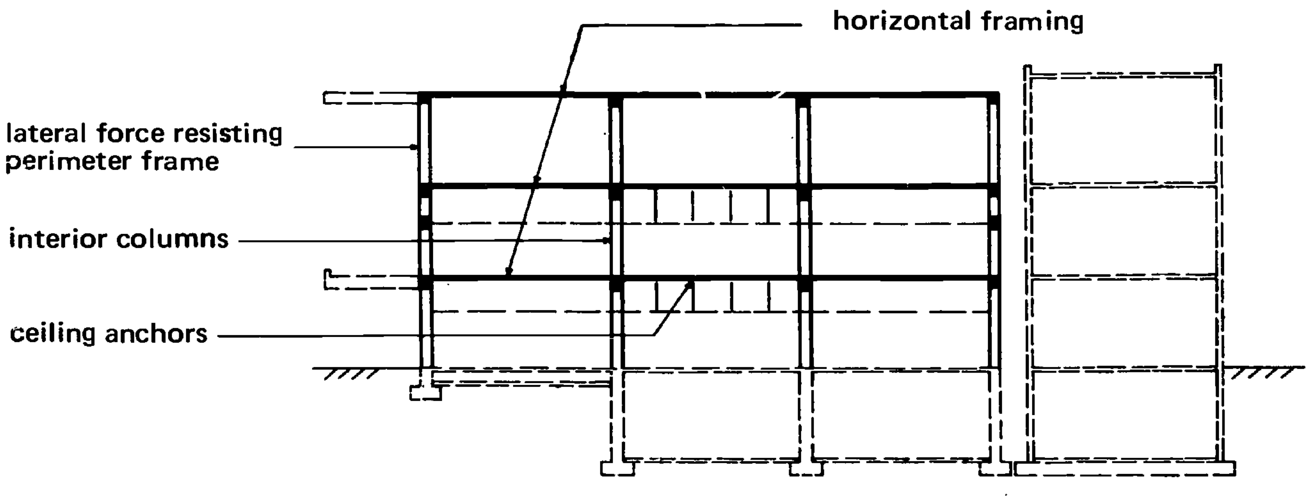
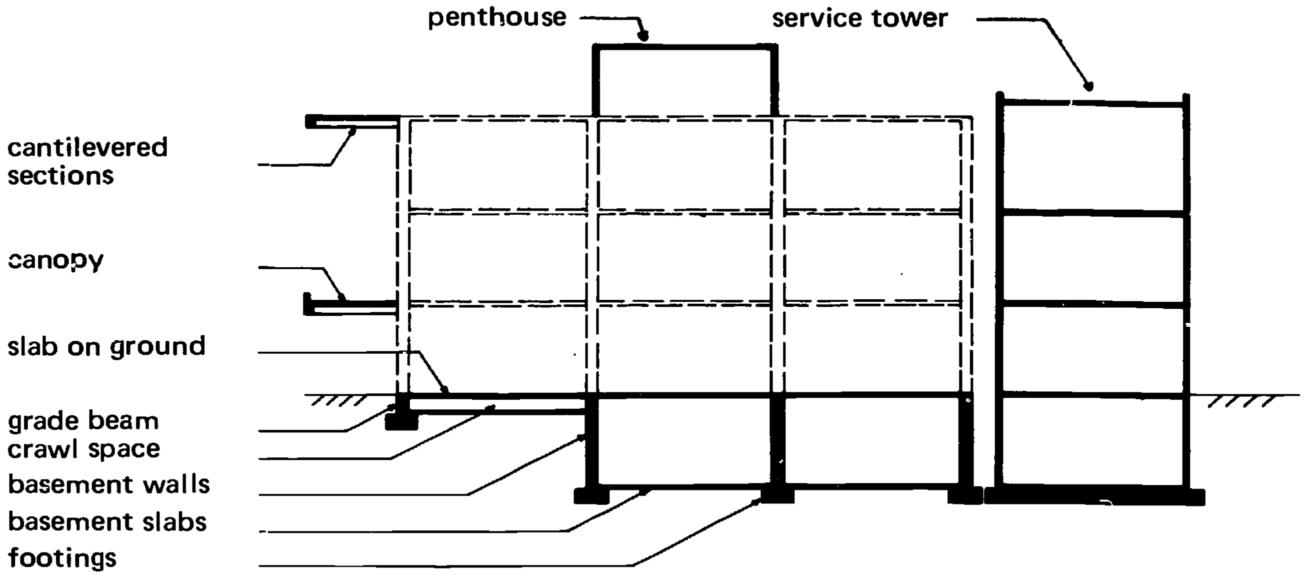
[6] The ABS SET demonstration building described in Section L uses this option with prestressing and post-tensioning. It was calculated by the load-balancing method, taking into consideration full continuity requirements.



F.5 Excluded from the ABS structure subsystem are:

a. Service Towers including mechanical rooms, stairs, toilets and elevators.
b. Penthouses.
c. Special structures including bridges, canopies, and cantilevers outside the perimeter frame.
d. Basement walls and slabs.
e. Crawl spaces.
f. Foundations including grade beams, footings and piles.
g. Slab on ground.



F.6 The above excluded elements may be constructed utilizing ABS structure components where particular job conditions allow it. For example:

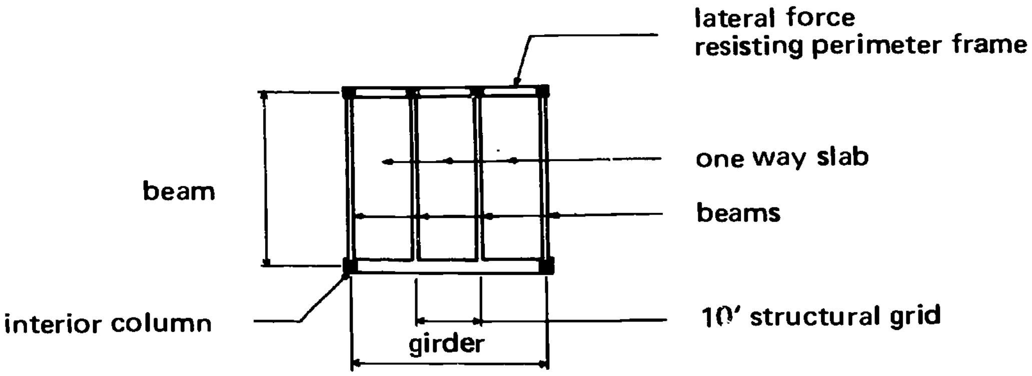
a. Cantilevers may be an extension of basic horizontal bay framing.
b. Penthouses may be an extension of ABS elements and alignments.
c. Service towers and other exterior elements may be constructed of ABS components.
d. Subgrade construction may be an extension of ABS framing.

F.7 HORIZONTAL FRAMING

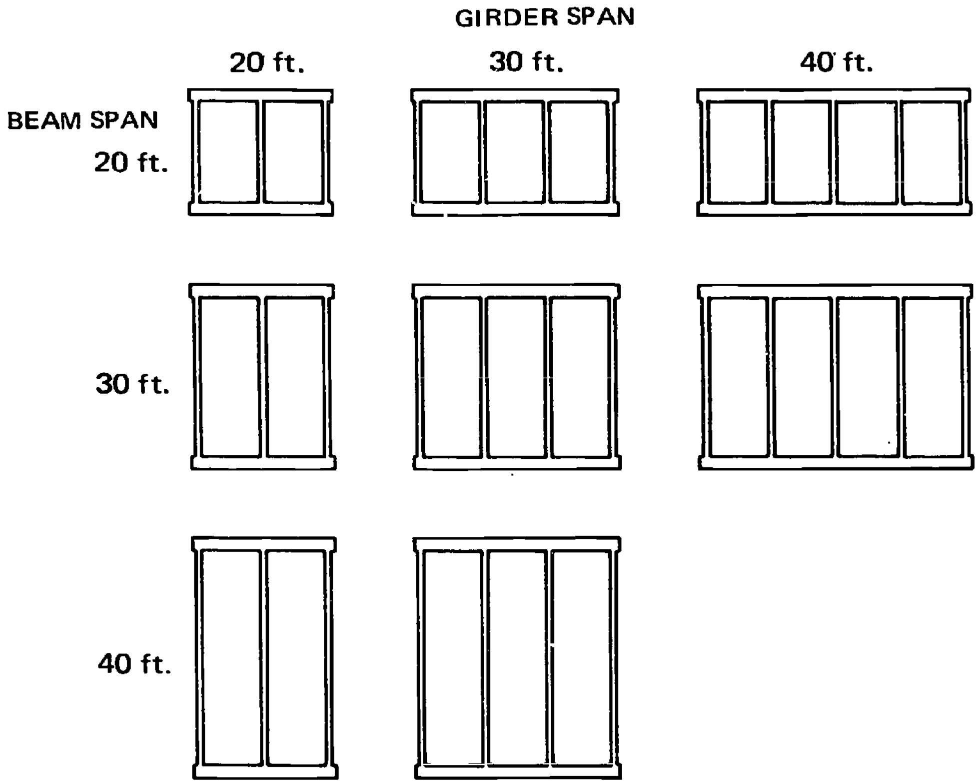
F.7.1 The structural bay is a conventional slab-beam-girder framing of the following fundamental design:

a. Structural components are located on a 10'-0" grid.
b. Slabs are one way, five inches deep, spanning 10'-0", and frame into beams.
c. Beams frame into girders and columns.
d. Girders frame into columns and the lateral perimeter frame.
e. Framing at any level must be in a single horizontal plane throughout a space module.
f. Framing direction in adjacent bay must be parallel.

F.7.2 FRAMING BAY SCHEMATIC PLANS:



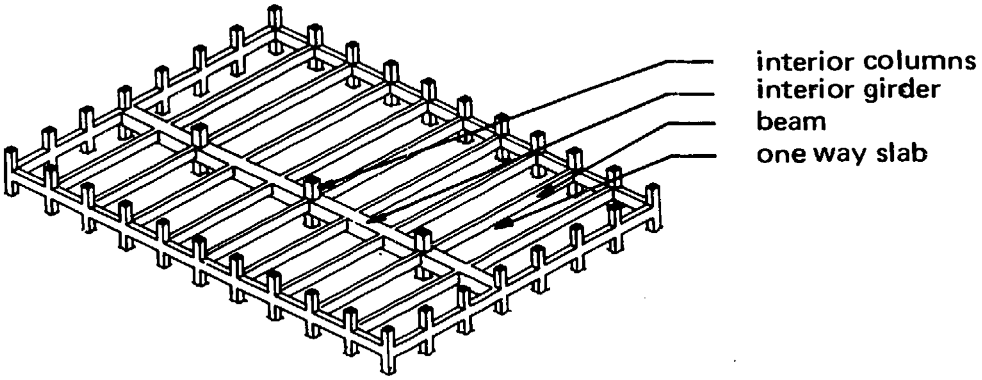
F.7.3 RANGE OF STRUCTURAL BAY SIZES:



F.7.4 Variations possible within system members size limitations using non-ABS elements are:

a. 10-foot girder span
b. Cantilever girder and beam spans to 10'

F.7.5 ISOMETRIC OF HORIZONTAL FRAMING

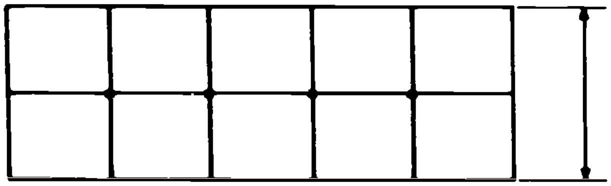


F.7.6 The horizontal framing bay is the primary structural component of the space module. Any combination of bay sizes may be grouped to produce the single space module.

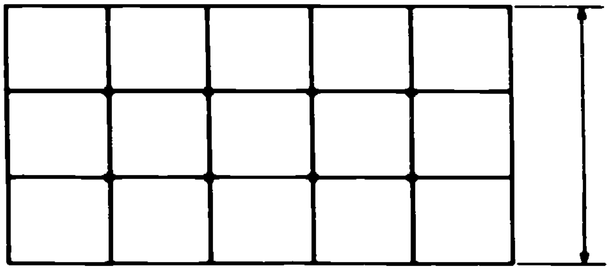
F.7.7 Any combination of beam spans and girder spans within the limits of specified bay sizes is possible. However, the 10-foot slab span and the 10-foot beam interval are fixed relationships.

F.7.8 Bays may be combined using a minimum of two adjacent bays to produce the space module length or width. A favorable situation, of course, is created with a minimum of three adjacent bays of compatible spans. Lower costs will be realized with beam spans of 30 feet and bays of 20 x 30 feet, 30 x 30 feet, and 30 x 40 feet.

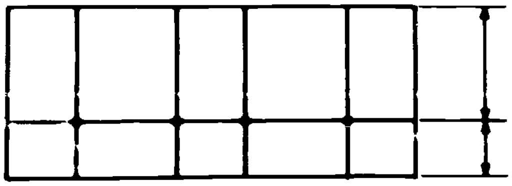
F.7.9 TYPICAL BAY COMBINATIONS:



2 bays minimum condition



3 bays favorable condition



uneven
bays possible condition

F.8 VERTICAL-LATERAL FRAMING

F.8.1 COLUMNS

Structural bay framing is supported at each corner. Interior columns are located only on 20, 30, or 40 foot centers each way and along the girder lines.

Exterior support is by the perimeter frame columns 10 feet on centers. Interior columns vary in size with building height.

F.8.2 PERIMETER FRAME

F.8.2.1 A load-bearing, moment-resisting perimeter frame surrounds the space module (or coupled space modules) to provide a completely self-contained lateral load-resisting frame.

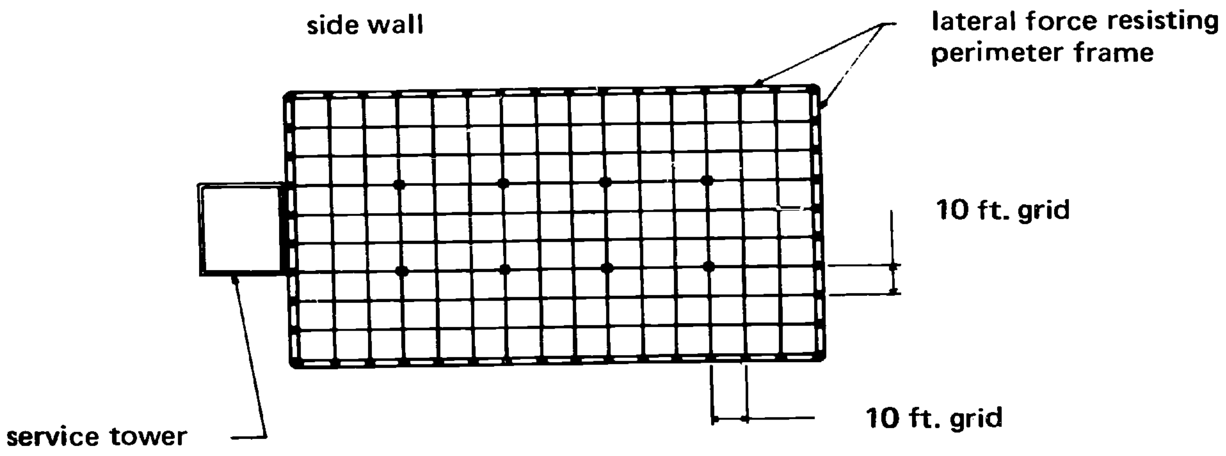
F.8.2.2 The perimeter frame described herein is based on columns at 10'-0" centers. This spacing provides resistance to high seismic loads, and conforms with the structural module beam spacing. Deviation from this column spacing, where seismic loads are negligible, will affect perimeter framing member dimensions that may be critical for interfacing conditions and clearances.

F.8.2.3 Severe seismic loading will require another interior lateral force moment frame in a building over six stories high that uses coupled space modules of maximum size. The frame will be required on the line of space module coupling.

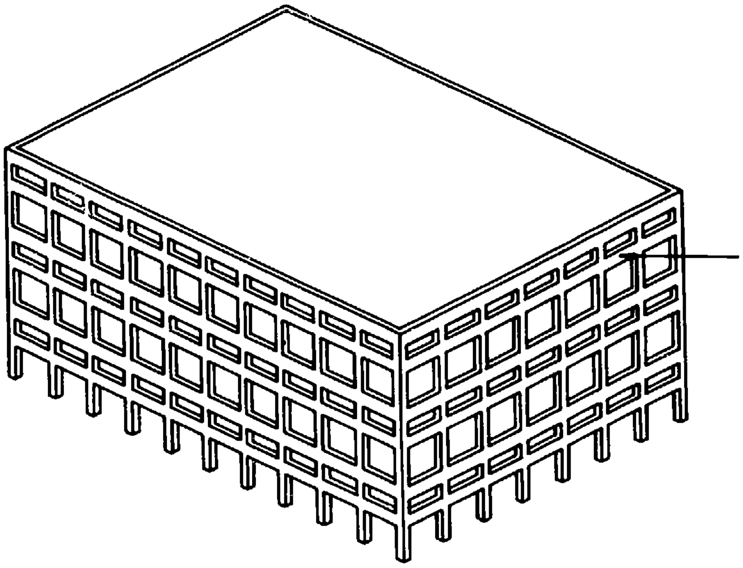
F.8.2.4 The perimeter frame shall be continuous and uninterrupted.

F.8.2.5 Frame columns may vary in size with building height.

F.8.2.6 Schematic Plan of Perimeter Frame

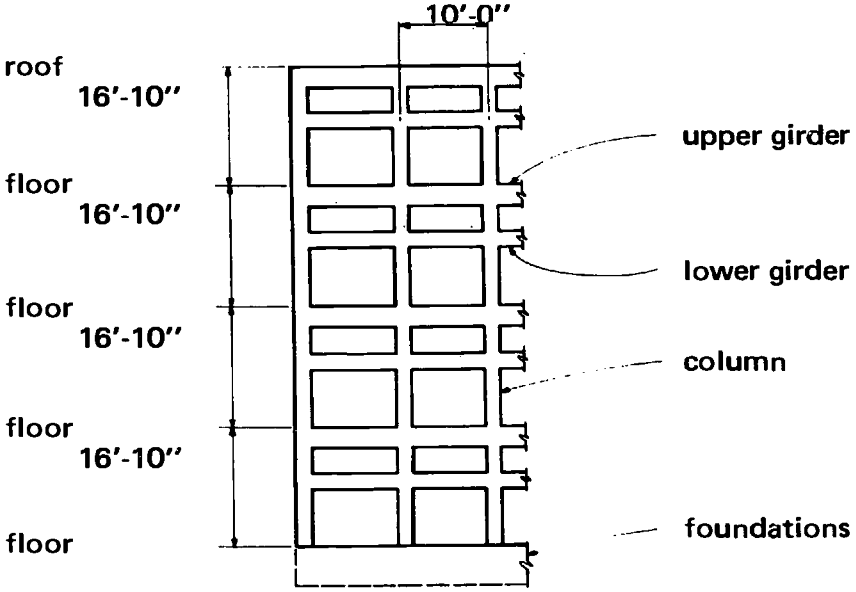


F.8.2.7 Isometric: Vertical Perimeter Framing

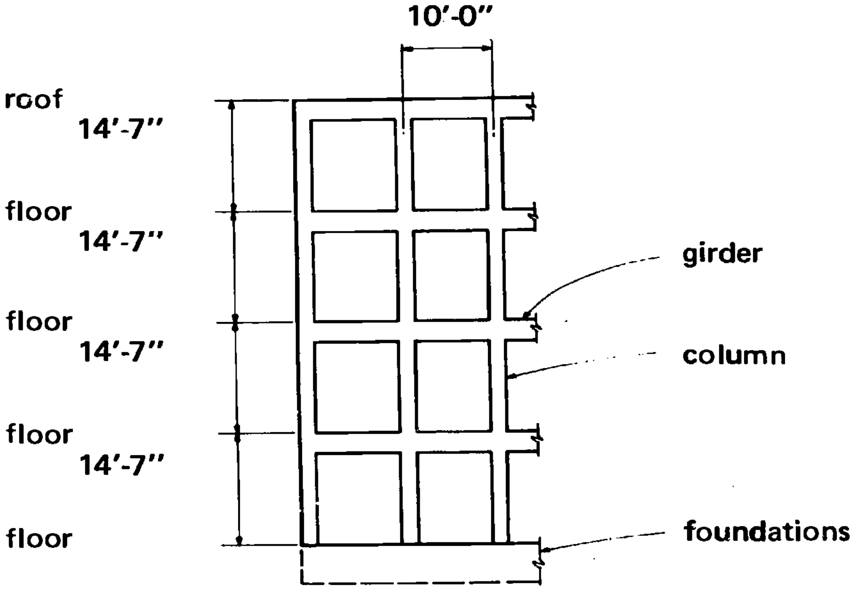


F.8.2.8 Elevation of Lateral Force Resisting Perimeter Frame

a. 16'-10" floor-to-floor option



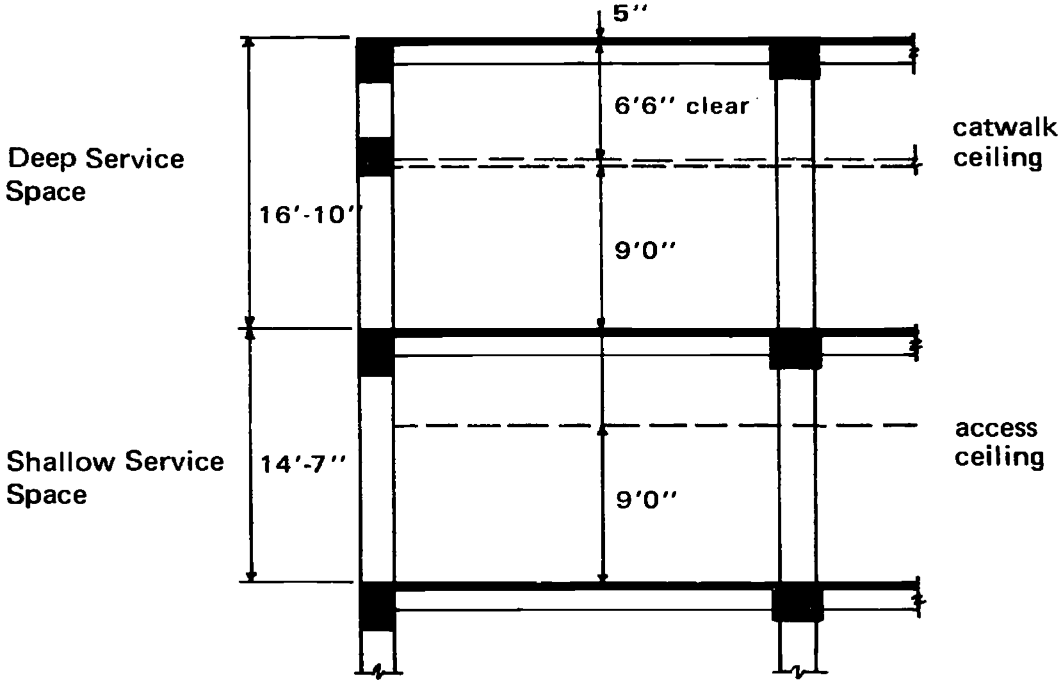
b. 14'-7" floor-to-floor option



F.9 STORY HEIGHT

F.9.1 The story height is developed from the service zone option forming a structure-ceiling sandwich layer for HVAC and utilities distribution.

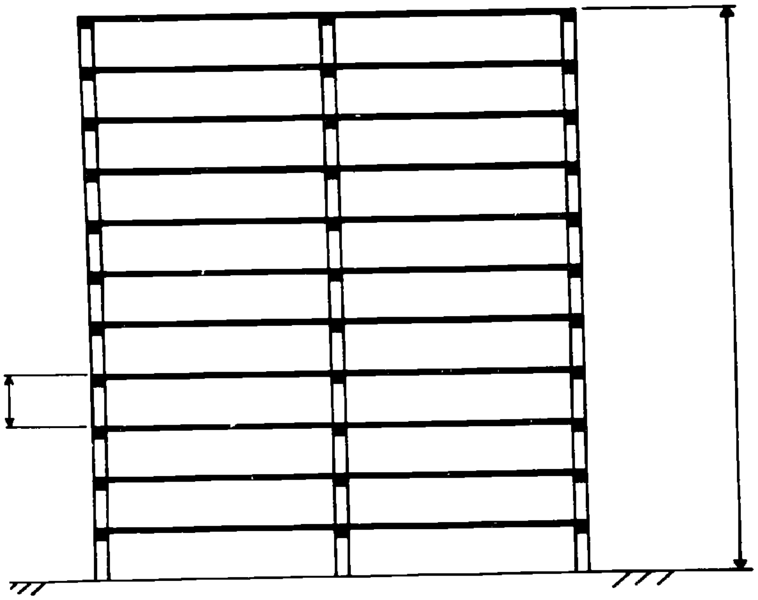
F.9.2 STORY HEIGHT VARIATIONS



F.10 BUILDING HEIGHT

F.10.1 The building height may vary from 2 to 11 stories, with a 160 feet height limit in severe seismic zones. (UBC Zone 3 or NBC Zone H). The building may be composed of stories of different heights depending on choice of service space options.

F.10.2 BUILDING HEIGHT RANGE

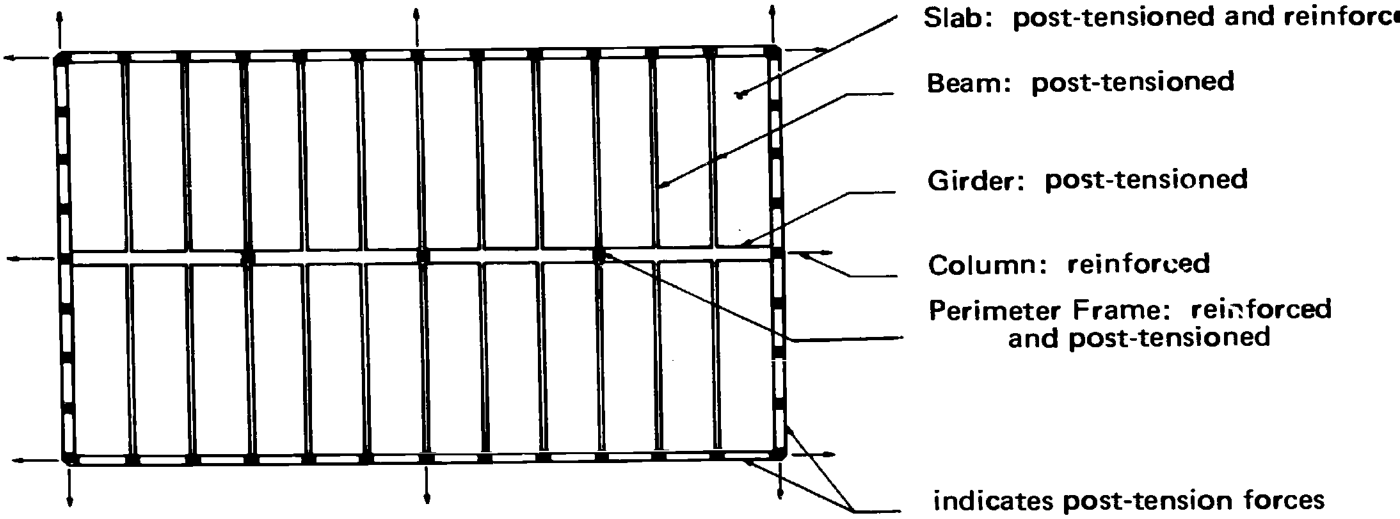


F.11 MATERIAL-CONSTRUCTION OPTIONS

Regional differences and design preferences are accommodated by three basic material-construction options.

F.11.1 CONCRETE, CAST-IN-PLACE, POST-TENSIONED AND REINFORCED

Plan of Typical Space Module

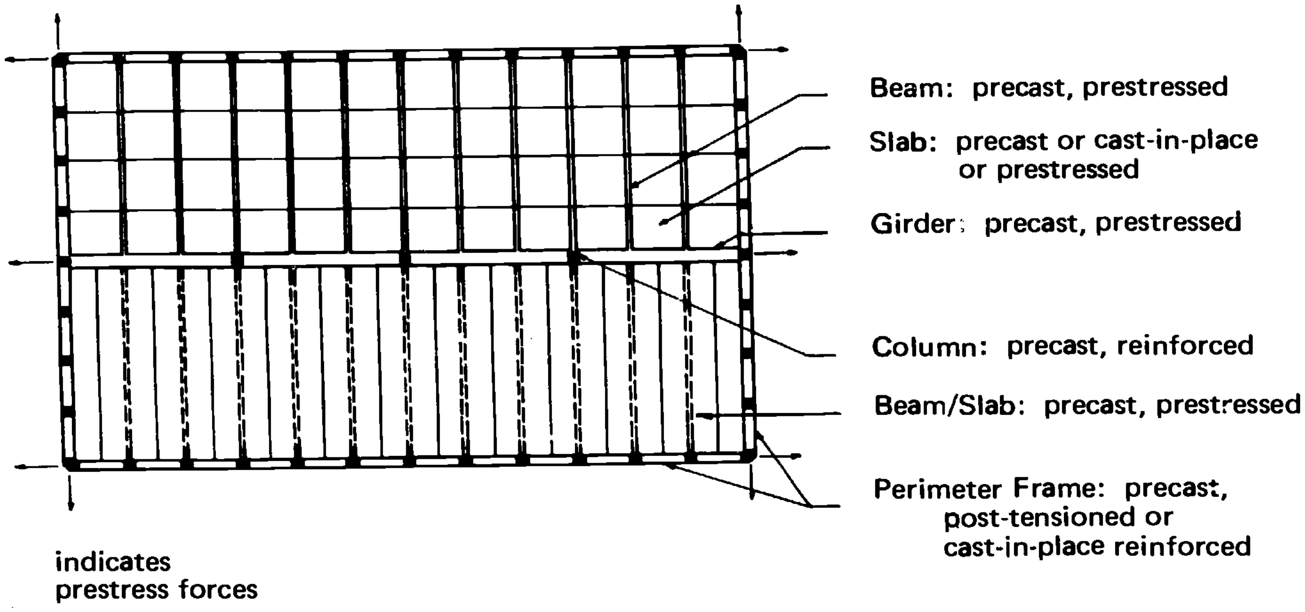


F.11.1.1 Post-Tensioning

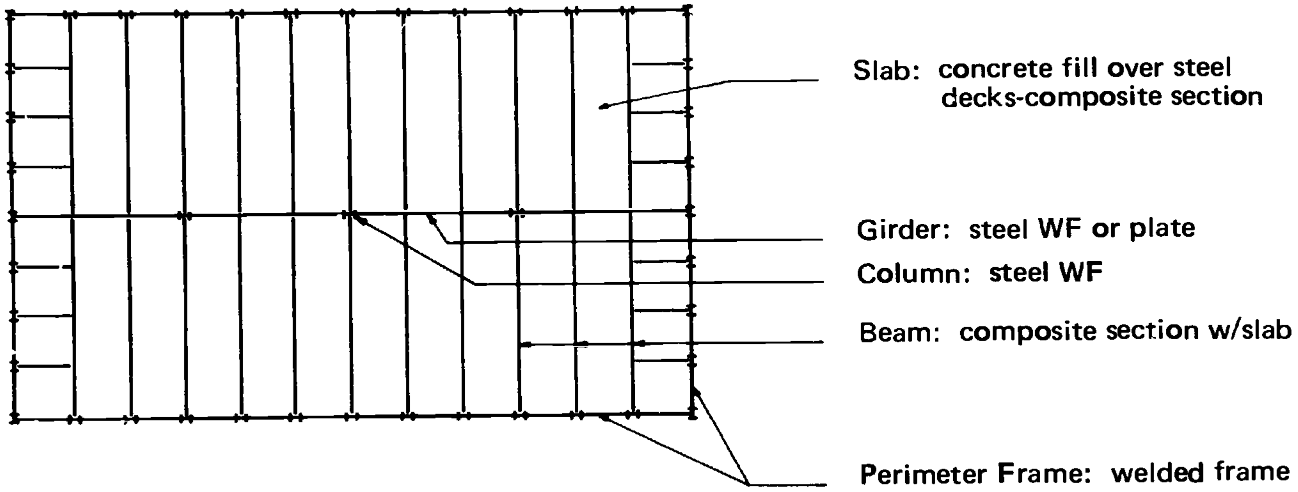
The horizontal framing is designed for an average prestress level of 250-300 psi in both directions. Slab prestressing, although optional, is recommended to achieve uniform levels of prestress compression throughout the building. The design professional must examine the prestress shortening effects on the building, and must design for the shears and moments induced by shortening effects. The selection of either bonded or unbonded strands is left to the discretion of the design professional. Costs will vary depending upon the post-tensioning selected.

F.11.2 CONCRETE, PRECAST, PRESTRESSED AND REINFORCED

Numerous sub-options within a precast solution are available:



F.11.3 STRUCTURAL STEEL, STEEL DECK, CONCRETE FILL



F.12 STRUCTURAL ANALYSIS

The ABS structural subsystem is based on design of horizontal and vertical components by the ultimate strength method. The horizontal framing—slab, beam and girder--is to be fully continuous, acting as a homogeneous rigid diaphragm for distribution of horizontal loads. Vertically, the interior columns resist axial loads and the bending moments caused by unbalanced loads. The perimeter frame columns form a vertical load bearing wall and have fixed base conditions. The perimeter frame resists all lateral loads—whether earthquake, wind or thermal forces—and extends around vertical corners to form a continuous, tubular moment resisting rigid frame cantilevered from the foundations.

F.12.1 The horizontal framework is to be analyzed by accepted methods. The concrete cast-in-place, post-tensioned option can be designed by the load-balancing method, taking into consideration full continuity requirements. The precast, prestressed concrete option can be designed using standard prestressed design methods. The structural steel option can be designed by composite methods, utilizing the full capacity of framework and slab.

F.12.2 The vertical perimeter frame must take into account the full continuity of the entire perimeter, with concrete option interior columns designed by ultimate strength methods. The perimeter frame must be analyzed for moments, shears, axial stresses and lateral distortions, and is readily done using an appropriate multi-member frame computer program. Among many currently available computer programs, the following are recommended:

Name	Source
STRESS	IBM
EAC/EASE	Control Data Corporation
STRUDL	MIT
MRI/STARDYNE	Control Data Corporation
FRAND	Omnidata Services, Inc.
PCA-FRAME	Portland Cement Association
FRAMSTAT	University of California Professor E. Wilson

F.12.3 The side effects to be considered for each building configuration include:

a. Thermal expansion and contraction forces
b. Prestress shortening effects
c. Foundation settlement effects
d. Opening and notch effects
e. Deflections and long-time creep effects

F.13 LIVE AND DEAD LOADINGS

F.13.1 Basic live loads assumed for the ABS structure subsystem as shown herein are based upon building code requirements and building user information. Dead loads assumed are for a cast-in-place, reinforced concrete structure. The loading requirements for a specific project are the responsibility of the design professional involved.

Note that the level of reinforcement in concrete members is a variable, as is the member size, as long as dimensional compatibility is maintained.

F.13.2 LIVE LOADS

F.13.2.1 Roof live loading of 40 psf covers nominal snow conditions and partial utilization of roof areas for apparatus.

F.13.2.2 A nominal 100 psf floor live load allowance is used by ABS. Where the catwalk ceiling is provided, this live load may be divided into two components: 80 psf floor live load and 20 psf catwalk ceiling live load. It is not anticipated that a full load condition on both floor and suspended ceiling would occur simultaneously.

F.13.2.3 Special loads created by heavy equipment must be accommodated by special design and, if required, by increasing the dimensions of slabs, beams and girders. Floor live loads on beam, girders, columns and lateral force resisting frame may be reduced in accordance with the applicable codes.

F.13.2.4 Floors shall be desinged for a concentrated load of 2,000 pounds placed upon any space 2½-foot square.

F.13.3 DEAD LOADS

In addition to their tributary dead loads and self weight, individual components shall have an allowance of 10 psf for mechanical equipment and ceiling.

F.13.4 LATERAL LOADS

F.13.4.1 The ABS lateral force resisting perimeter frame as described herein will comply with normal building code requirements applicable to the different geographical locations across the country. Wind loads of 40 psf and UBC Zone 3 and NBC Zone H seismic loads can be accommodated by the ABS structure.

F.13.4.2 The total seismic lateral force is defined in both UBC and NBC codes with the following formula:

$V = KCWZ$ where:

V = Total lateral force at base
K = Horizontal force factor
(K = 1/0, space frame, moment resisting height less than 160 feet)
W = Total dead load
C = Dynamic coefficient
Z = Seismic zone coefficient ($Z = 1.0$ maximum value)

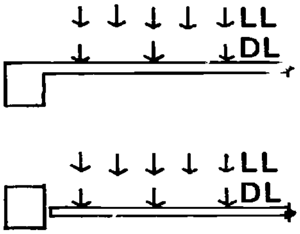
F.13.5 **TABLE OF COMBINED VERTICAL LOADS**

The vertical loadings for both service space options are:

Combined Loads

Catwalk Ceiling

roof

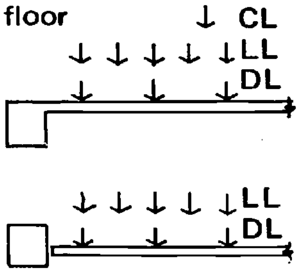


40
9 roofing
72 structure
10 mechanical

20
10

total 60 lbs. live load
101 lbs. dead load

floor



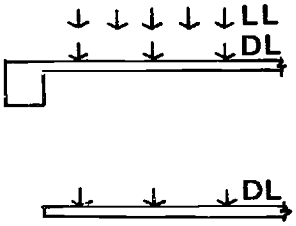
2000
80
20 partitions
72 structure
10 mechanical

20
10

total 100 lbs. live load
112 lbs. dead load
2000 lbs. concentrated

Access Ceiling

roof

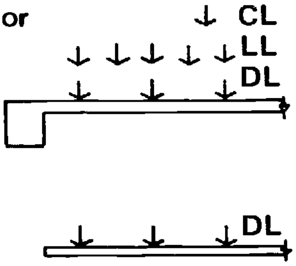


40
9 roofing
72 structure
10 mechanical

10

total 40 lbs. live load
101 lbs. dead load

floor



2000
100
20 partitions
72 structure
10 mechanical

10

total 100 lbs. live load
112 lbs. dead load
2000 lbs. concentrated

F.13.6 SPECIAL LOADS

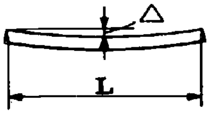
Provisions shall be made for individual loads of a special nature, such as sensitive scientific equipment, heavy equipment, special framing configurations and dynamic or reciprocating loads. Special framing and details will be required for dynamic load isolation.

F.14.1 DEFLECTIONS

All structural components shall be designed within the following criteria:

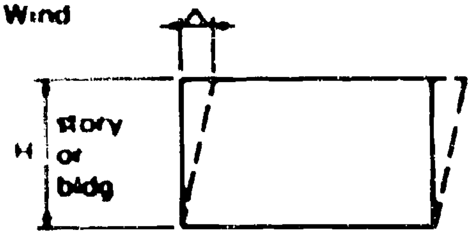
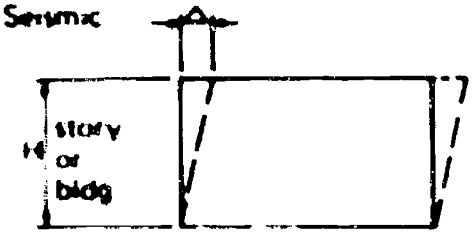
Vertical deflection limitations for horizontal framing shall conform to accepted criteria. In addition to span-ratio limits, actual dimensional limitations are imposed for beams and girders to insure framing of adequate rigidity for the occupant use.

Roof framing systems shall be designed to insure positive drainage of water.

	element	deflection limitation for DL+LL
slab		$\Delta = L/360$
beam girder		$\Delta = L/360$

Loading	Element	Span Ratio Limit	Dimensional Limit
Dead Load long-term condition (2x Dead Load)	Slab	1/360	--
	Beam	1/360	1 inch
	Girder	1/360	1 inch
Combined Dead plus live Load condition	Slab	1/360	--
	Beam	1/360	1 inch
	Girder	1/360	1 inch

criteria for wind and seismic induced loads. These limitations insure adequate rigidity of the frame for normal occupant conditions, and are intended to minimize problems of interface with other non-structural components.

	story or building element	limitation for horizontal drift	
		storm	total building
Wind		Δ = 0.0025H 0.44" for H = 14' 7" 0.50" for H = 16' 10"	Δ = 0.0025H varies with building height
Seismic		Δ = 0.0035H 0.61" for H = 14' 7" 0.70" for H = 16' 10"	Δ = 0.0035H varies with building height

Loading	Element	Height Limit	Dimensional Limit
Wind (40 psf) or	Building or story	.0025 H	1/2 inch
Seismic (UBC Zone 3 or NBC Zone H)	Building or story	.0035 H	

F.15 TOLERANCES

F.15.1 Construction tolerances are established primarily to allow proper component interface. Tolerances for components of either concrete or structural steel are the same insofar as the ABS demands are concerned. However, the individual materials and methods do have their unique requirements and standards to be observed during both detailing and construction.

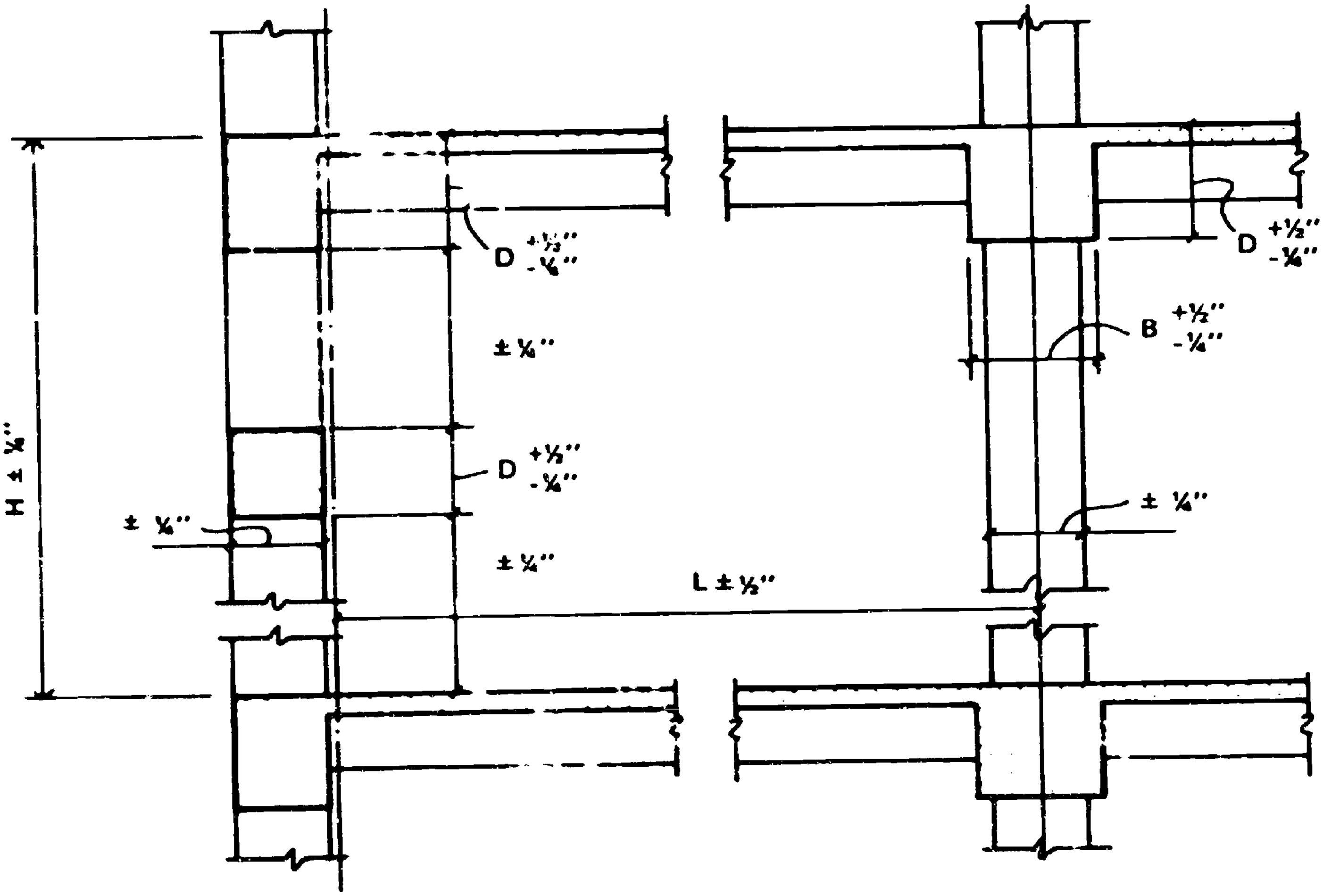
The following areas of tolerance are of concern:

a. Floor-to-floor height control for ceiling and partition installation.

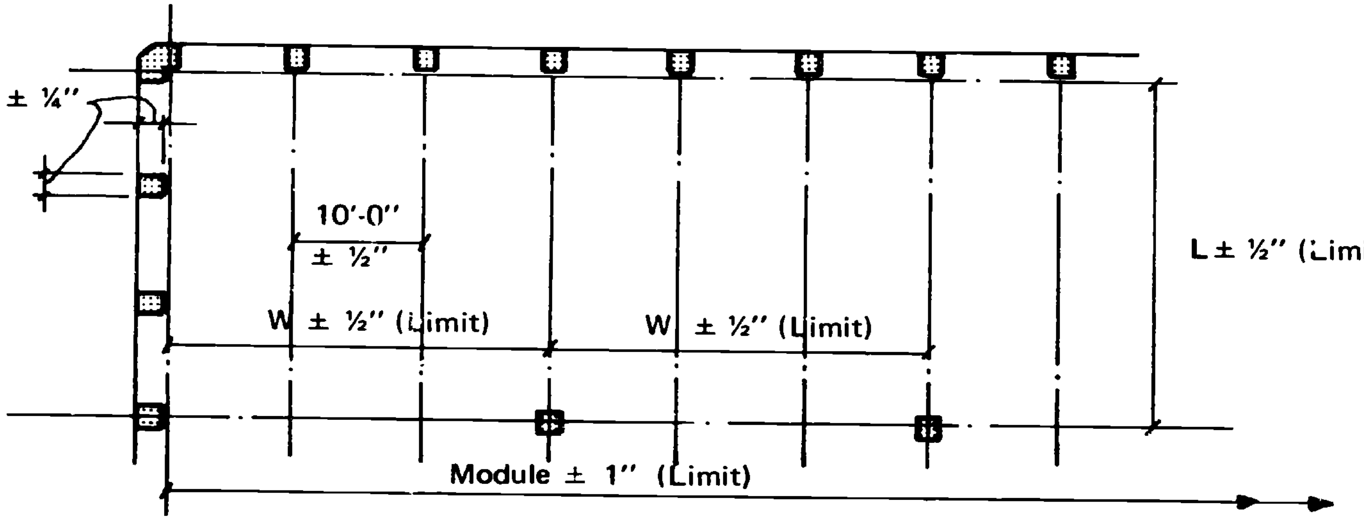
b. Ten-foot installation interval control for ceiling, partition installation and HVAC network support.

c. Perimeter frame control for exterior cladding.

F.15.2 TYPICAL CROSS SECTION



F.15.3 PARTIAL PLAN



F.16 FIRE RATINGS

The ABS structural subsystem shall conform to the requirements of UBC Type I or NBC Type A construction to provide the following fire ratings:

Slabs, beams, girders	3 hours
Columns	4 hours
Perimeter frame	4 hours

F.17 THERMAL CONTRACTION AND EXPANSION

F.17.1 Consideration shall be given to thermal contraction and expansion effects on the structural components and on the entire space module.

F.17.2 Thermal separation joints are not required with either a single or coupled space module for a normal range of operating temperatures.

F.17.3 The lateral force resisting perimeter frame and horizontal framing shall be designed for a temperature variation appropriate to the locality. Temperature extremes will require thermal insulation of exterior perimeter frame members to limit excessive stresses, strains and distortions.

F.18 STRUCTURAL SEPARATIONS

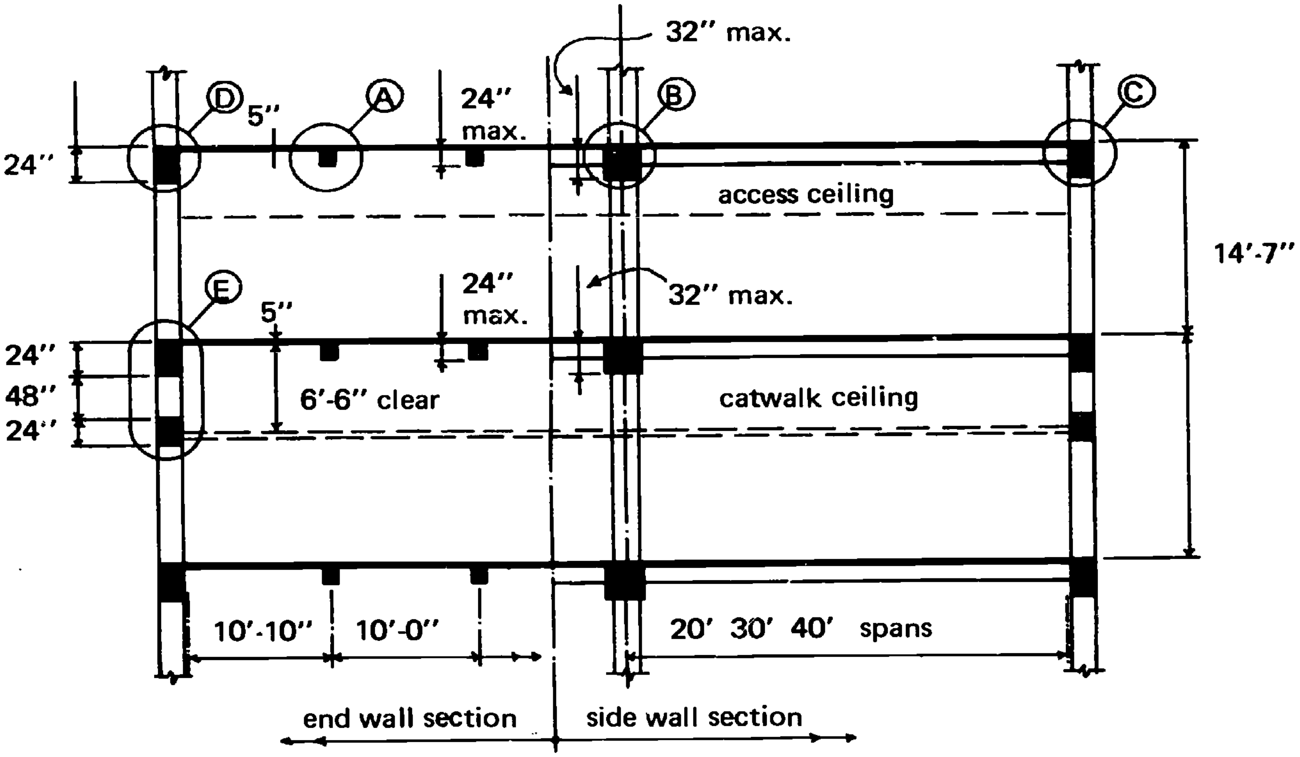
F.18.1 Structural separations shall be designed to accommodate the movements due to thermal changes and lateral seismic and wind loads.

F.18.2 Provide separations under the following conditions:

a. Between separate structures.
b. Between wings of L-shaped or offset space modules.
c. Between space modules and service towers or non-system elements.

F.19 FRAMING COMPONENTS

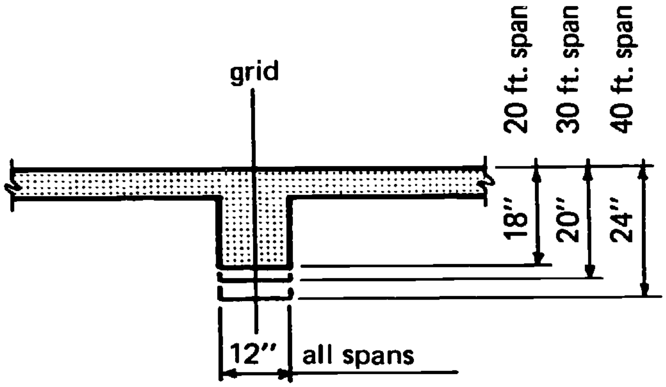
F.19.1 SCHEMATIC PARTIAL BUILDING SECTION



F.19.2 COMPONENT SIZE: HORIZONTAL FRAMING

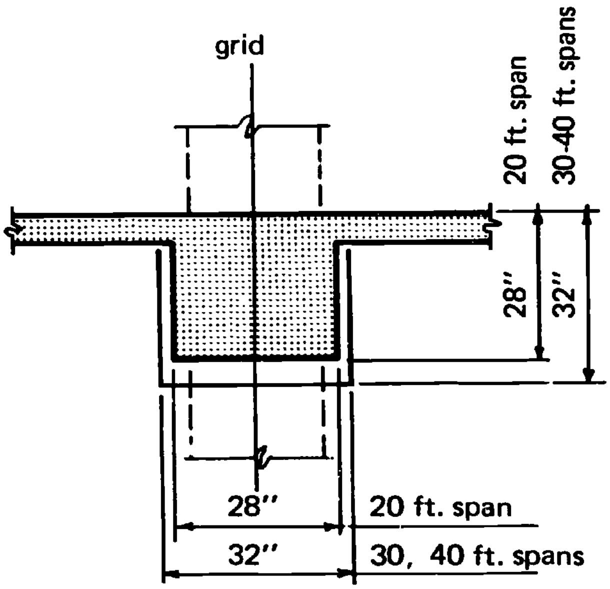
a. Girders support beams at 10-foot intervals.
b. Span range: 20, 30 and 40 feet.
c. Depth shall be cosntant in adjacent bays regarless of span.
d. Beam section utilizes T-beam action.

Section: (A) <u>Beam</u>



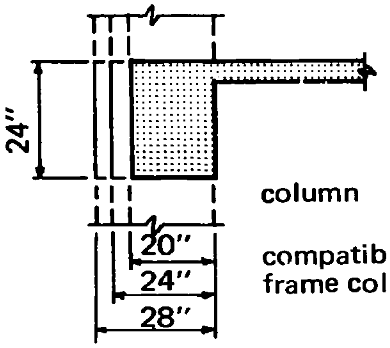
Beams are spaced 10' on center

Section: (B) <u>Girder</u>



F.19.3 COMPONENT SIZE: VERTICAL-LATERAL FRAMING

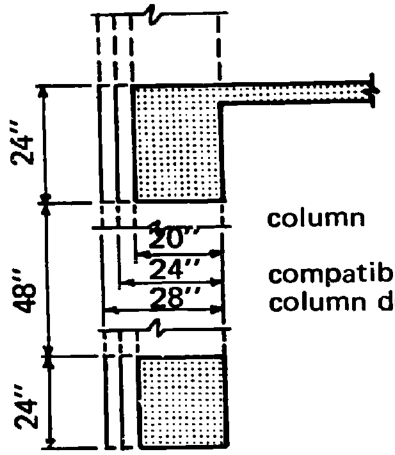
The horizontal framing element forms the moment-resisting perimeter frame. The span is 10 feet.



column

compatible with lateral perimeter frame column depths.

Section (C): Lateral Force Resisting Perimeter Frame Girder
Section (D): Side Wall, End Wall



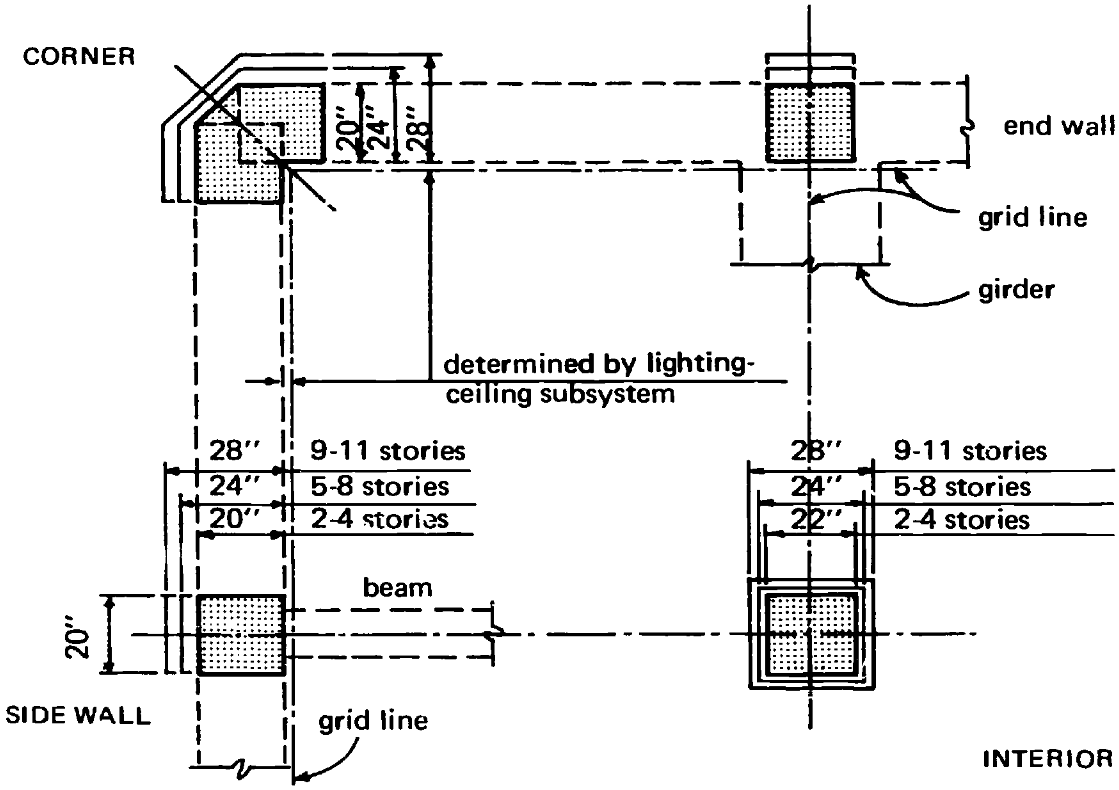
column

compatible with perimeter frame column depths.

Section (E): Lateral Force Resisting Perimeter Frame Multiple Girders

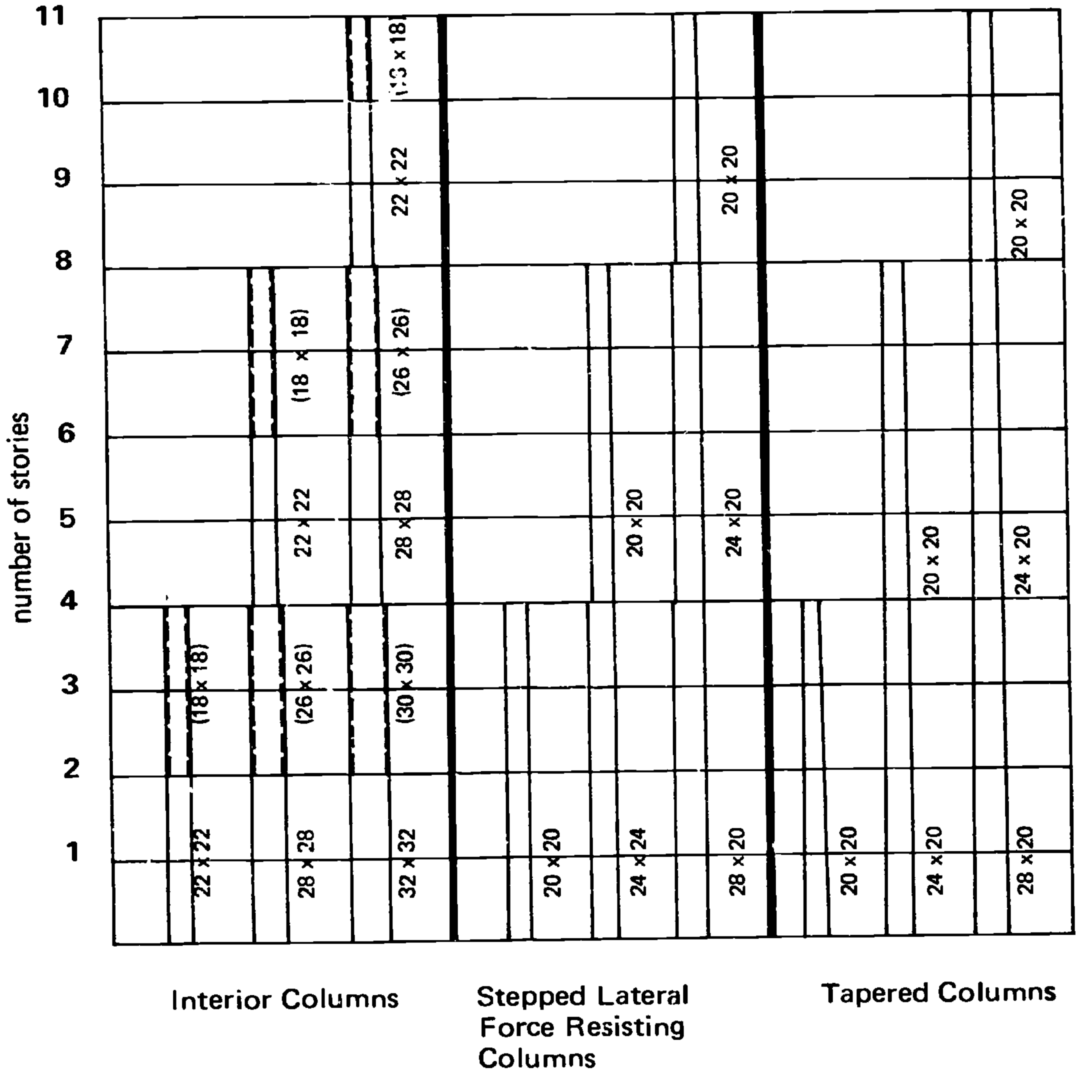
F.19.4 COMPONENT SIZE: VERTICAL FRAMING

Column size and capacity varies with the magnitude of superimposed load. The concrete column size variation is progressive and is indicated in four-story load-demand increments.



F.19.5 VERTICAL FRAMING HEIGHT VS. SIZE

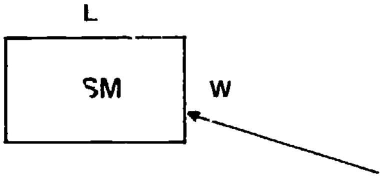
Column size may vary with change in magnitude of superimposed loads, on either a stepped or tapered basis, or may be arbitrarily held at a constant size.



F.20 CONFIGURATIONS

The planning of an individual building utilizes the space module as the basic element. Space modules are grouped and connected in conformance with the following rules:

F.20.1 THE SINGLE SPACE MODULE

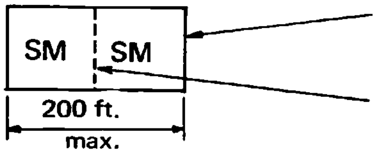


$\frac{L}{W}$ (max.) = 2

area = 7,500 to 12,500 sq.ft.

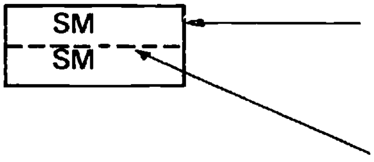
lateral force resisting perimeter frame

F.20.2 COUPLED SPACE MODULES



lateral force resisting perimeter frame

no lateral force resisting frame (6 stories or less)
area (max.) = 15,000 to 25,000 sq.ft.

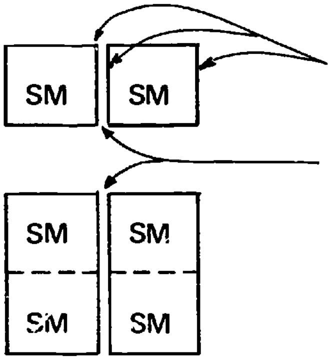


lateral force resisting perimeter frame

no lateral force resisting frame

Construction of coupled space modules must be carried out as a single operation without expansion joints.

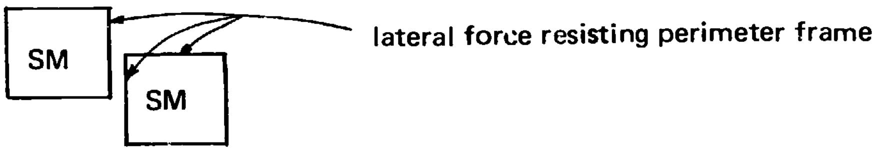
F.20.3 Connected space modules occur when single space modules are constructed in phases, allowing for expansion.



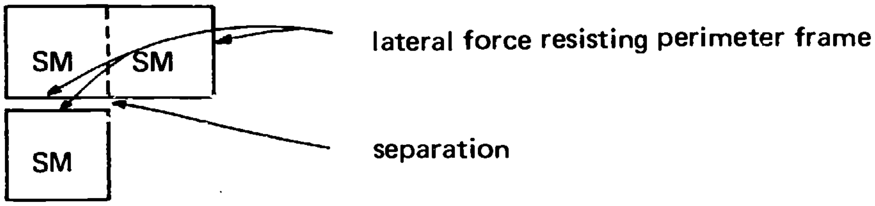
lateral force resisting perimeter frame
(double frame at separation for buildings over six stories)

separation

F.20.4 Offset space modules require complete perimeter frames at the offset zones.



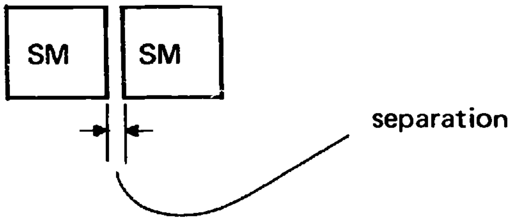
F.20.5 L-shaped configurations require separations at re-entrant corners.



F.20.6 SPACE MODULE SEPARATION

Where separations are required between space modules, or between coupled space modules, adequate clearance shall be provide movement of structure under all loading conditions.

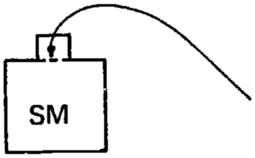
Separation shall be a minimum of 1" (basic) + 1/2" for each story of height.



F.20.7 VARIATIONS WITHIN SPACE MODULES

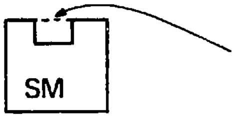
The integrity of the perimeter frame shall not be interrupted by horizontal framing or planning variations.

Projections



lateral force resisting perimeter frame continues through projection

Recesses



lateral force resisting perimeter frame continues across recess

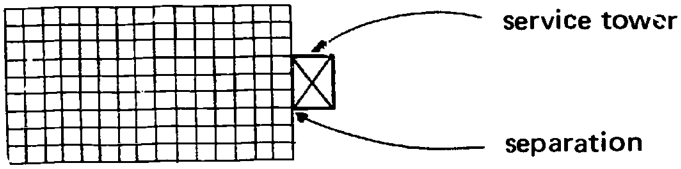
F.20.8 Variation in floor elevation, within a single space module, is not permitted. Elevation variations between connected space modules with separation between is permitted because these are treated as separate buildings.

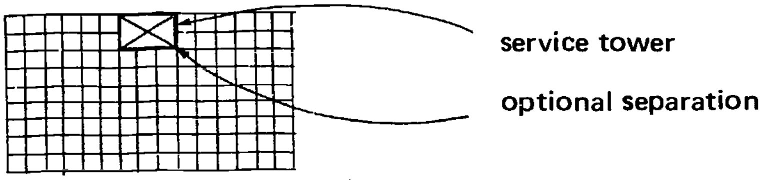
F.20.9 SPACE MODULE RELATIONSHIP WITH SERVICE TOWER

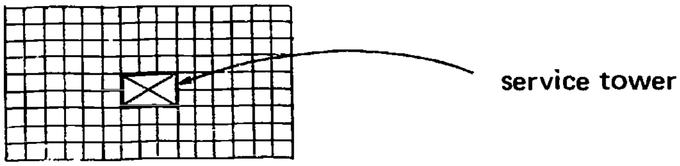
The service tower may be non-ABS; is structurally separate from the space module to prevent eccentric loading from thermal, seismic or wind loading, and to provide vibration isolation. The service tower may be located at random outside the space module, but must conform to the basic 10 foot column interval for interface compatibility.

The typical locations of the service tower are indicated for single and connected space modules.

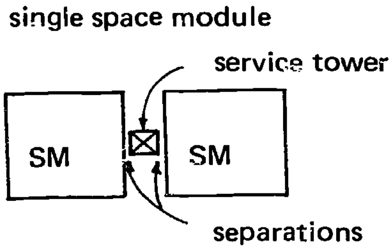
F.20.9.1 Single Space Modules

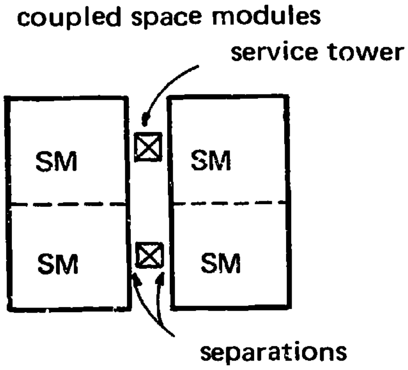






F.20.9.2 Connected Space Modules





F.21 VARIATIONS IN STRUCTURAL COMPONENTS

F.21.1 OPENINGS IN THE ONE-WAY SLAB

Vertical openings through the slab are allowed providing surrounding beams, girders and perimeter frames are not cut or interrupted.

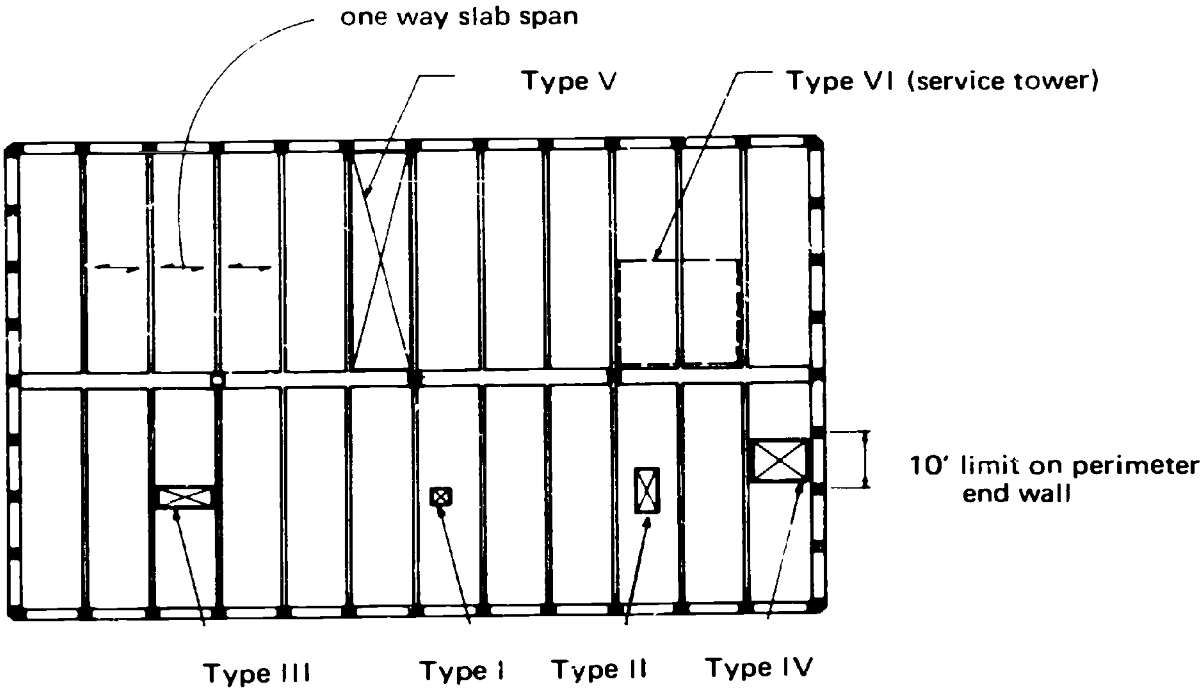
All openings require special design of slab and supporting framing.

Vertical alignment of openings on adjacent building stories is not required.

Horizontal framing must remain intact as a horizontal diaphragm for transfer of loads to the perimeter frame.

The types of openings are:

I	Small size for pipes located within slab, supported by slab edge bands.
II	Medium size cutting across slab, maximum length 4'-0", supported by slab edge bands.
III	Medium size clear opening between supporting beams.
IV	Large size, limited to 10' x 10' (nominal), located on perimeter wall, to insure perimeter frame stability.
V	Large size, limited to single beam-girder bay.
VI	Large size, to accommodate service tower, does not allow for numerous random penetrations.



F.21.2 BEAMS

a. Depth to a maximum dimension of 24 inches varies with span.

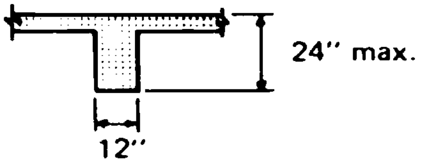
b. Depth is limited to afford HVAC and service network clearances.

c. Depth for a single space module will be constant, being determined by the longest span.

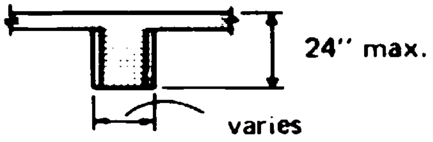
d. Width is 12 inches for normal conditions.

e. Beams may not be penetrated either horizontally or vertically for service or HVAC lines.

Largest standard beam



Optional for special loads



F.21.3 **GIRDERS**

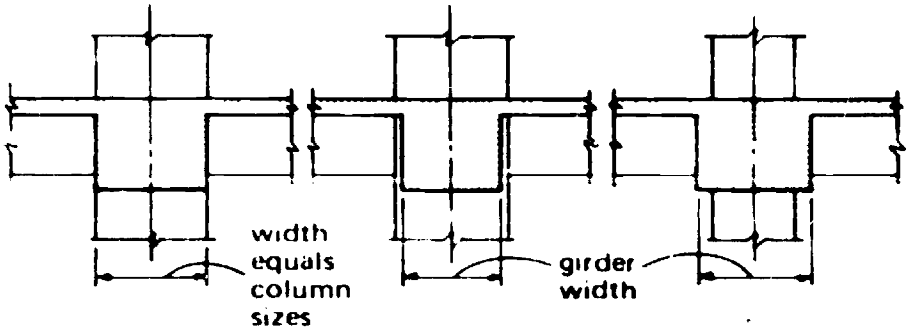
a. Depth to a maximum dimension of 32 inches varies with span.

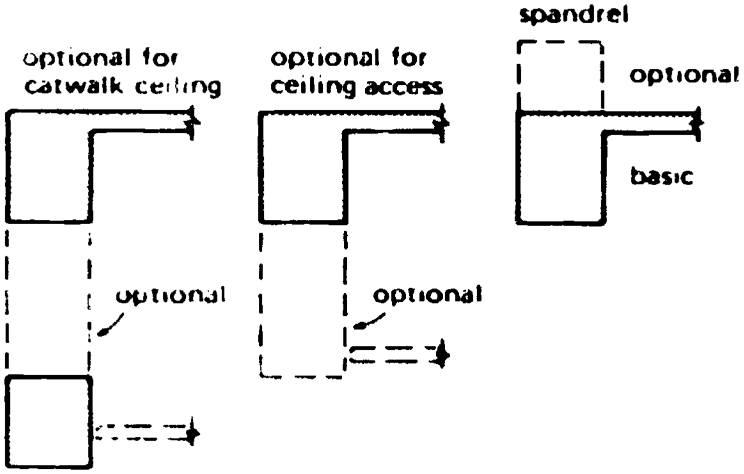
b. Depth is limited to afford HVAC and service network clearances.

c. Depth for a single space module will be constant, being determined by the longest span.

d. Width is variable from 28 to 32 inches and is generally consistent with column size.

e. Girders, if specially designed, may be penetrated either horizontally or vertically for service or HVAC lines.

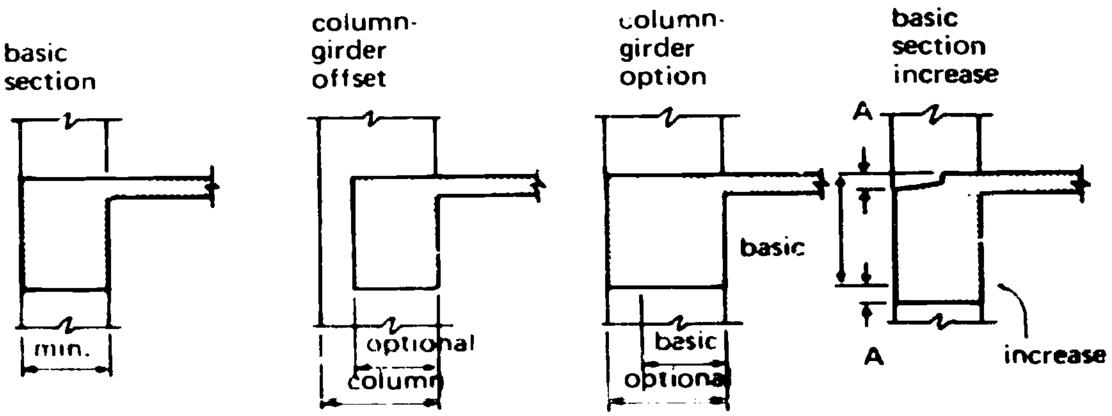




F.21.4 LATERAL FORCE RESISTING PERIMETER FRAME

F.21.4.1 Basic element sizes are those required for structural performance, and are based upon the concrete cast-in-place post-tensioned construction option.

F.21.4.2 Girder and column size may vary individually and in relation to each other within reasonable limits, provided minimum cross sections are maintained and the integrity of the entire perimeter frame is not diminished.



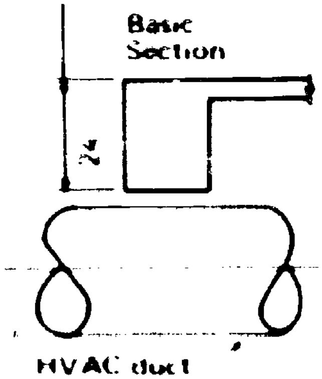
F.22 COMPATIBILITY WITH OTHER SUBSYSTEMS

The ABS structural subsystem provides the following interface compatibility with other subsystems.

F.22.1 HVAC SUBSYSTEM

The horizontal structural framing permits the HVAC duct and equipment network to pass below the floor framing and above the ceiling. The horizontal structure provides support for all HVAC ductwork and equipment below it.

The lateral force resisting perimeter frame permits HVAC ductwork to pass from an exterior service tower through the structure and into the mechanical service zone in the space module.



F.22.2 UTILITIES DISTRIBUTION

The horizontal structural framing permits the total utilities network (communications, electrical and plumbing) to pass horizontally between the floor framing and ceiling. The horizontal structure provides support for all utility lines.

The lateral force resisting perimeter frame permits utility lines to pass from an exterior service tower through the structure and into the mechanical service zone in the space module.

F.22.3 LIGHTING-CEILING SUBSYSTEM

The horizontal structural framing provides the method of attaccment and support for the ceiling. Inserts in the concrete framing receive the suspension hanger rods.

Catwalk ceiling:	Attachment points at 5-foot intervals along the soffit of each beam.
Access ceiling:	Attachment points at intervals dependent on the grid bar used.

F.22.4 EXTERIOR WALLS

The perimeter frame provides support for the exterior walls.

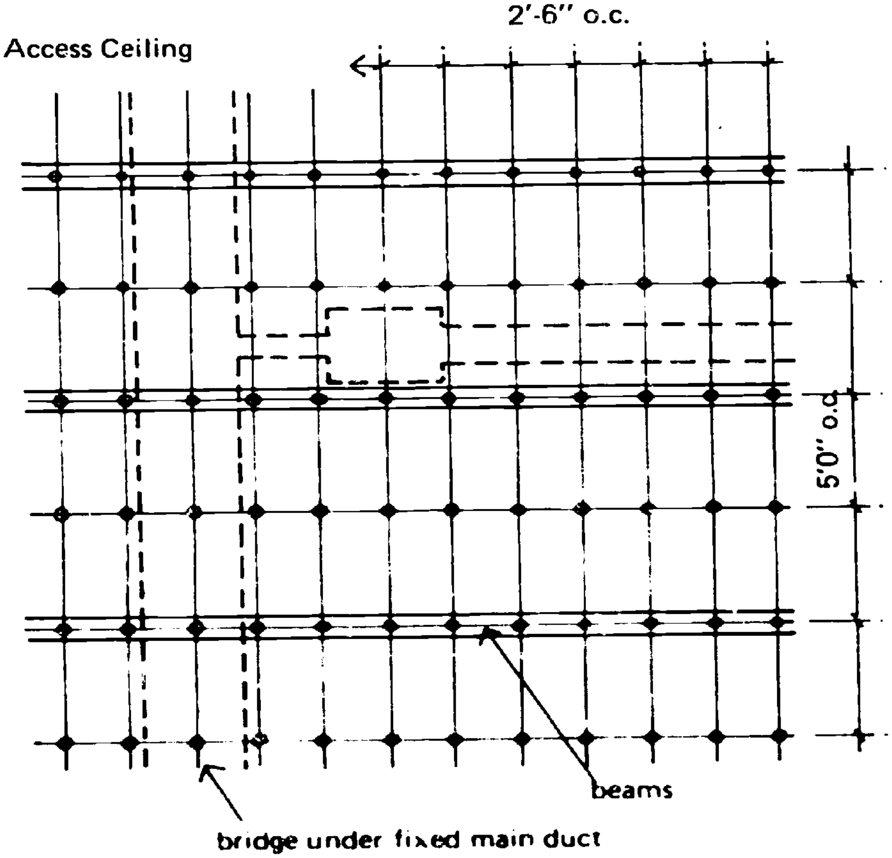
F.22.5 STRUCTURE INSERTS FOR OTHER SUBSYSTEMS

F.22.5.1 The design professional is responsible for designating the location of all structure inserts required for the support of HVAC, utilities distribution and lighting-ceiling subsystems for both the initial installation and possible future alterations.

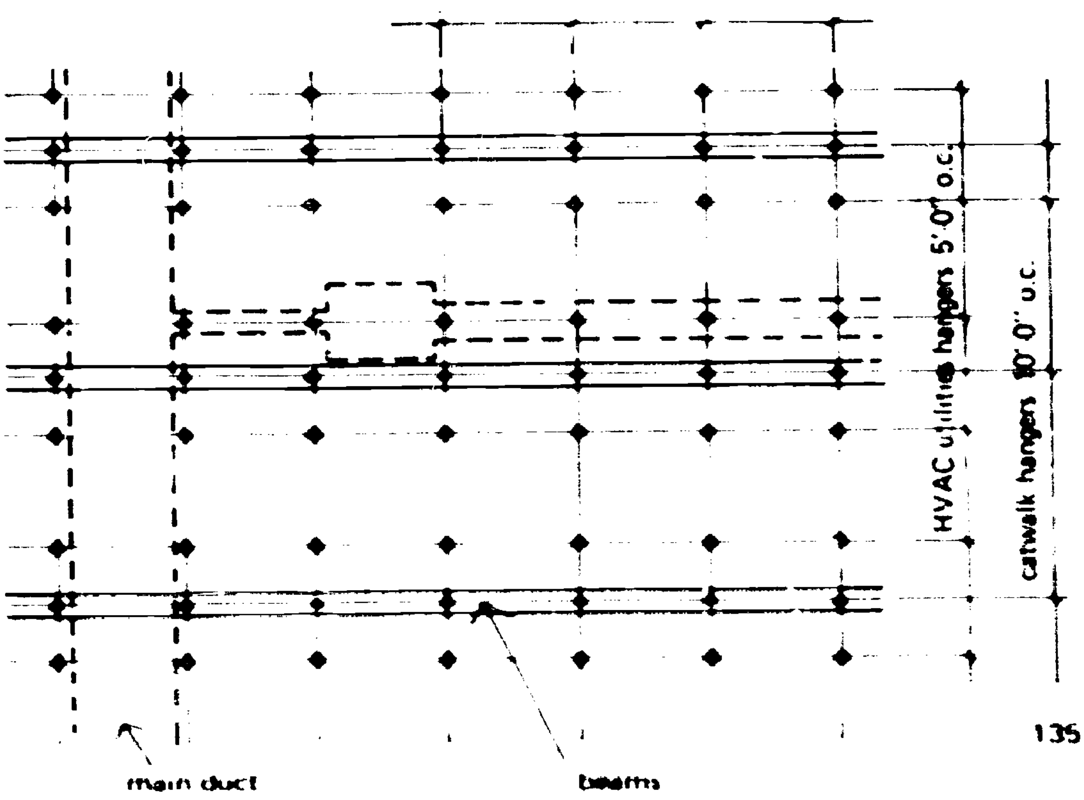
F.22.5.2 The loading requirements on the suspension hangers are indicated in Section H.15.

F.22.5.3 To provide maximum future adaptability, inserts in the structure should be installed in accordance with the layout dimensions shown on the following two drawings. Only those suspension rods required by the initial configuration need be installed at time of building configuration.

a. Access Ceiling



b. Catwalk Ceiling



G. HEATING, VENTILATING AND AIR CONDITIONING

G.1 BACKGROUND

G.1.1 The ABS Heating, Ventilating and Air Conditioning (HVAC) subsystem is intended to so constrain the effects of climate, occupancy, and the many physical characteristics of the specific building that a reasonable interrelationship is insured among them. The subsystem results from an effort to establish optimum relationships among the HVAC subsystem, the other ABS subsystems, the building in general and the functional use thereof. The description herein outlines the HVAC subsystem together with variations thereon. The methods indicated are valid within California and Indiana, and should be appropriate for most of the continental United States.

G.1.2 The information in this section is provided as a guide to the design professional, whose responsibility must include its interpretation and application. Local conditions, preferences and more stringent requirements for a specific project may suggest to him variations which he is encouraged to investigate. When the design professional's requirements differ from the defined relationships, careful appraisal of the interface with the other subsystems will be required.

G.2 FUNCTIONAL AREAS SERVED

G.2.1 The HVAC subsystem is intended to be applicable for the following functional areas and their ancillary spaces:

a. Laboratories
b. Classrooms
c. Offices
d. Corridors
e. Public Spaces
f. Meeting Rooms
g. Toilet Rooms

G.2.2 The conditions for each specific project involving areas such as the following must be examined to determine if supplementary equipment is needed:

a. Computer Rooms
b. Clean Rooms
c. Animal Rooms
d. Auditoriums
e. Growth Chambers

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G.3 ENERGY SOURCES

G.3.1 ABS makes no recommendation as to selection of the energy source and energy conversion equipment. This is the responsibility of the design professional for the specific project, and should involve consideration of the lowest total annual owning cost derived from conditions of climate, energy cost, energy source availability, labor and equipment cost, maintenance and financing charges.

G.3.2 Energy sources available to university buildings include:

a. Campus steam or hot water
b. Campus chilled water
c. Natural gas
d. Fuel oil
e. Electric power

G.4 WORK INCLUDED IN THIS ABS SUBSYSTEM

The work included is those parts directly serving academic areas:

a. Supply, return and exhaust fans
b. Cooling coils
c. Heating coils
d. Filters
e. Humidifying equipment
f. Dampers
g. Controls
h. Supply ductwork
i. Piping
j. Reheat boxes
k. Duct and piping insulation
l. Exhaust ductwork from labs and fume hoods

G.5 WORK NOT INCLUDED IN THIS SUBSYSTEM

The work not included consists of:

a. Central campus energy conversion equipment
b. Central boilers
c. Central chillers
d. Cooling towers

e. Domestic or laboratory hot or cold water
f. Ceiling supply and return registers
g. Fume hoods
h. Snow melting equipment

G.6 DESCRIPTION OF HVAC SUBSYSTEM

G.6.1 MECHANICAL SERVICE ZONE

Each building is composed of one or more space modules that are one floor in height and from 7,500 to 12.500 square feet in area. A mechanical service zone is located above the ceiling in each space module. Each space module is mechanically independent of the rest of the building except for central energy conversion and distribution, and exhaust fans. Each mechanical service zone is served by an independent air handling unit located in the space module's mechanical room in the service tower. The mechanical service zone houses ducts for air supply and exhaust, and it also serves as a plenum for air return to the mechanical room.

The air handling equipment, all vertical exhaust ducts, and all vertical conduit and piping are contained in mechanical rooms in the service tower, the latter is contiguous to the space module. Mechanical rooms are stacked in the service tower in proportion to the stacked space modules.

G.6.2 AIR DISTRIBUTION

Supply of HVAC is medium velocity,[7] by single duct with terminal reheat, with treatment of the air for all zones—interior and perimeter—in the individual space module. Outlet terminals are strip diffusers in the ABS ceiling subsystem. Ceiling registers may be used, also.

Supplementary convective heating at the exterior walls may be added in cold climates.

Cool air is tempered by coils in the reheat boxes. Reheat boxes have integral automatic constant volume dampers.

G.6.3 EXHAUST AND RETURN AIR

G.6.3.1 Air from toilet rooms, some laboratories, and fume hoods cannot be recirculated. This air is ducted to a vertical shaft in the mechanical room and exhausted above the roof. Roof fans maintain a negative pressure throughout the exhaust ducts. Multiple fans, operating in parallel on the building's main exhaust shafts, provide standby and facilitate subsystem expansion.

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[7] Differential static pressure at the supply fan will be in the range of 4" to 5" water column; the static pressure in the supply duct in the range of 1" to 2½" water column. For reference, ASHRAE defines medium pressure ductwork as applicable to duct pressures between 2" and 6" water column

G.6.3.2 The exhaust from fume hoods wherein radioactive materials are used shall be independently filtered before entering the exhaust duct. Fume hoods using potentially explosive materials, such as perchloric acid, must be restricted to the top floor of each building so they can be equipped with internal washdown sprinklers and independently ducted vertically directly to the outside.

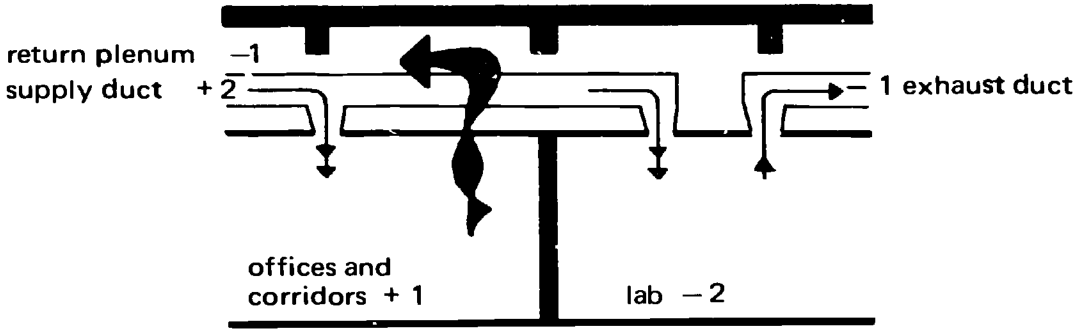
G.6.3.3 All other air is returned through the mechanical service zone, acting as a return plenum, to a separate fan in each mechanical room. From this fan, air is blended with and/or exhausted to the outside in a variable ratio.

G.6.4 RELATIVE AIR PRESSURE

G.6.4.1 The entire building shall be designed under higher pressure than the out-doors, so as to result in building exfiltration.

G.6.4.2 Air pressures within the building, to prevent undesirable odor migration, shall range as follows:

a. Supply ducts (highest pressure)
b. Offices, classrooms, corridors
c Return air plunum
d. Laboratories, toilets
e. Exhaust ducts (lowest pressure)



relative air pressure

G.6.5 CONTROLS

The central heating and chilled water plants shall have controls to maintain desired supply water temperatures.

C.6.5.1 Each heating plant shall have a control panel to include:

a. Means for stopping and starting heating equipment with "on" and "off" indication provided by flow switches for fans and pumps with visual and audible malfunction alarms.

b. Indications with visual and audible malfunction alarms of outside air temperature, supply and return of heating, chilled and cooling tower water temperatures, and of outside air moisture content.

c. Heat, smoke and combustion detectors with visual and audible alarms, and connection to the building and/or campus fire alarm system. The "HVAC system malfunction" and "HVAC fire" alarm shall be connected with a 24 hour day manned station.

C.6.5.2 Each supply air equipment area shall have a control panel to include:

a. Indicators for temperature of return air, mixed entering air, and supply air; of supply air moisture content.

b. Means of stopping and starting fans.

C.6.5.3 The air handling equipment coils and humidity control equipment shall maintain a constant cold air temperature in the main supply duct, within the limits established for the room relative humidities.

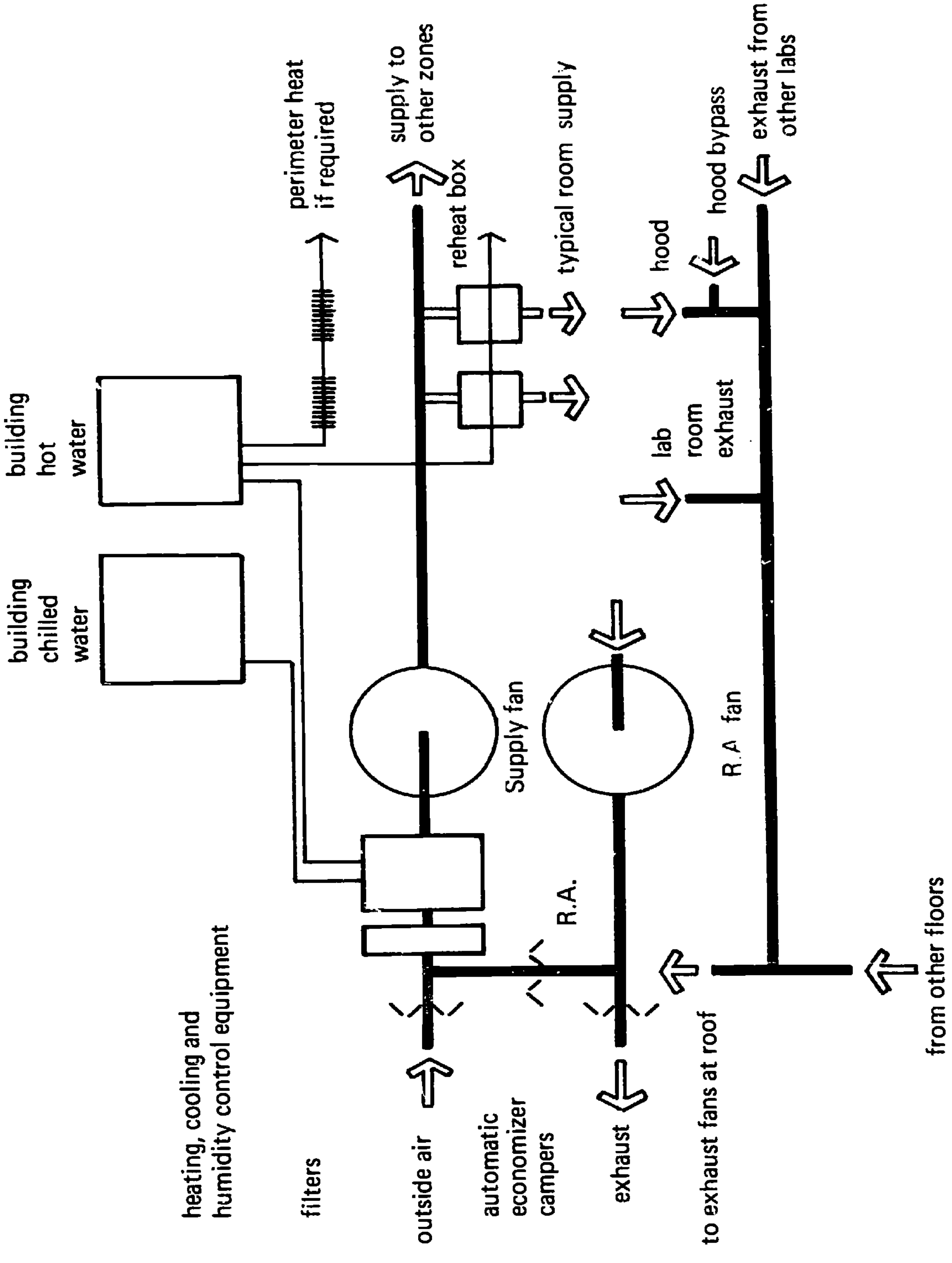
C.6.5.4 Perimeter heating shall have separate controls for each exposure zone. The zone supply water temperature shall be controlled by outside air thermostats with solar compensators.

C.6.5.5 Each control zone shall have a wall mounted thermostat to modulate the zone reheat coil control valve.

C.6.5.6 Provide appropriate controls for snow melting, and for freeze protection of water systems.

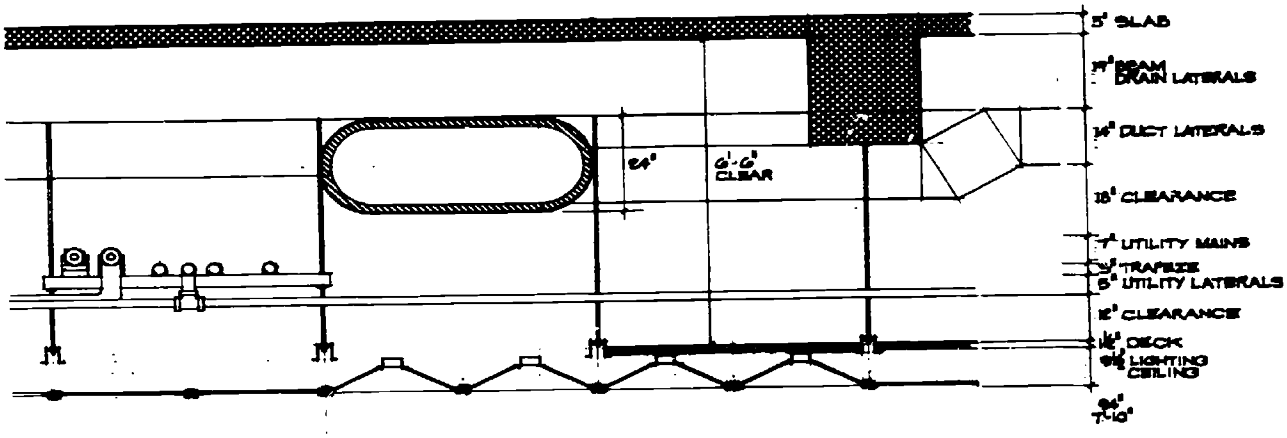
C.6.5.7 Provide smoke dampers and controls for heat, smoke and combustion detection as required by applicable codes.

G.6.6 SCHEMATIC FLOW DIAGRAM: HVAC SUBSYSTEM

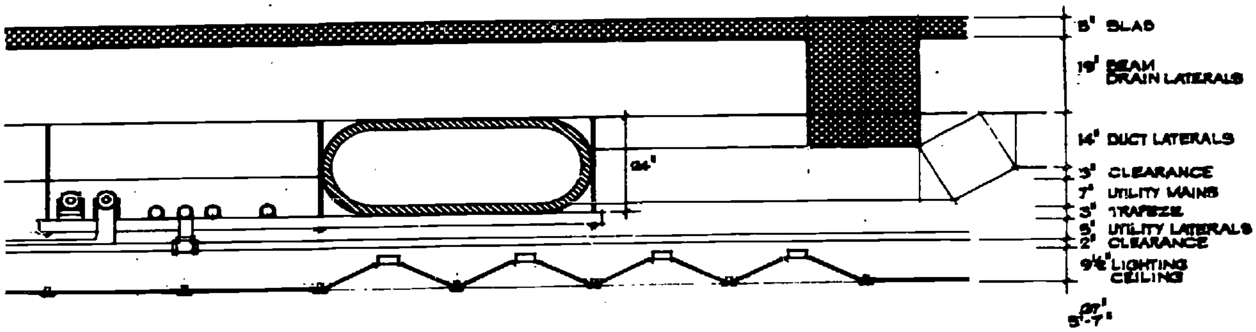


G.7 OPTIONS FOR MECHANICAL SERVICE ZONE

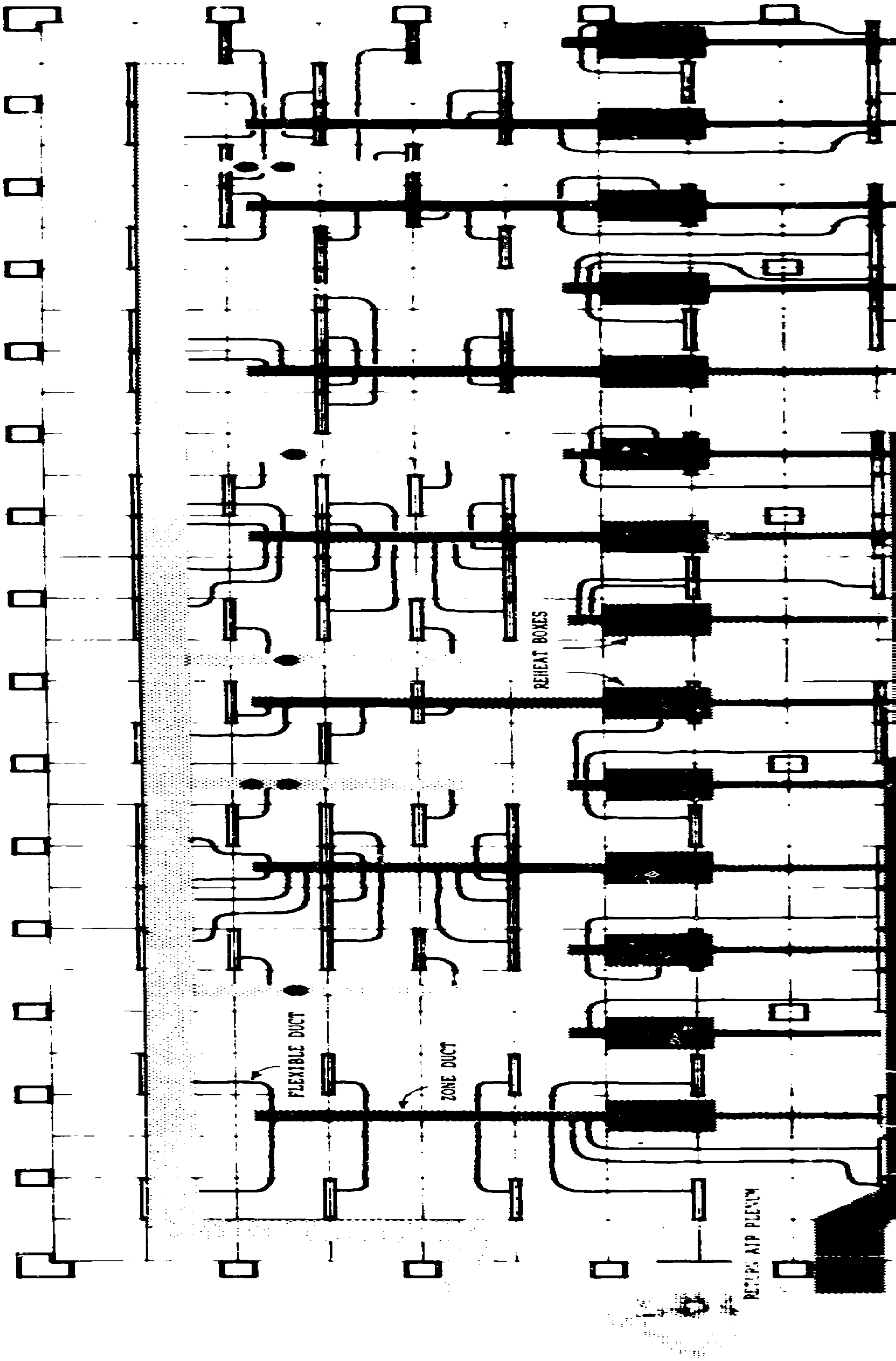
G.7.1 The ABS structure subsystem provides two options for the mechanical service zone. Laboratories and similar spaces involving frequent change will use the deep service space. Offices and classrooms involving infrequent service changes may use the shallow service space. Access to the deep service space is via catwalks from the mechanical room, while access to the shallow service space is through the ceiling, as shown below.



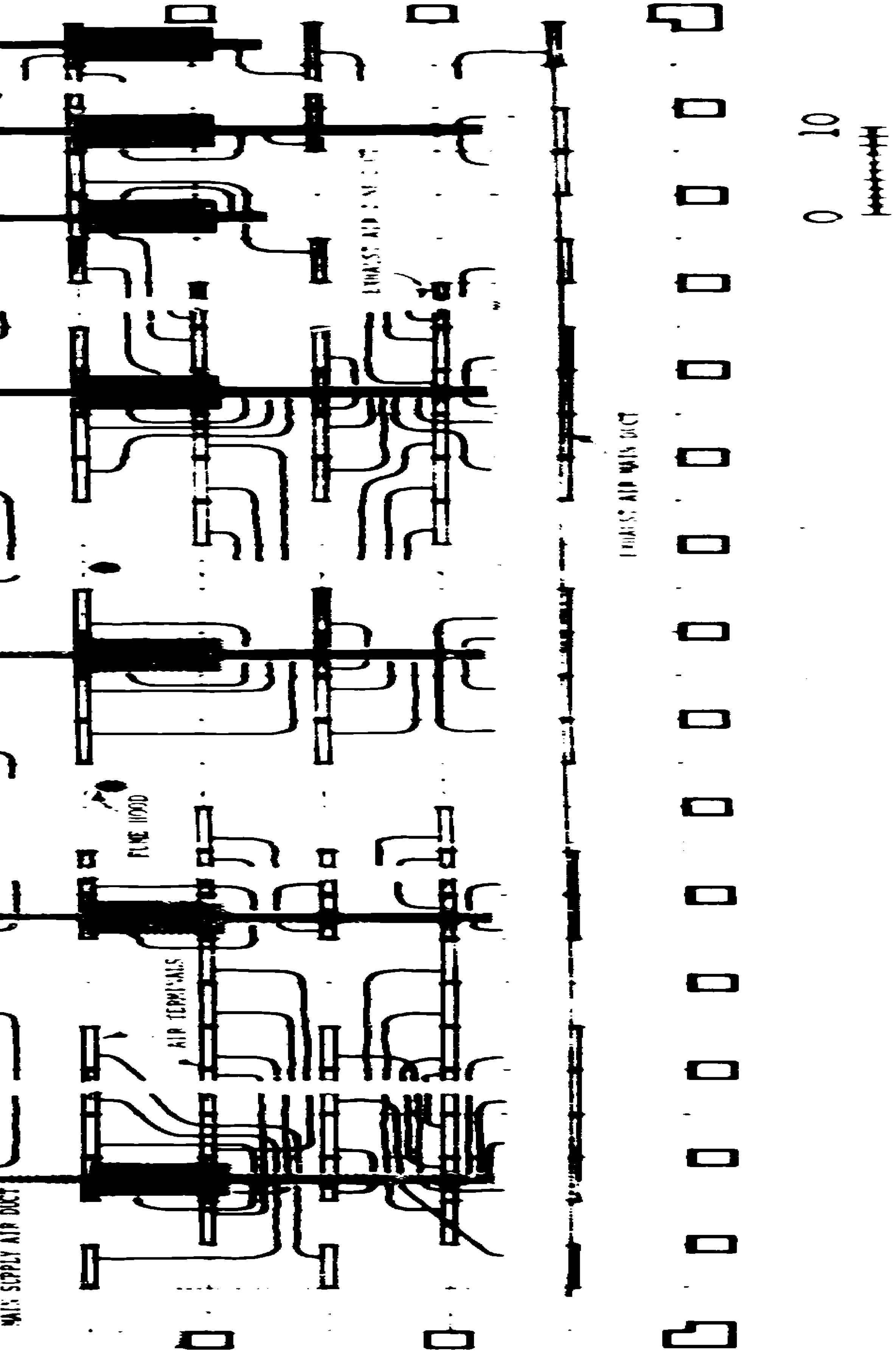
Deep Service Space



Shallow Service Space

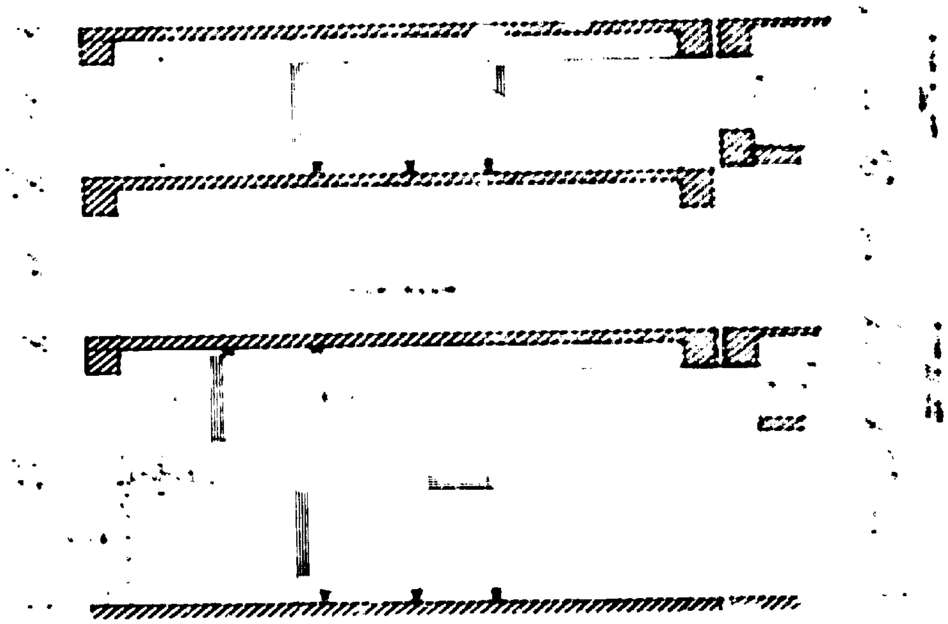

REHEAT BOXES
FLEXIBLE DUCT
ZONE DUCT
RETURN AIR PLENUM

NG DISTRIBUTION

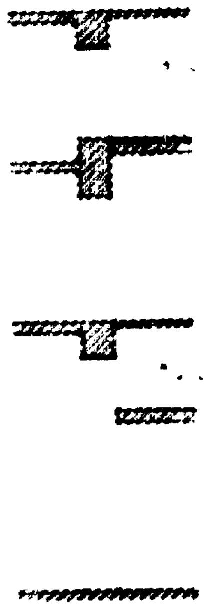


G.8 TYPICAL SECTIONS: MECHANICAL ROOM AND SERVICE SPACE

G.8.1 Use of the deep service space permits the alternate stacking of toilet/janitor rooms below the mechanical room



typical service tower structural separation



alternate structural condition

G.9 PERMANENT ELEMENTS OF THE HVAC SUBSYSTEM

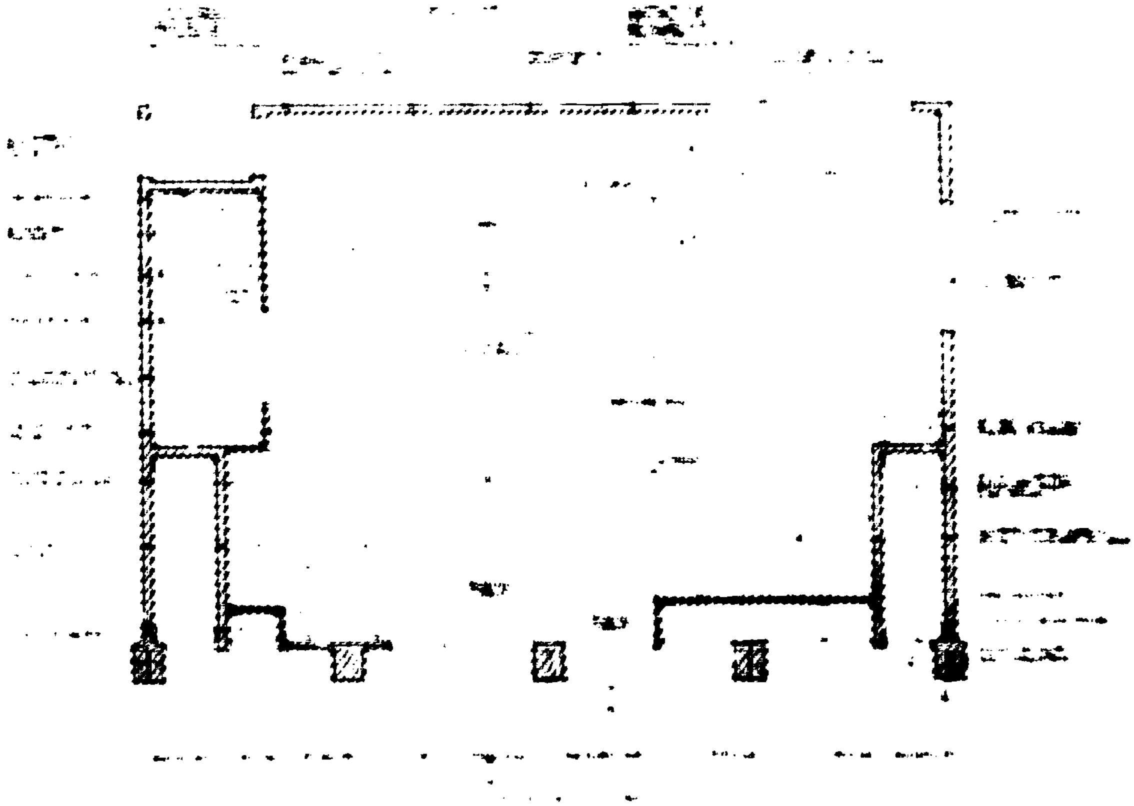
G.9.1 Components located in the mechanical room and sized for the maximum anticipated space module loading are:

a. Hot and chilled water risers
b. Exhaust air shafts

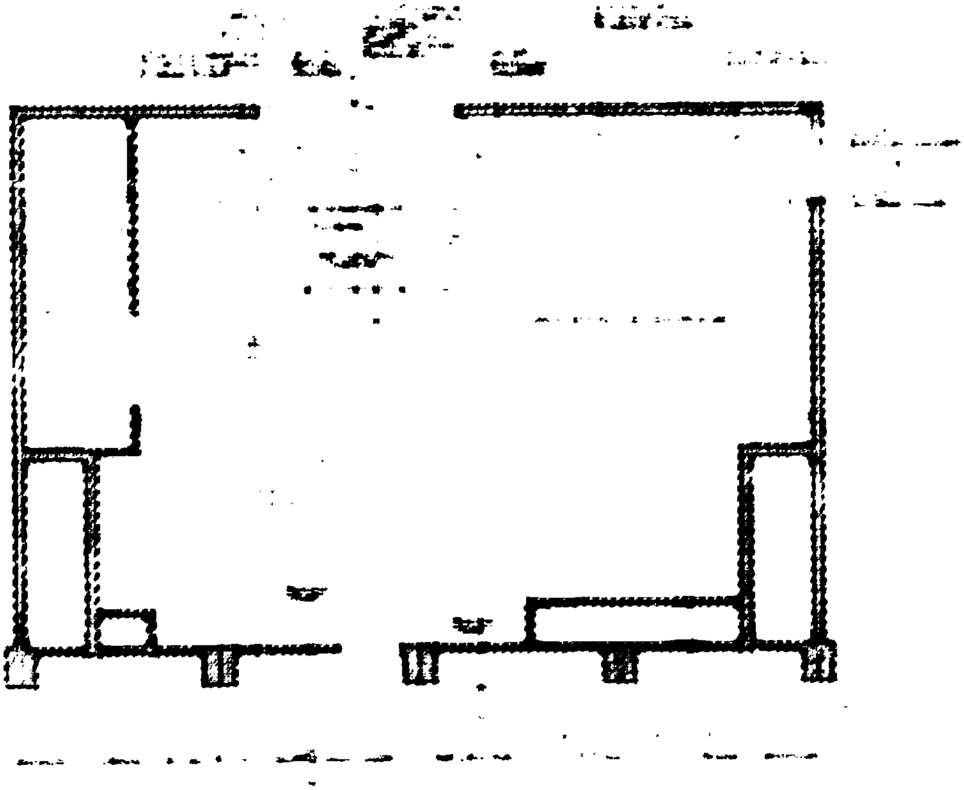
G.9.2 Components located in the mechanical service zone above the ceiling of the space module, and sized for the maximum anticipated space module loading are

a. Hot water supply and return, serving reheat boxes
b. Air supply main trunk duct
c. Air exhaust main trunk ducts

6.9.3 TYPICAL PLANS: MECHANICAL ROOM



deep
service
space



shallow
service
space

G 10 ADAPTABLE ELEMENTS OF THE HVAC SUBSYSTEM

G 10 1 Components located in the mechanical room include the supply air handling units return air fans and if required supplementary perimeter heat convectors

G 10 1 1 The mechanical room must be of sufficient size to accommodate the equipment required for the greatest anticipated use Presumably this would be laboratory use as its required air volume can exceed that for office use by a factor of two Although the output of any fan can be varied to accommodate a certain increment of more or less demand occasioned by future alterations change from offices to laboratories would require installation of a new air handling unit if redundant capacity is not included initially

G 10 1 2 Thus wherever possible the outside air intake should be a separate opening for each mechanical room large enough to allow the removal and replacement of units rendered obsolete by age or upgraded space use

G 10 2 Components located in the mechanical service zone above the ceiling of the space module include

a The zone air supply ducts
b Reheat boxes
c Hot water supply and return branch piping to reheat boxes
d Exhaust branch ducts
e Controls for supply air

G 10 3 *Zone* supply air ducts and special exhausts should conform to initial configuration requirements

G 10 3 1 In future alterations, new ducts will be tapped off the trunks as required The fixed main exhaust ducts running horizontally should have capped stubs at 10 foot centers, to allow branch connections without damage to main duct lining

G 10 3 2 Each temperature control zone will require one or more reheat boxes, positioned for maximum accessibility These temperature modulating devices should be in orderly rows for easy maintenance and piping economy

G 11 ADAPTABILITY CRITERIA

G 11 1 The HVAC subsystem should be capable of sustaining from ten to thirty control zones per space module

G.11.2 Equipment must be capable of incremental modifications to accommodate future alterations and should be designed so as to conveniently shut down only that portion of the space module directly served for the shortest practicable time

G.11.3 Distribution should be designed with sufficient capacity to accommodate substantial variation in air volumes over the building's life

G.11.3.1 Flexible ductwork should be used for branches serving those terminals expected to be relocated

G.11.3.2 Addition and subtraction of branch elements should be possible without requiring elaborate rebalancing. The design must permit rapid, efficient, accurate and stable balancing for future alterations as well as initially

G.11.4 Terminals should be capable of modification or simple replacement to provide changes in performance in special areas, or throughout large areas. Whether economically relocatable, or placed in a modular pattern assuring reasonably efficient performance regardless of plan alterations, the individual terminal must be removable for repair or replacement without disrupting any other part of the subsystem

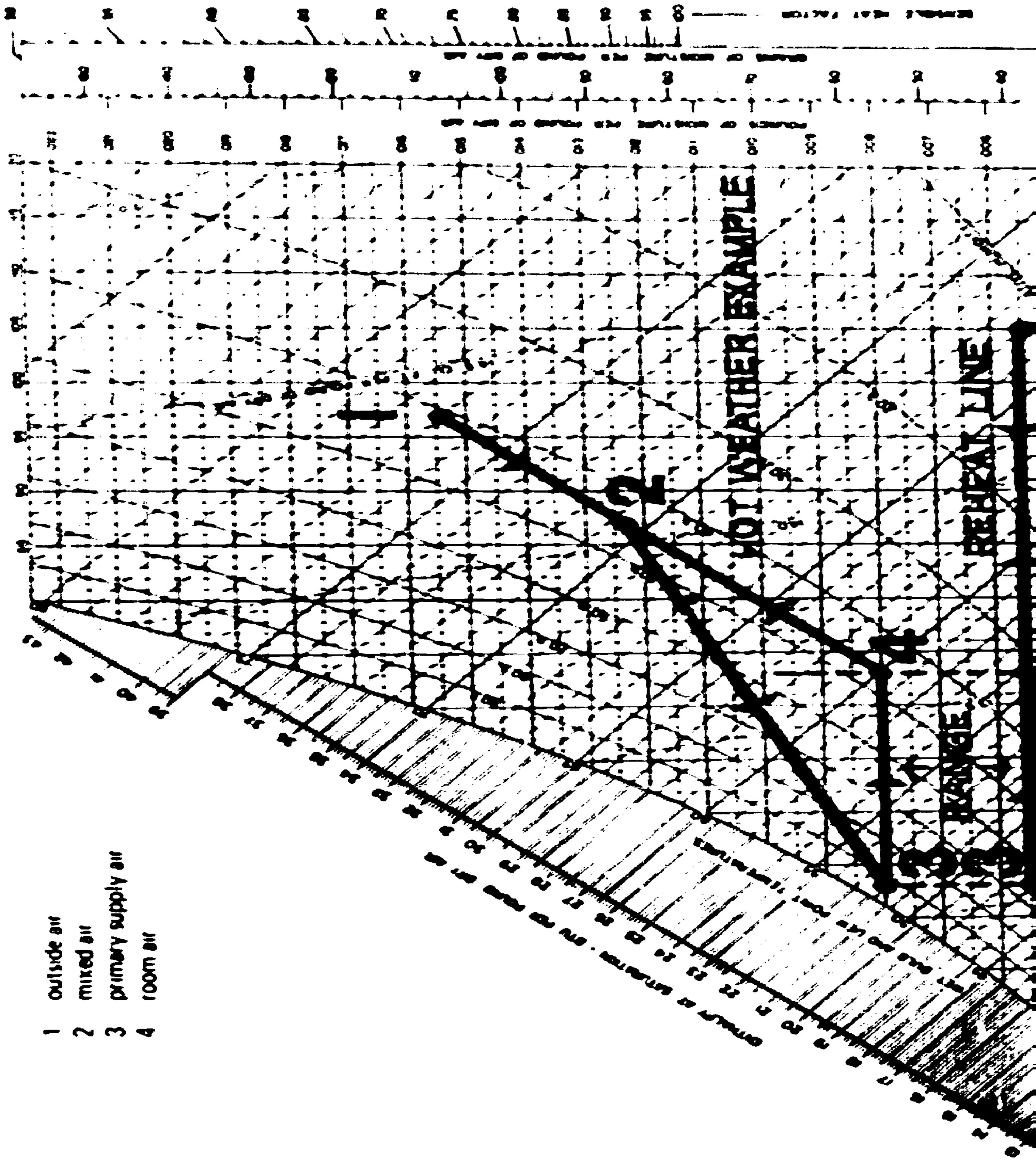
G.11.5 The controls should be designed for rapid, economical modification of equipment, to accommodate alterations in plan or performance requirements. Particular attention should be given to reassignment of terminals to thermostats, and relocation of thermostats.

G.12 HVAC SUBSYSTEM ALTERNATIVES

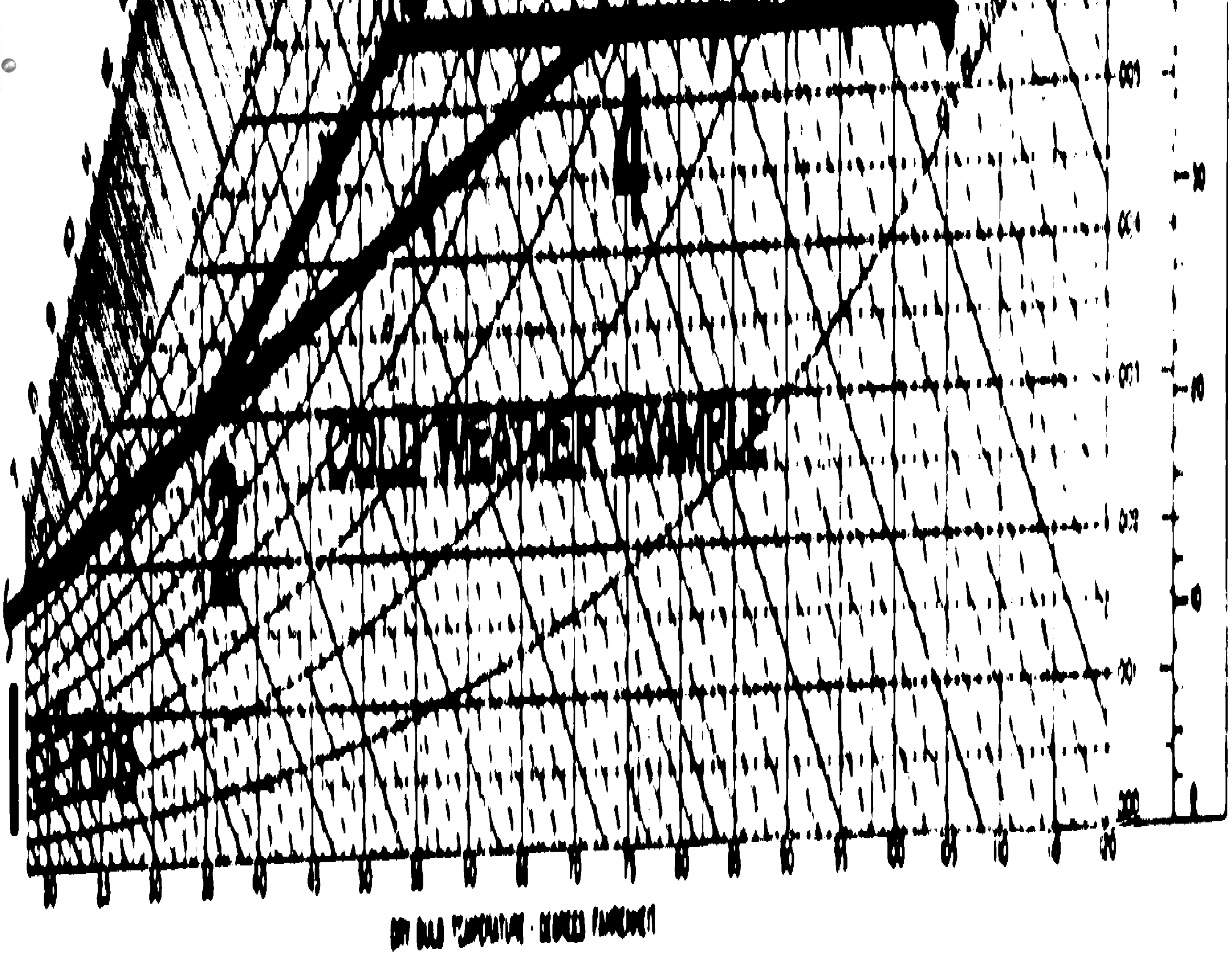
G.12.1 The medium velocity, single duct reheat system is appropriate for general application Alternatives may be considered.

G.12.2 A double duct non reheat system may be appropriate in hot weather situations, reducing the operating costs associated with reheat. Heating and cooling would be done in the warm and cold ducts, respectively. This system would not have a cooling coil on the suction side of the fan

G.12.2.1 Referring to the following Psychrometric Chart, the warm duct would be at Condition 2 and the cold duct at Condition 3, with mixing occurring on line 2-3. The extreme condition is an unoccupied interior room with no load. The blended air would be the same as the room condition at 74°F and 60% RH. If, for a no load room, the annual weather conditions and the percentage of introduced outside air result in a room relative humidity at or below the allowable maximum, the operating cost advantage is realized.



G.12.2.2 Example: Psychrometric Chart



STANDARD ATMOSPHERIC PRESSURE—29.921 IN. HG

SECTION OF ASHAE PSYCHROMETRIC CHART WITH SENSIBLE HEAT FACTOR ADDED [illegible]

G.12.3 A double duct, reheat system requires that the air to the warm duct be reheated, the operating costs associated with this reheat energy are the same as for a single duct reheat system. No cost advantage is gained although other considerations may make this system practicable.

G.12.4 Initial cost can be reduced, at the probable expense of higher operating costs, by installing package type equipment in the mechanical room. Such equipment would include integral air or water cooled refrigeration equipment, and gas fired or hot water heating equipment. Water cooled refrigeration equipment would probably require use of a cooling tower; hot water heating equipment would require a boiler, or converters from campus steam or hot water. There are obvious problems associated with condenser air in relationship to outside air intakes, and with flues from gas-fired equipment.

G.12.5 The adaptability objective indicates medium, or high pressure, package air handling equipment, because of the need to use dial adjustable, mechanical constant volume control terminal units.

G.13 SAFETY OF PERSONNEL AND PROPERTY

G.13.1 Design of the HVAC subsystem shall preclude:

a. Uncontrolled dispersion of materials harmful to persons, animals, plants, and building materials.

b. The transfer of fire and smoke from their source to other parts of the building. The central system equipment shall have appropriate alarms to indicate malfunctions, and to provide advance warning for academic experiments dependent upon a controlled environment.

G.13.2 Fire safety design shall be per NFPA Standard 90A. Where approved by the State Fire Marshal, provide automatic exhaust operated by automatic smoke detectors per NFPA 90A, paragraph 1004, 1969 edition. The HVAC control system, when activated by a smoke detector or fire alarm, shall make the necessary adjustments to insure a negative air pressure in the fire section relative to all adjacent areas of refuge.

G.14 ACCESSIBILITY

G.14.1 All components should be designed and so located that routine maintenance, repair and minor alterations with minimal disturbance to the occupants and their activities.

G.14.2 Major repairs and alterations must be accomplished with minimum down-time within the space involved, without interrupting activities in adjacent spaces.

G.15 HVAC SUBSYSTEM PERFORMANCE CRITERIA

G.15.1 The following criteria is intended to aid the design professional. Variations may be made to accommodate a specific building, subject to maintaining the appropriate interface with the other ABS subsystems, and compatibility with the total building requirements.

G.15.2 OUTSIDE AIR CONDITIONS

The design shall accommodate those outside air temperatures and humidities exceeded during 2½% of the summer hours and 99% of the winter hours, as reported in the current ASHRAE Handbook of Fundamentals.

G.15.3 ROOM TEMPERATURE

The subsystem shall maintain 73°F on both a summer design day and a winter design day. Each control zone shall be locally and independently adjustable to maintain the set temperature, plus or minus one and one-half degrees (± 1½°).

G.15.4 ROOM RELATIVE HUMIDITY

a. The subsystem shall maintain 30% to 60% relative humidity at a 73°F room temperature when room sensible heat ratios range from 90% to 100%.

b. If humidity control equipment is installed, its controls shall be adjustable at the air handling equipment. Independent, local zone controls are not required.

G.15.5 ROOM AIR QUANTITIES

G.15.5.1 The suggested minimum total air circulation rates are:

a.	Offices	1 CFM/sq.ft.	6.7 air changes/hour
b.	Classrooms	1½ CFM/sq.ft.	10.0 air changes/hour
c.	Laboratories	2 CFM/sq.ft.	13.3 air changes/hour
d.	Corridors	½ CFM/sq.ft.	3.3 air changes/hour
e.	Toilets and janitor closets	2 CFM/sq.ft.	

G.15.5.2 The maximum air circulation rate should not exceed 3 cfm/sq.ft. in any single room, nor an average 1.75 cfm/sq.ft. in the building.

G.15.6 OUTSIDE AIR VENTILATION

G.15.6.1 The suggested minimum outside air quantities are:

a.	Offices	25 CFM/person
b.	Classrooms	15 CFM/person
c.	Laboratories	20 CFM/person
d.	Corridors	¼ CFM/sq.ft.
e.	Lobbies	¼ CFM/sq.ft.
f.	Undertermined	½ CFM/sq.ft.

G.15.6.2 The system should have sufficient outside air to provide 100% exhaust of laboratory rooms, fume hoods and special exhaust systems, and result in building pressurization.

G 15.7 ROOM AIR VELOCITY

Air motion within a room, between 3 inches and 72 inches above the floor, should be between 20 and 50 feet per minute.

G.15.8 ACOUSTICS

G.15.8.1 Room noise levels resulting from the HVAC subsystem supplying 3 cfm/sq.ft. to any occupied space should not exceed the following levels, expressed as Noise Criterion Curves as defined in the current ASHRAE Guide and Data Book:

a.	Offices	NC 35
b.	Classrooms	NC 35
c.	Laboratories	NC 40
d.	Corridors	NC 40
e.	Lobbies	NC 40
f.	Toilets	NC 45

G.15.8.2 To insure acoustical privacy, the HVAC subsystem should produce room noise levels not less than NC 30 when supplying 2 cfm/sq.ft. to any occupied space. Sound transmitted from room to room via the HVAC distribution system must not exceed that permitted by partitions, floor and ceiling.

G.15.8.3 All equipment generating vibration, or subject to forces causing it to vibrate, must be located and/or isolated so as to prevent significant transmission to other building elements and spaces.

G.15.9 ROOM SUPPLY AIR QUALITY

G.15.9.1 The supply air shall be free of objectionable impurities including gases, products of combustion, fumes, odors, and particulate matter from the use of laboratories, toilets and janitor closets, that may be transported from:

a. Within the building by the return air system.

b. The out of doors, in accordance with criteria established based on local conditions.

G.15.9.2 Filters in the mixed return air and outside air stream should have 95% minimum efficiency in laboratory space modules, 45% in all other spaces, in accordance with the National Bureau of Standards Atmospheric Dust (Discoloration) Method.

G.15.9.3 Short circuiting of exhaust air into the outside air intake shall be prevented if possible, by proper location of the air intake in relation to the building configuration.

G.15.10 ROOM AIR QUALITY

Air within the occupied zone, up to six feet above the floor, shall have a quality resulting in normal occupant comfort, and minimizing occupant complaints about air described as "stuffy" or "odorous."

G.15.11 BUILDING EXHAUST AIR QUALITY

The quality of exhaust air shall comply with enforceable anti-pollution codes, rules and regulations. In the absence thereof, criteria may be established by the owner.

G.15.12 RADIANT ENERGY FACTORS

The subsystem shall result in a comfortable balance of radiant energy between occupants and other influences, including direct solar radiation and cold window glass. Radiation may be controlled by limiting the amount and type of window glass, exterior shading, interior shading, and/or with the use of supplementary heating elements below the glass.

G.15.13 Suggested energy flow rate limitations are:

a. Maximum roof heat transfer

Summer	8.4 BTU/hr/sq.ft.
Winter	7.0 BTU/hr/sq.ft.

b. Maximum wall and glass heat transfer

Summer	377 BTU/hr/lineal foot of wall
Winter	845 BTU/hr/lineal foot of wall, including filtration

c. Architects and engineers working on ABS buildings shall manipulate building orientation, exterior wall shading, percentage of glass exterior wall, glass type, interior shading, and exterior wall insulation to achieve energy flow rates not greater than those listed above.

G.15.14 CLIMATOLOGICAL AND GEOGRAPHICAL FACTORS

a. The subsystem shall relate to the local climate in a manner complimenting other specified, and non-specified implied criteria. Implied criteria includes considerations such as freeze protection, snow melting, the relationships building exhaust, outside air intake and prevailing winds, materials of construction and protection of materials.

b. The subsystem components and their maintenance shall relate to geographically available spare parts, and maintenance contractors and qualified personnel.

G.15.15 LABORATORY EXHAUST

a. Hoods and other special laboratory exhausts shall provide constant exhaust air quantities, and contribute to proper air balance and relative air pressures in the rooms. Fume hoods shall have a dampered bypass for use when the hood door is closed.

b. The requirements for laboratory exhaust may require the use of high chemically resistant exhaust grilles and ductwork, rather than the use of T-bars, air boots, and flexible ducts.

G.15.16 HUMIDITY CONTROL

The choice of humidity control equipment must result from consideration of local climatic conditions.

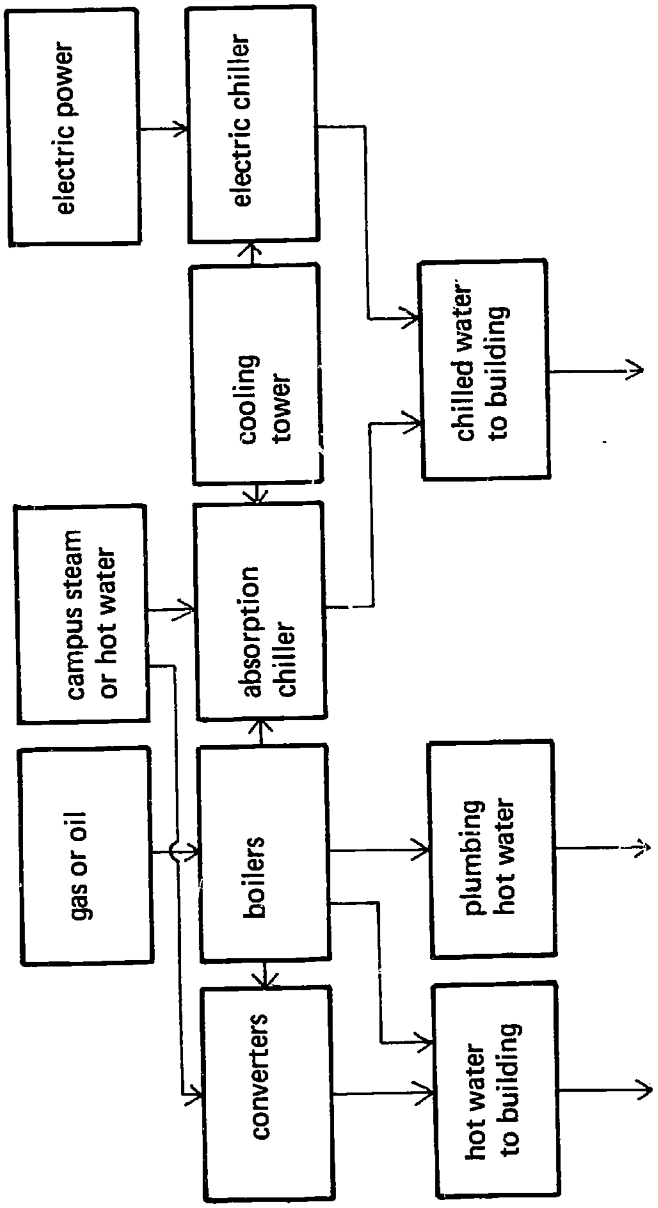
G.15.17 ENERGY RECOVERY

a. In areas of severe climatic extremes, energy recovery equipment should be considered to transfer, from the exhaust air to the supply air, energy otherwise wasted. There are two associated considerations: first, the effect of vapors in the exhaust air on the materials of the energy recovery equipment and, second, the rerouting of the outside air and exhaust air through the energy recovery equipment that would be necessary.

b. The decision regarding the use of energy recovery equipment should be based on an economic analysis, including additional investment cost for the energy recovery equipment and revised air paths, less investment costs associated with the central plant heating and cooling equipment, and reduced heating and cooling energy costs.

G.15.18 CENTRAL PLANT

a. A schematic outline of the central plant, including possible variations, is illustrated below. The variations recognize that the selection will be dependent upon the availability and costs of local energy sources, and should result from a comparative study of the long-range economics (i.e., total annual costs).



Central Plant Schematic Flow Diagram—Indicating Alternatives

b. The central plant must deliver hot and chilled water to supply air handling and terminal equipment.

c. Alternative heating equipment includes boilers and/or hot water converters. Consideration should be given to providing energy to the domestic hot water heaters from the central heating plant.

d. Alternative water chillers include electric reciprocating types (for loads less than 150 tons) and electrical centrifugal, steam absorption and hot water absorption types (for loads in excess of 100 tons). For loads between 100 and 150 tons the type is optional; the choice should include consideration of future additional loads.

e. Alternative sources of heat rejection include cooling towers, spray ponds, wells, rivers and lakes.

f. The sizes of the central plant equipment requires study for each individual building. There may be two loads for each building: the first representing the loads calculated for the initial construction and building usage, and the second representing the loads expected when the building is utilized to its future greatest capabilities.

g. If the two loads above are very close together, the central plant equipment should be sized for the larger. If the initial loads are significantly lower than the future loads, the central plant equipment should be designed in multiples so that equipment can be added as the load increases.

G.16 COMPATIBILITY WITH OTHER ABS SUBSYSTEMS

G.16.1 WITH STRUCTURE

The HVAC subsystem must not place concentrated loads on the structure that are in excess of those accommodated by the structure subsystem. Methods of attachment and support should not require modification of the basic structure configuration. No mechanical element may penetrate any structural element except floor slabs. Such penetration will occur only via openings specifically provided for that purpose.

G.16.2 WITH PARTITIONS

Terminals should not be located in, or supported by, partitions. Control leads from wall thermostats should rise directly into the ceiling service space without horizontal run.

G.16.3 WITH LIGHTING-CEILING

a. Air outlets will be located exclusively in the ceiling and sufficiently sound insulated to prevent degrading the STC rating of the ceiling. Preferred are terminals light enough to rest directly on the ceiling without additional support from the structure above.

b. HVAC and utilities distribution loading on hangers shall not exceed that provided by the lighting-ceiling subsystem.

G.17 COMPATIBILITY WITH NON-ABS SUBSYSTEMS

G.17.1 SERVICE DISTRIBUTION

The mechanical service zone will be subdivided into reserved zones for specific components of service distribution. As ductwork will require the largest amount of space, it must be carefully located to avoid interference with the efficient layout of other services.

G.17.2 PIPING

a. Hot water and chilled water lines serving HVAC equipment must have zone valves for each mechanical service zone. These lines must be completely independent of all other water lines.

b. The following is an example of pipe sizes suggested for a building of 10,000-12,000 sq.ft. space modules:

Condenser water piping	3,500 GPM	12"
Chilled water piping	21,100 GPM	10"
Heating water piping	250 GPM	4"
Reheat water piping	250 GPM	4"

G.18 ENGINEERING GUIDE

G.18.1 The intent herein is to establish certain techniques, methods and criteria to be used during design of the HVAC subsystem.

G.18.2 LOAD CALCULATIONS

Heat gain and loss calculations shall be performed in accordance with the latest ASHRAE Handbook of Fundamentals including hour averaging of radiant portions of the cooling loads. Minimum room air quantities, in cubic feet per minute (cfm), shall be determined from these loads.

G.18.3 RETURN AIR FAN

The return air fan should be sized for the air quantity required in a situation without laboratories, but should be modifiable to facilitate future changes in building usage - the reduced operation in a situation with maximum laboratories.

G.18.4 DUCT SIZING

a. The medium velocity main duct shall have a maximum velocity of 3,000 feet per minute (fpm). Ducts downstream from the mains shall be at reduced velocities, creating static regain. The regain shall be accounted for in the fan static pressure calculation.

b. Low velocity supply ducts, downstream from reheat boxes, and return and exhaust ducts shall be sized on the basis of 0.08 inch of water per 100 feet of duct, but not to exceed a velocity of 1,500 fpm.

c. The following is an example of HVAC distribution capacities suggested

FOR A 12,5000 SQ.FT. SPACE MODULE

Service	Flow Rate Capacity	Size
Supply air (duct)	21,000 CFM	48" x 24" oval
Return air (sound trap)	16,000 CFM	56" x 52"
Exhaust air (ducts)	11,000 CFM	2 @ 26" x 24"
Reheat water piping	20 GPM	1½"
FOR TEN SPACE MODULES		
Exhause air (shafts)	120,000 CFM	2 @ 120" x 36"

G.18.5 ECONOMIZER DAMPERS

Automatic outside, return and exhaust dampers shall be sized for maximum possible air quantities. A section of each damper, sized and manually adjusted for minimum quantities, shall be disconnected from the control system. Those sections of the dampers automatically controlled shall travel from full closed to full open to achieve minimum to maximum air quantities.

G.18.6 SOUND ATTENUATION

a. The air handling components shall incorporate sufficient sound attenuating characteristics, including duct lining and/or sound traps if necessary, to maintain the required minimum room noise levels. The determination of the requirements for such characteristics shall be based on the sound power levels of the supply, return and exhaust fans, and the calculation method outlined in the latest ASHRAE Guide and Data Book.

b. Adequate precautions will have to be taken with respect to equipment, piping and duct mountings, penetrations of sound barriers, structure, piping and duct-born vibrations, and noise transmissions through equipment area enclosures.

G.18.7 PIPING VELOCITIES

Water velocities in the hydronic systems shall not exceed the following:

PIPE DIAMETER

Inches	GPM[a]	FPS[b]
¾	3	2.0
1	7	2.5
1¼	15	3.5
1½	20	3.5
2	40	4.0
2½	70	4.5
3	125	5.5
4	250	6.5
6	700	8.0
8	1400	9.0
10	2100	9.5

[a] GPM = gallons per minute

[b] FPS = feet per second

G.18.8 **FOR 100% AIR EXHAUST, NO RECIRCULATION**

Where the requirements for a specific building suggest an HVAC subsystem design for 100% outside air, the deep service space shall be used, and the following conditions will apply

G.18.8.1 With the flexibility to convert to the use of return air:

a. Adjust the outside, return and exhaust air dampers to fixed positions of 100% outside, no return and 100% exhaust air.

b. Alternatively, delete the outside, return and exhaust air dampers and substitute plenum walls for the return air damper and plenum openings for the outside and exhaust air dampers.

G.18.8.2 Without the flexibility to convert to the use of return air:

a. Delete the return air fan; the outside, return and exhaust air dampers; the exhaust louver; the return air sound trap and much of the related plenum construction. The supply fan would connect directly to the outside air louvers.

b. Increase the size of the exhaust ducts above the ceiling of the module, the exhaust risers and the roof mounted exhaust fans.

G.19 AIR BALANCING

G.19.1 A critical step in the development of an adequately performing HVAC subsystem involves the balancing of the air and water distribution. The following requirements are appropriate:

a. Balancing shall be performed by an approved balancing specialty firm per recommendations of AABC.

b. Duct and outlet readings shall be made with Anemotherms or Velometers of recent calibration. Readings on large air intakes, coil banks and filter banks shall be made with anemometer. Static pressure readings shall be taken with inclined tube manometer. Electrical current readings shall be made with clamp-on type ammeter.

c. Automatic control systems shall be adjusted for normal operating conditions.

d. Tests shall not be conducted until all doors and windows are in place, or under normal traffic conditions.

G.19.2 A continuous record should be kept of all test readings with a typewritten air balancing report to be submitted upon completion. Report shall include at least the following information, giving both specified design figures and actual observed figures:

a. Fans:

Number, service, model and size
Delivery in CFM
Static pressure: suction, discharge and total
Voltage: rated and actual
Motor amperage: rated and actual
Motor sheave diameter: adjustable or solid
Fan sheave diameter
Motor RPM
Fan RPM

b. Filter banks and outside air, return air and exhaust air cfm's.

c. All supply, exhaust and return air outlets; showing outlet location by room number or other suitable means. Include key plans if necessary to identify location.

Supply outlet deflection setting
Supply outlet size
Supply outlet design CFM
Supply outlet actual CFM
Return or exhaust outlet size
Return or exhaust outlet design CFM
Return or exhaust outlet actual CFM

G.19.3 Adjust air quantities to following tolerance:

a. Each outlet: 10% plus or minus
b. Each room with multiple outlets: 0% to plus 10%
c. Fans: 0% to plus 10%. Adjust or change fan drives as required to provide required air quantity.

G.19.4 In addition to the foregoing tolerances, balancing shall result in a total building pressure greater than the outdoor pressure, and relative pressures among building elements ranging from higher to lower in the following order:

a. Supply ducts (highest)
b. Offices, classrooms, corridors and lobbies
c. Return air plenum above ceiling
d. Laboratories, toilets and janitor closets
e. Exhaust ducts (lowest).

G.19.5 Allowance shall be made for air filter resistance at time of tests. Main air supply to be at design air quantity at pressure drop across filter banks midway between pressure drop for clean and dirty filters.

G.19.6 After completion of balancing, operate all systems and equipment under normal working conditions for three (3) consecutive seven (7) hour days and submit record of performance.

G.20 WATER BALANCING

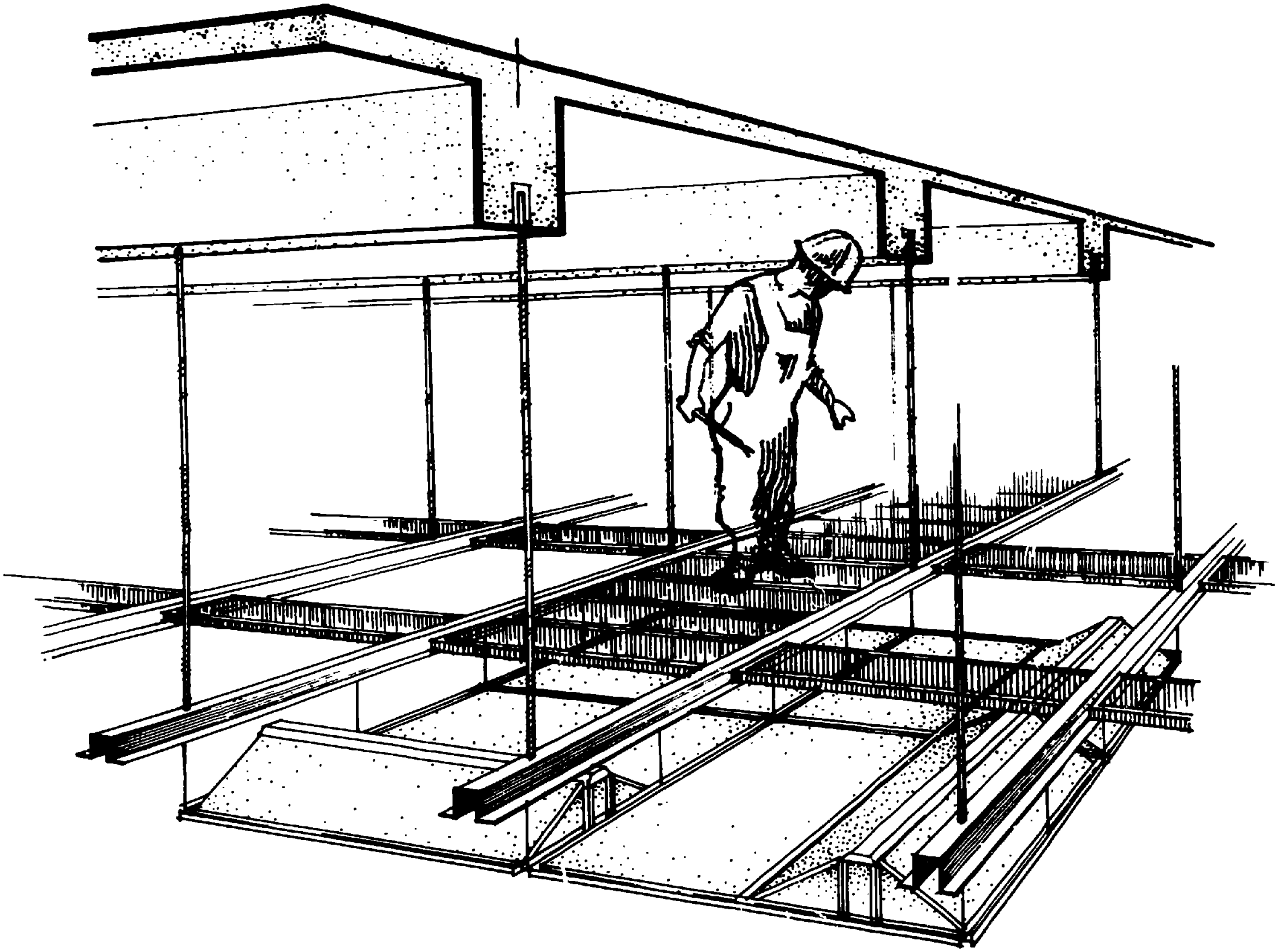
G.20.1 Balancing should be performed by an approved balancing specialty firm, in accordance with recommendations of AABC.

G.20.2 Balance all water quantities to specified gpm's at venturis. At all other locations balance by return water temperatures. The following data should be submitted:

a. Venturis: Service, location, size, required gpm, measured pressure difference, resultant actual gpm from venturi curves.

b. Pumps: Number, service, model and size, impeller diameter, suction pressure, discharge pressure, total head, elevation of each gauge above floor, rated motor voltage and amperes, actual motor voltage and amperes, required gpm, resultant actual gpm from pump curves.

c. After completion of balancing, operate all systems and equipment under normal working conditions for three (3) consecutive seven (7) hour days and submit record of performance.



H. LIGHTING-CEILING SUBSYSTEM

H.1 This ABS subsystem provides lighting-ceiling throughout the space module, below the service space reserved for horizontal distribution of utilities and services. The criteria and designs shown herein derive from relationships with the other ABS subsystems in satisfaction of the ABS objectives. There is no intent to imply that any particular material or application thereof is mandatory.

The information in this section is provided as a guide to the design professional, whose responsibility must include its interpretation and application. Local conditions, preferences and less stringent code requirements for a specific project may suggest to him economies and variations which he is encouraged to investigate. When the design professional's requirements differ from the defined relationships, careful appraisal of the interface with the other subsystems will be required.

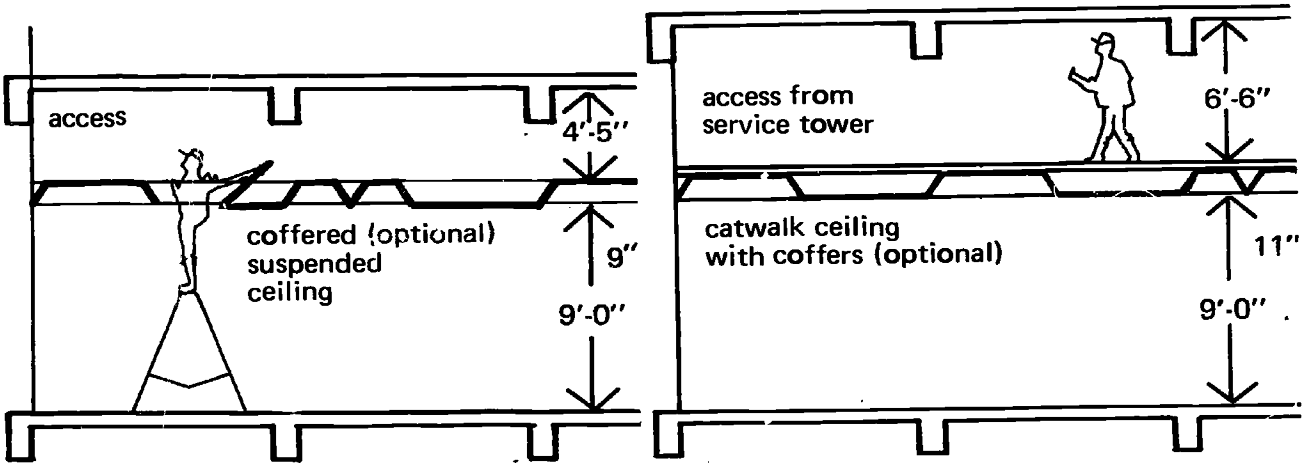
H.2 Two basic lighting-ceiling conditions are to be accommodated:

H.2.1 First, a lighting-ceiling subsystem suspended directly from the structure. Access to the service space is through the ceiling from rooms below, via removable components.

H.2.2 Second, a lighting-ceiling subsystem with walk-on capability, consisting of catwalk framing suspended from the structure, with lighting-ceiling components suspended from the catwalk framing. Access to the service space is from the service tower via catwalks.

H.3 The ceiling and lighting components for both conditions are identical except for length and attachment of the suspension wires.

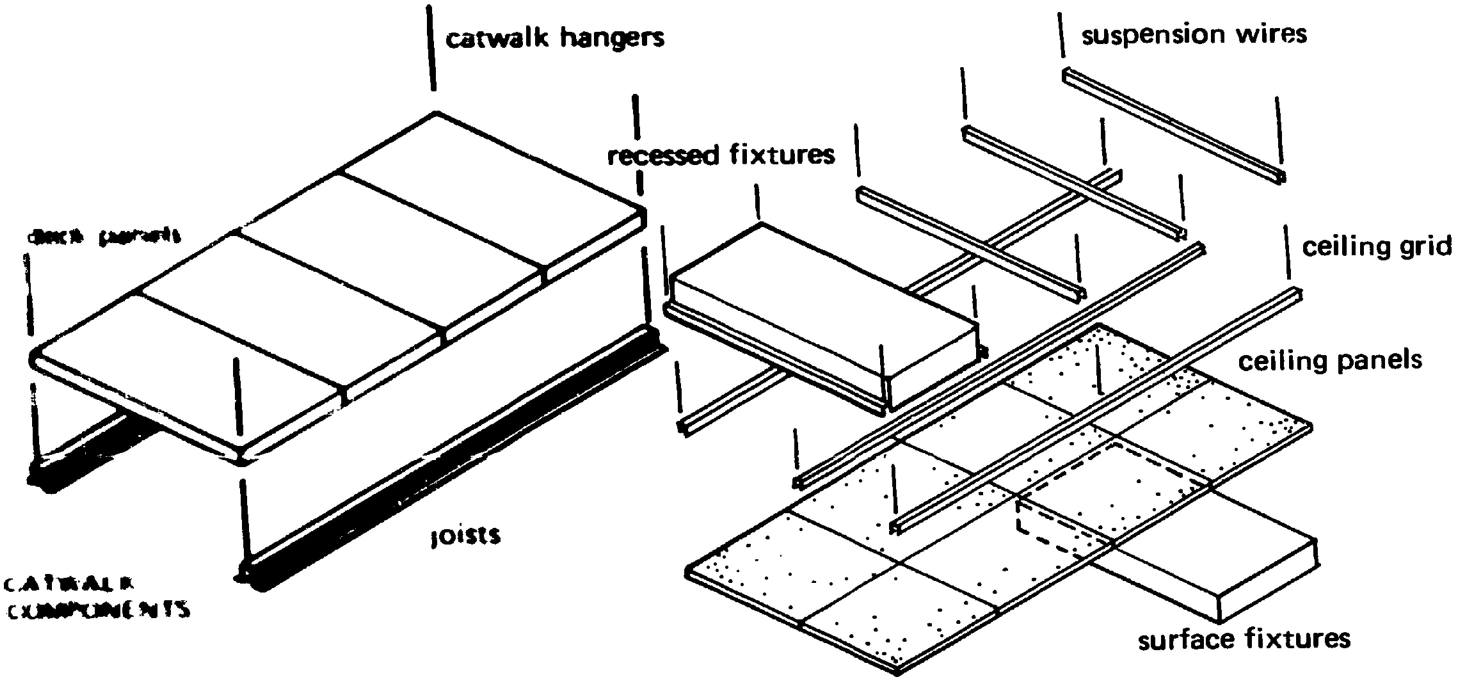
The two conditions are shown below, in vertical section:



[illegible] The ABS lighting ceiling subsystem includes:

a. Catwalk components, consisting of hangers, joists, and catwalk panels.
b. Lighting ceiling components, consisting of suspension wires, ceiling grid, ceiling panels, and lighting fixtures.

[illegible] LIGHTING AND CEILING COMPONENTS



LIGHTING AND CEILING COMPONENTS

Suspension Hangers include method of adjustment, attachment above, and provision for attaching utility and ductwork trapezes.

Joists include attachment to hangers and provision for receiving catwalk panels and ceiling suspension wires.

Catwalk panels include attachment to joists, gaskets, and penetrations for vertical services where required.

Suspension wires to either structure or catwalk joists include attachment and method of adjustment.

Ceiling grid includes attachment to wires, attachment and support of intermediate grid bars, ceiling panels, lighting fixtures, vertical services penetrations, and HVAC terminals.

Ceiling panels include attachment to grid, penetrations where required for vertical services, HVAC terminals, and recessed lighting fixtures.

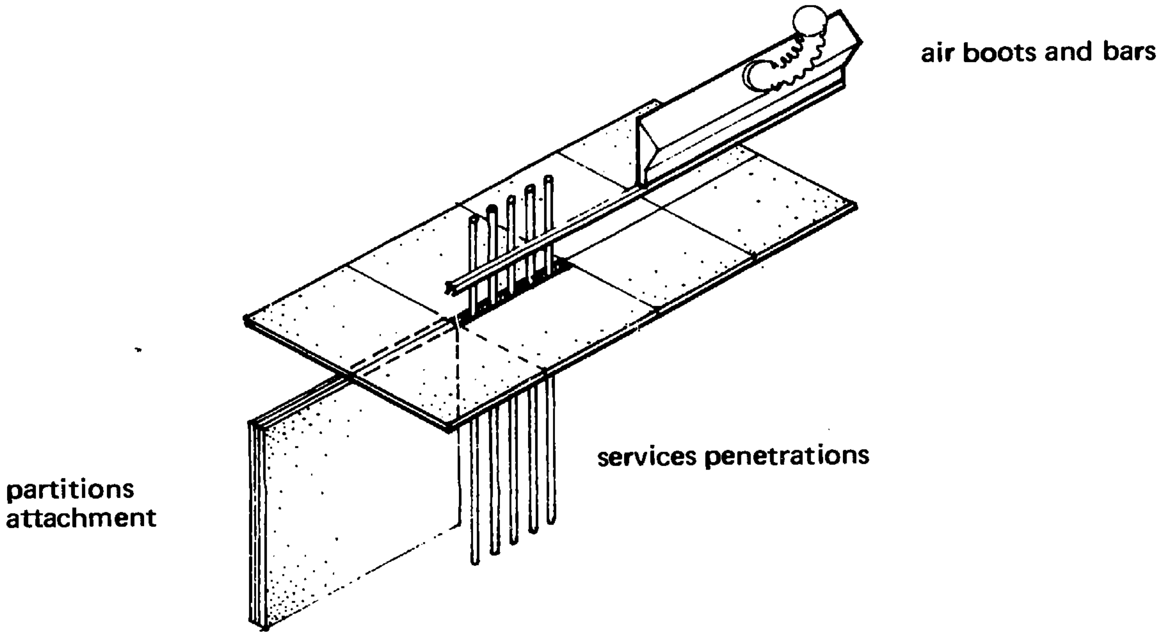
Lighting fixtures, recessed or surface mounted, include attachment to ceiling grid, flexible

H.5 This subsystem shall make provision for other subsystems as follows:

H.5.1 HVAC terminals: supported by ceiling grid, includes any mechanical boots, diffusers, fire dampers or return air devices integral with luminaires, suspension devices, panels, insulation and trim pieces required to maintain acoustic and fire-rating qualities.

H.5.2 Services penetrations: supported by ceiling grid or ceiling panels, includes method of penetration, trimming, insulating, and sealing around services piping required to maintain acoustic and fire-rating qualities.

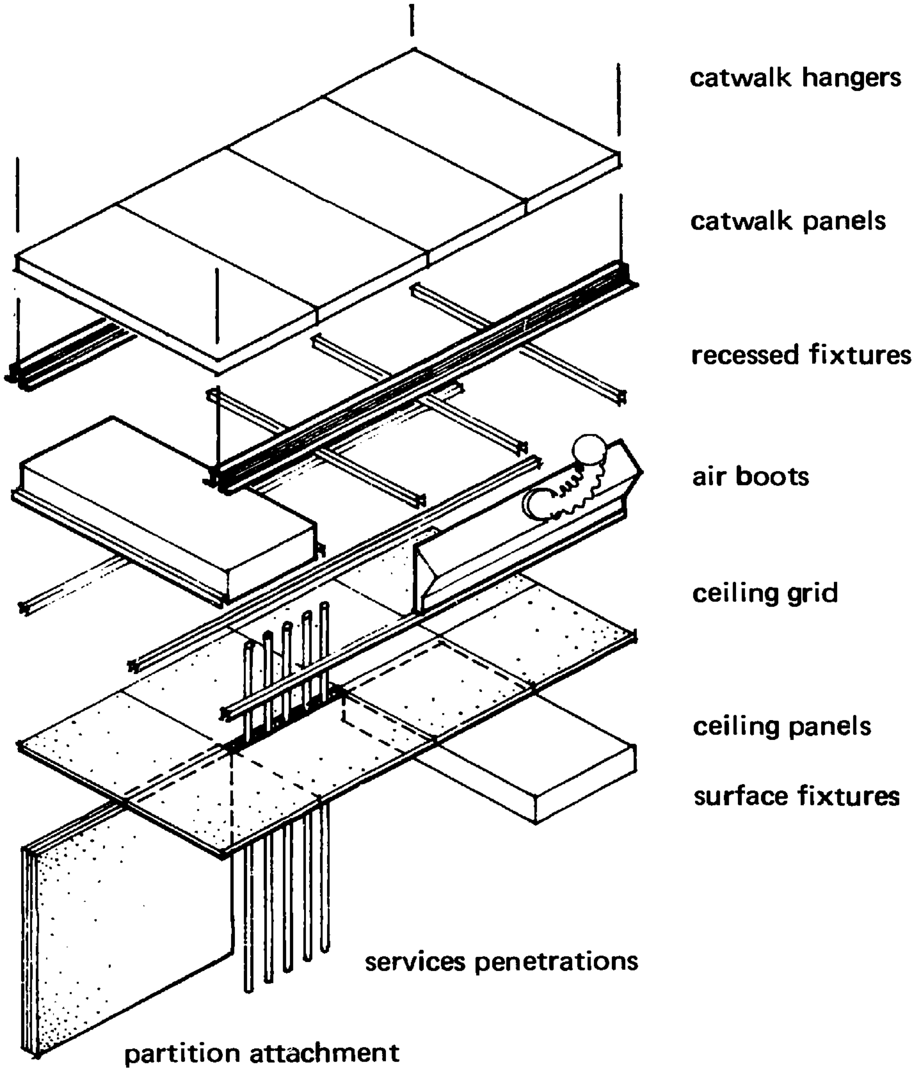
H.5.3 Partitions attachment: to grid bars on 5'-0" x 5'-0" module or intermediate bars as required, for fixing partition head and transmitting lateral forces from partitions to structure.



PROVISIONS FOR OTHER SUBSYSTEMS

H.5.4 Hangers for HVAC and utilities distribution: suspended from structure, coordinated with hangers for support of lighting-ceiling subsystem, sustaining loads as described in Section H.15.

SCOPE OF ABS LIGHTING-CEILING SUBSYSTEM

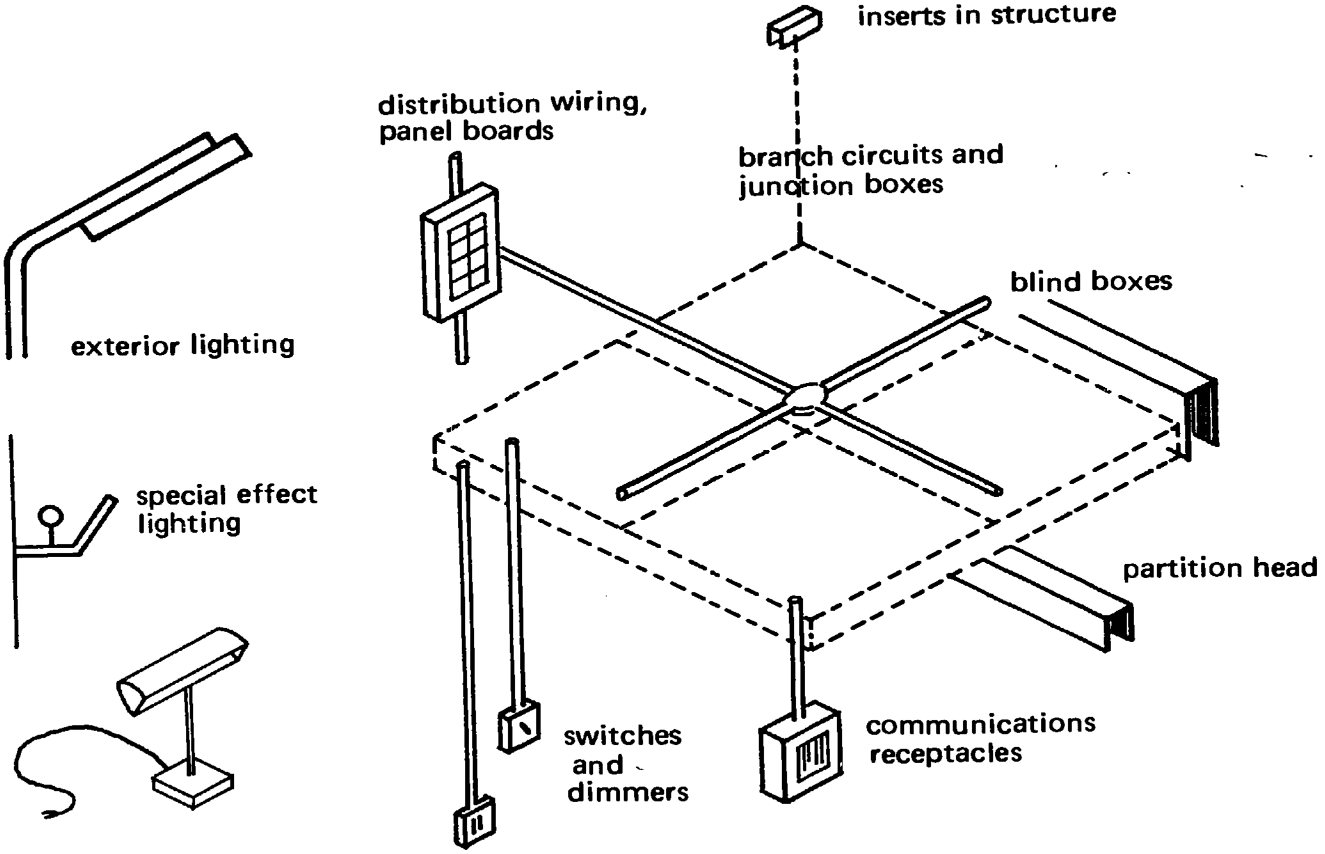


7 WORK EXCLUDED FROM THE ABS LIGHTING-CEILING SUBSYSTEM

a. Exterior lighting.
b. Special effect lighting.
c. Supplementary lighting: any activity level lighting required in addition to the lighting-ceiling.
d. Distribution conduits and wiring.
e. Branch circuit conduits and wiring.

8

f. Switchboards and panel boards.
g. Switches and switch-drops.
h. Diming devices.
i. Convenience outlets, communications or other receptacles and wiring.
j. Inserts in structure: for hangers or suspension wires.
k. Partition head.
l. Perimeter trim or blind-boxes: other than standard perimeter ceiling grid bar.



Supplementary Lighting

Convenience Outlets

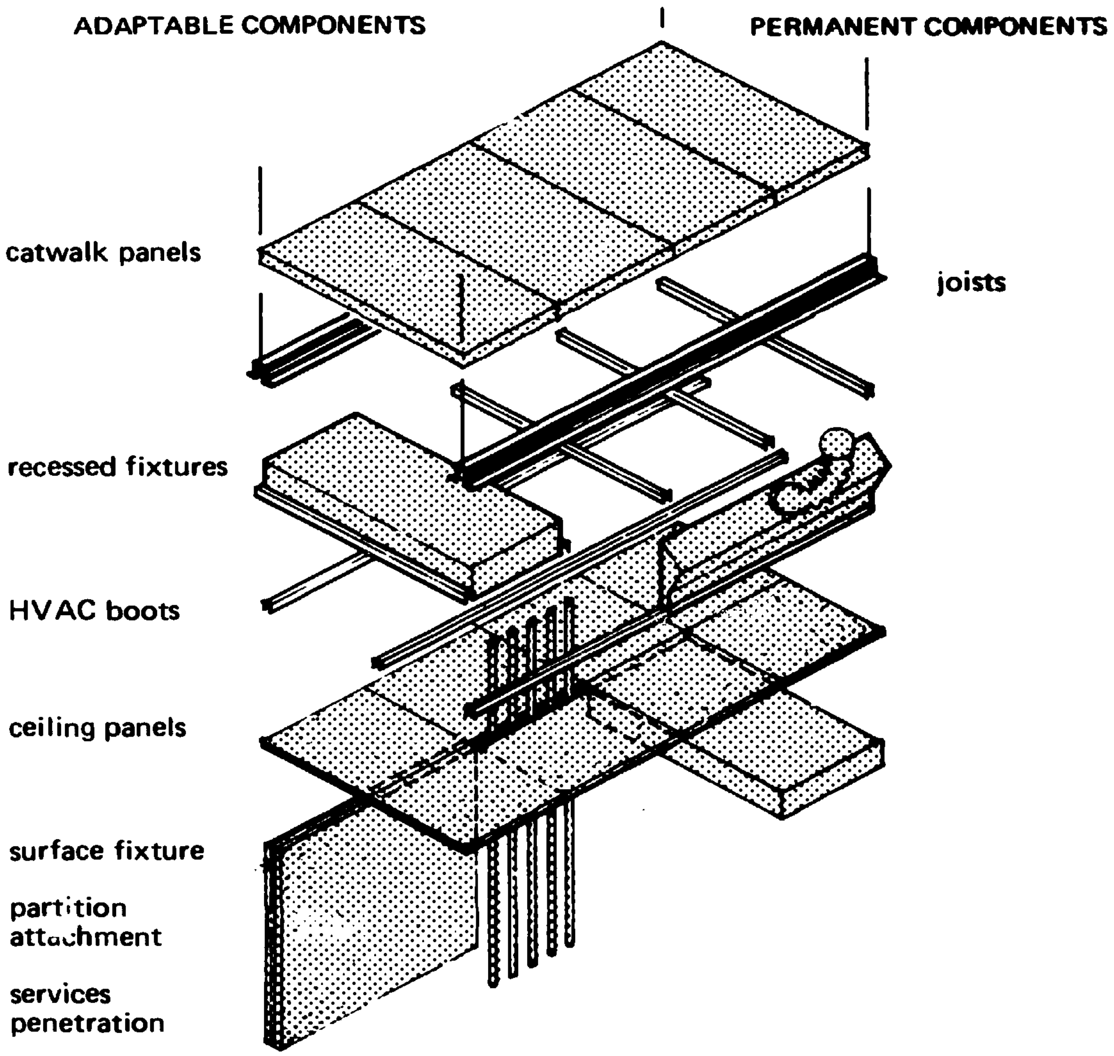
H.8 FIXED AND ADAPTABLE COMPONENTS

H.8.1 The catwalk's *fixed* components are the suspension hangers and joists, together with the number of catwalk panels required to maintain lateral stability of this subassembly. The catwalk's *adaptable* components are the remainder of catwalk panels required for access to services and utilities for maintenance and alteration purposes.

H.8.2 The lighting-ceiling's *fixed* components are the suspension wires and the 5'-0" x 5'-0" ceiling grid. The *adaptable* components are the intermediate grid bars, ceiling panels, lighting fixtures, and HVAC terminals.

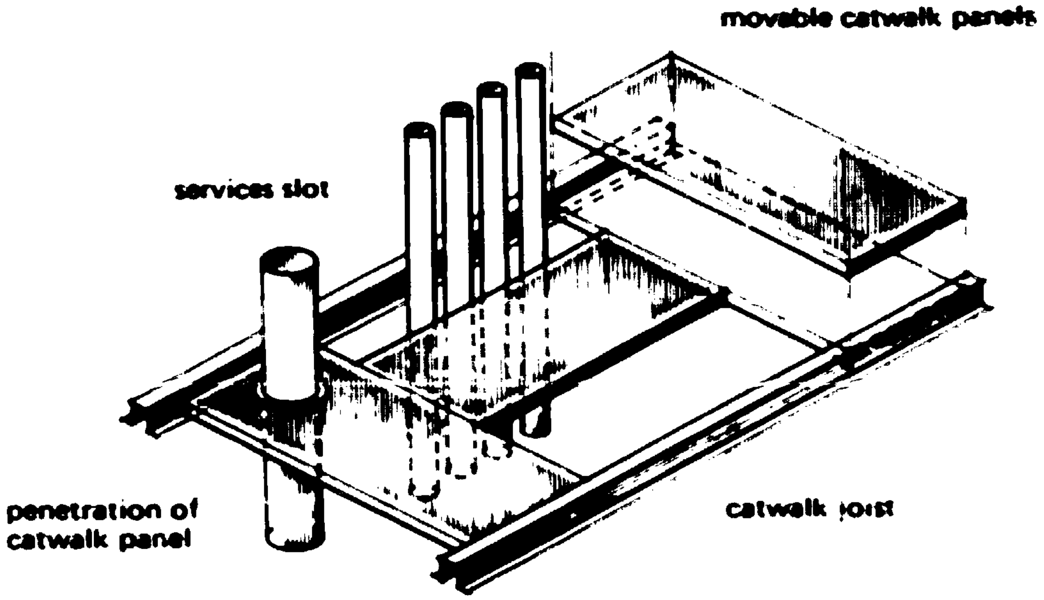
H.8.3 The adaptability of the academic spaces is improved as intermediate grid bars, ceiling panels, lighting fixtures, HVAC terminals, and service penetrations can be changed and rearranged within the 5'-0" x 5'-0" planning module to accommodate varying requirements.

H.8.4 The fixed and adaptable components are shown below:



H.9 CATWALK ADAPTABILITY

Adaptability of the catwalks provides access to other building components within the service space. The catwalk areas and locations may vary during the life of the building, with some panels relocated, removed, or added. Catwalk locations should be such as to avoid concentrations of vertical penetrations for HVAC terminals and vertical services. However, catwalks and ceiling panels shall be capable of penetration, such as shown below.



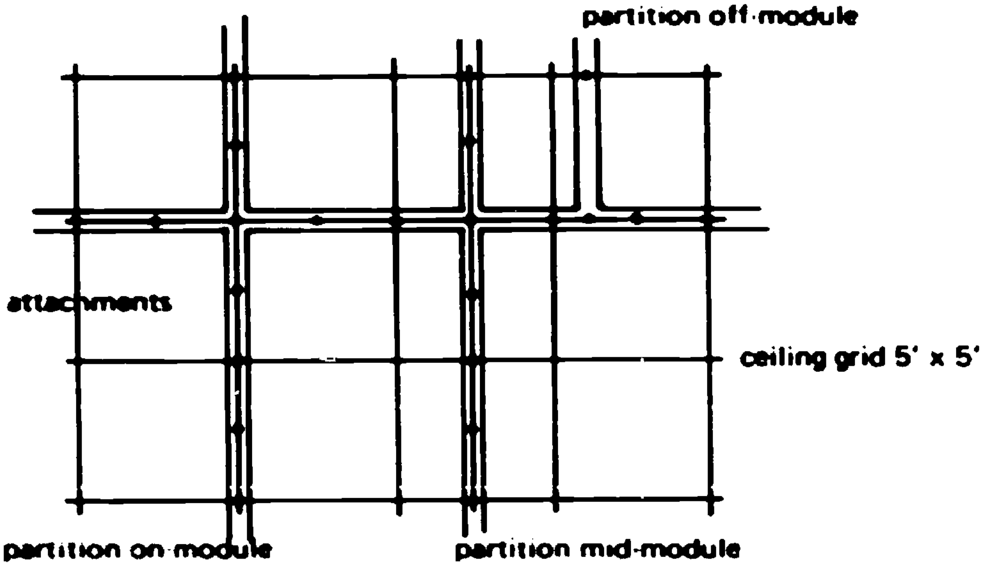
H.10 CONFIGURATION ADAPTABILITY

A major design requirement of the lighting-ceiling subsystem is the ability to rearrange catwalk panels, partitions, lighting fixtures, ceiling panels, air diffusers, and all services penetrations as needed to accommodate room changes.

H.10.1 All terminations shall be achieved with a visually and structurally compatible trim. A special configuration shall be provided for terminations at columns, located at the intersection of module lines.

H.10.2 All elements shall coordinate with the planning grid of 5'-0" x 5'-0", both on the grid and within it.

H.10.3 Ceiling grid bars and panels shall allow for simple partition head attachment, and for partition relocation, without major damage to the materials. Partition attachment must be possible at points not more than 60 inches apart in either direction where partitions are off the grid, and not more than 30 inches apart otherwise.



H.10.4 The ceiling may be other than a horizontal plane, but horizontal ceiling grid bars are required to receive the partitions.

H.10.5 The ceiling shall be hung at a uniform height above the floor.

H.10.6 Lighting elements shall be interchangeable with ceiling panels without alteration to the suspension. A lighting element shall be able to rotate 90 degrees within the grid, with all services accommodated. A lighting element shall be allowed within each 5'-0" x 5'-0" grid, and within a half-grid of 5'-0" x 2'-6".

H.11 SERVICES ACCESS AND PENETRATIONS

Access to service space above ceiling is by either a catwalk or up through the ceiling. In either case, the service space shall be accessible without damage or alteration to any component.

H.11.1 Electrical utilities must be allowed routing from the service space above the ceiling into partitions and adjacent to partitions.

H.11.2 Utilities other than electrical must be allowed routing from the service space above the ceiling down adjacent to, but not within, partitions.

H.11.3 Horizontal distribution of utilities and services occurs above the ceiling. Distribution to partition service consoles, where used, shall be vertically through ceiling penetrations. Such penetrations shall be by simple cutting and drilling of holes as services are installed, sealing to preserve acoustic qualities, and replacing panels when services are removed.

H.11.4 HVAC supply and return air openings shall be accommodated by the lighting-ceiling subsystem.

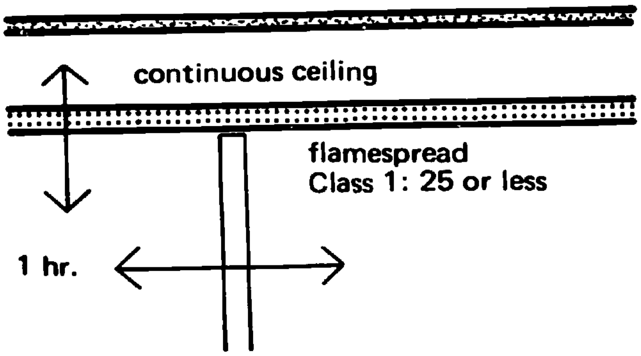
H.11.5 The lighting-ceiling subsystem shall provide the required sealing to provide the air return integrity of the plenum service space above.

H.12 FIRE PROTECTION REQUIREMENTS

H.12.1 The ABS lighting-ceiling subsystem shall be U.L. listed as a one-hour fire-rated assembly. Thus, when used with the ABS partitions subsystem, a one-hour fire separation can be provided at the ceiling plane.

H.12.2 Ceiling panels shall have a Class 1 flame spread rating of 25 or less, per ASTM E 84-68.

H.12.3 Light control elements shall not contribute irritating acid or noxious gases as by-products of combustion, and shall have a Class 1 flame spread index. (Class III materials may be used if exposed surface does not exceed 20 square feet in any 100 square feet of ceiling area.)



H.13 ACOUSTIC REQUIREMENTS

H.13.1 The room-to-room sound attenuation shall be STC-40, per ASTM E 90-66T.

H.13.2 The lighting-ceiling subsystem, including light control, ceiling panels, grids and suspension shall have a sound absorption level of NRC 0.65 to 0.75 at 500 cycles per second.

H.14 LIGHTING REQUIREMENTS

H.14.1 Ceiling light reflectance values for non-luminous elements shall be 80%, minimum.

H.14.2 Light reflectance value of the ceiling panels shall not be reduced by more than 5% when cleaned per the manufacturer's instructions.

H.14.3 The lighting components shall be capable of providing illumination levels between 30-100 footcandles at the work plane.

H.14.4 Illumination at the work plane at any point more than 4'-0" from walls shall be within 25% of the average illumination level. (For test purposes, illumination shall average 70 footcandles maintained.)

H.14.5 To prevent distracting non-uniformity in brightness, crosswise and endwise brightness distributions of luminaires shall comply with the scissors curve graph. The ratio of maximum to average luminaire brightness must not exceed 5 to 1. The luminance ratio between luminaires and surfaces adjacent to them must not exceed 20 to 1.

H.14.6 Minimum brightness of any area within the room:

a. Not more than 12" in least dimension shall not be less than 10-foot lamberts measured at any angle.

b. More than 12" in least dimension shall not be less than 16-foot lamberts measured at any angle.

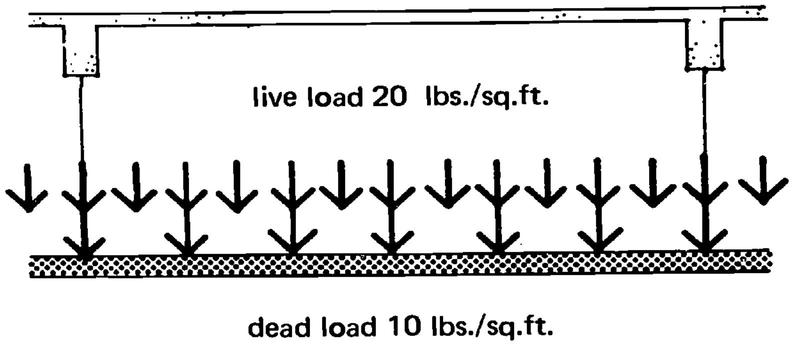
(Brightness measurements of all surfaces within the room shall be made using a 1½° luminance meter listed in IES Handbook, 4th Edition. Measurements shall be made from points 48" above the floor.)

H.15 LOADING REQUIREMENTS FOR CATWALK

The catwalk deck shall extend over areas as designated by the design professional. The catwalk components shall support workmen engaged in construction, maintenance, repairs and alterations, as well as HVAC and utilities distribution, and the lighting-ceiling components. Vertical loads shall be transferred to the structure only through the suspension hangers, located at 5'-0" x 10'-0" centers for catwalk, and additionally as needed for HVAC and utilities distribution at 5'-0" x 5'-0" centers maximum.

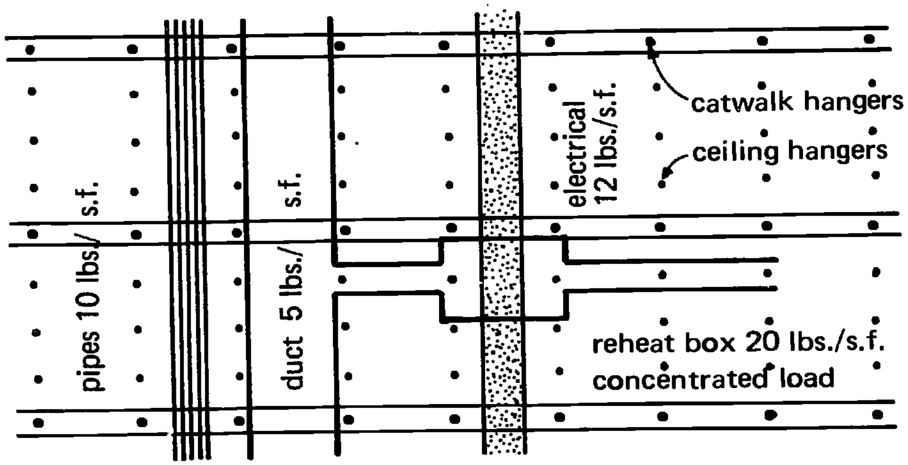
H.15.1 Suspension hangers for catwalk panels shall support the following loads:

a. Live load: 20 lbs./sq.ft. total ceiling area regardless of catwalk deck area.
b. Dead load: 10 lbs./sq.ft. catwalk and lighting-ceiling components.



H.15.2 Suspension hangers for HVAC and utilities distribution:

a. Piping: 10 lbs./sq.ft. in maximum density areas.
b. Ducts: 5 lbs./sq.ft. in maximum density areas.
c. Electrical: 12 lbs./sq.ft. in maximum density areas.
d. Branch panel: 100 lbs. each.
e. Electrical: 24 lbs./sq.ft. in limited areas near mechanical room.
f. The maximum loading occurs at crossover of electrical main and HVAC lateral with reheat box. Use 20 lbs./sq.ft. in that area.



H.15.3 LATERAL LOADS

The catwalk does not contribute to the lateral force resistance of the structure, but shall transmit all lateral forces developed within itself and the lighting-ceiling to the structure. The catwalk shall be fitted around and fastened to the structural columns with acceptable tolerances, but yet transfer lateral loads to them.

H.16 LOADING REQUIREMENTS FOR LIGHTING-CEILING

Vertical loads shall be transferred to the structure either directly, or indirectly through catwalk framing, solely through the suspension wires, located at 2'-6" x 5'-0" centers.

H.16.1 The lighting-ceiling shall support a wide range of items, such as partition service consoles, HVAC terminals, TV consoles, vertical floor-to-ceiling power and communication consoles.

H.16.2 The lighting-ceiling shall provide the necessary stability for interior partitions, whether located on or off the planning module, including the thrust imposed by eccentrically loaded partitions.

H.16.3 The lighting-ceiling shall transmit all lateral forces developed in the partitions and the ceiling itself, to the catwalk framing and/or the structure.

H.16.4 The lighting-ceiling shall abut shear walls and columns in such manner as to allow construction tolerances while transferring all lateral loads to the structure.

H.16.5 Joint at two-hour fire-rated partitions and at exterior walls shall allow for construction tolerances, and deflection due to wind loads.

H.17 INSTALLATION OF CATWALK

Within the structural shell, sufficient catwalk panels should be installed early to provide an adequate platform for installation of utilities and services. The assembly shall be adjusted to form a level plan at a uniform height above floor. On completion and testing of services, location of catwalk panels may be adjusted as required for maintenance purposes.

H.17.1 **Suspension Hangers:** 5/8" steel rod, threaded full length to allow periodic adjustment during life of the building. Hangers shall be attached to joists by nuts and washers with neoprene gaskets to prevent vibration.

The suspension hangers shall be located at 5' centers along the structural beams by threaded inserts in the concrete beams as shown in the drawings below:

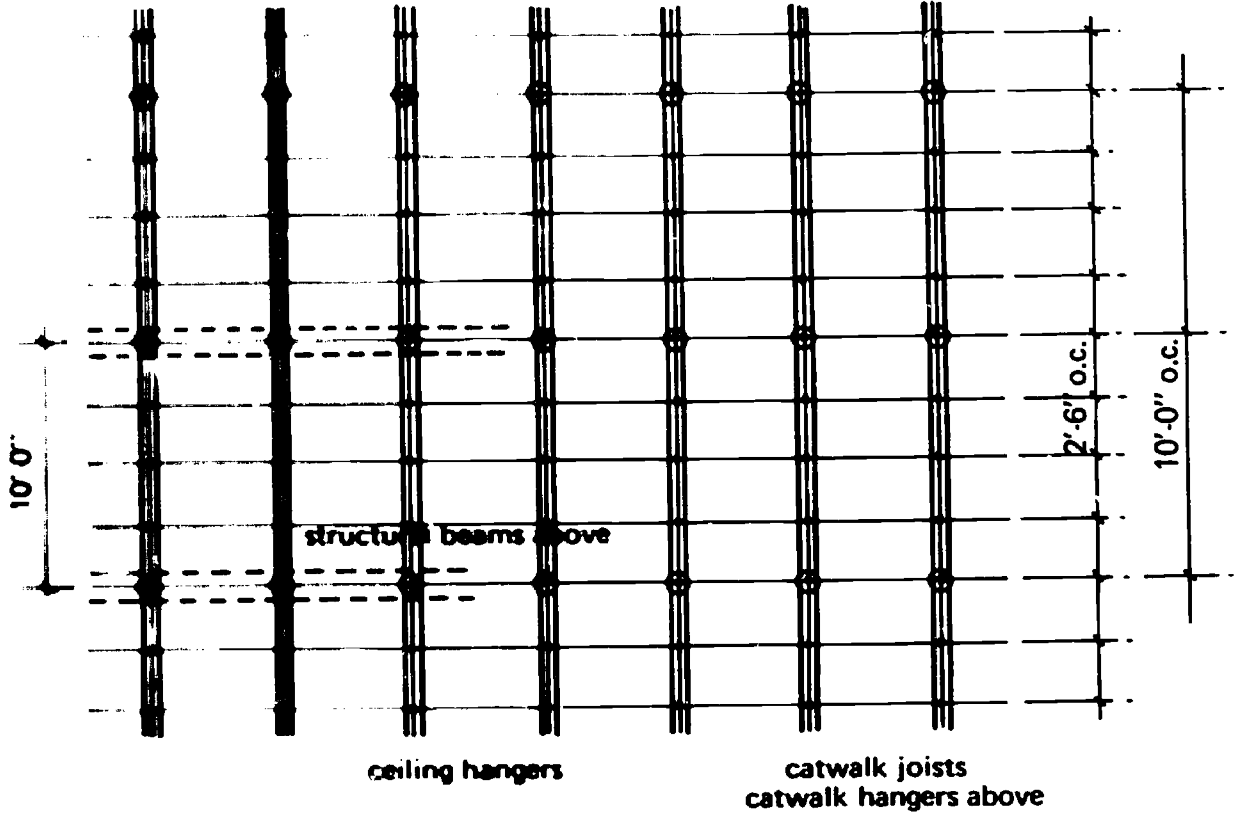
H.17.2 **Joists:** No. 10 gauge galvanized hat section cold formed steel, with No. 10 gauge galvanized splicing members.

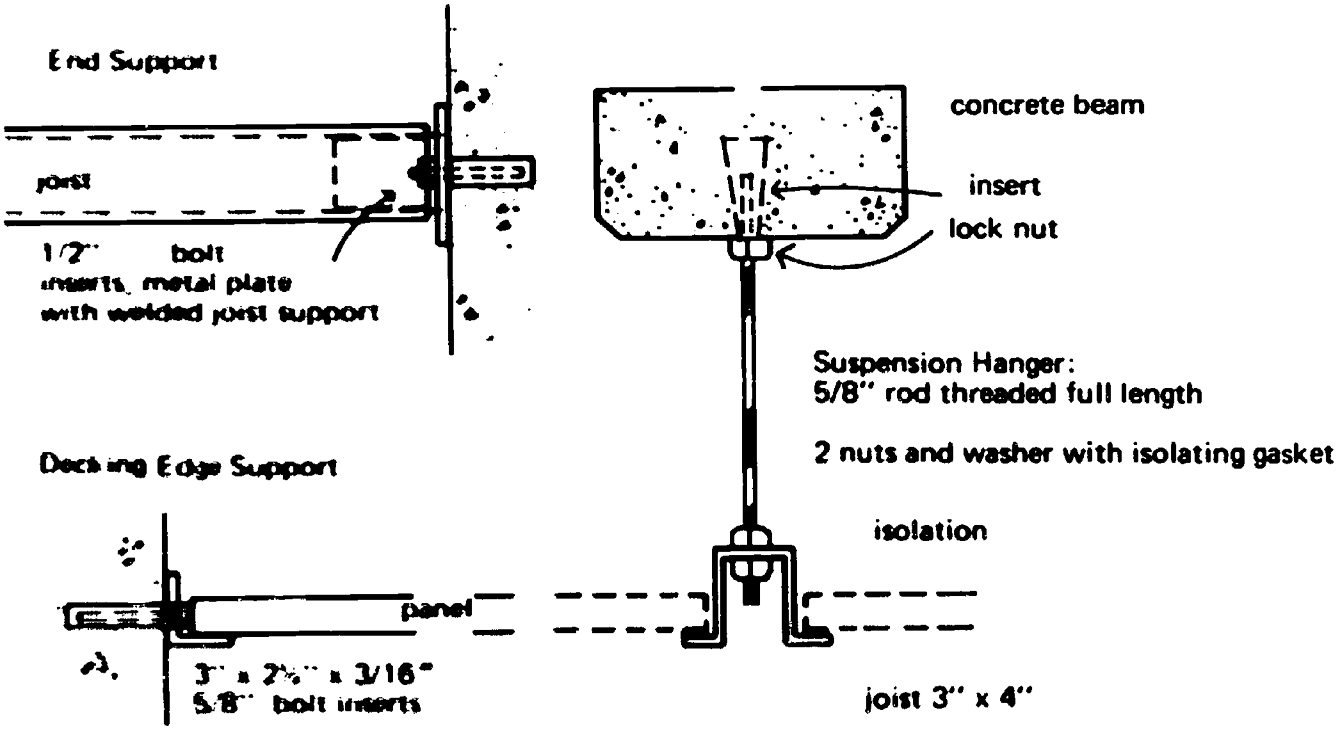
Drill top at 5'-0" centers for hanger attachment to structure; drill each flange at 30" centers for attachment of ceiling suspension wires.

H.17.3 **Catwalk Panels:** Approximately 5'-0" x 2'-0" x 1½" steel deck or expanded steel grating complying with ASTM 283-58T. Framing and grating shall be hot dipped galvanized after fabrication.

Deck shall be attached to joists with self-tapping screws and neoprene gaskets between joists and deck.

Where deck is pierced by pipes, conduit, or ductwork, openings shall be cut neatly and accurately to size, and a strap steel collar not less than 1/8" thick shall be welded around the opening.


10'0"
2'-6" o.c.
10'-0" o.c.
structural beams above
ceiling hangers
catwalk joists
catwalk hangers above


End Support
joist
1/2" bolt
inserts, metal plate
with welded joist support
concrete beam
insert
lock nut
Suspension Hanger:
5/8" rod threaded full length
2 nuts and washer with isolating gasket
isolation
Decking Edge Support
panel
3" x 2½" x 3/16"
5/8" bolt inserts
joist 3" x 4"

H.18 INSTALLATION OF LIGHTING-CEILING

H.18.1 If a catwalk ceiling is provided, the lighting-ceiling suspension wires attach to the catwalk joists in the locations shown in Section H.17 above. If the access ceiling is used, the lighting-ceiling suspension wires attach to the structure as shown in Section F.22.5.

H.18.2 The horizontal support is the ceiling grid. It supports lighting fixtures, ceiling panels and air diffuser bars capable of installation on 5'-0" centers in both directions. The ceiling grid shall be capable of division by cross-runners, in either direction, on non-modular spacing.

H.18.2.1 PRIMARY COMPONENTS

a. Suspension wires: galvanized, soft annealed, mild steel wire, No. 12 minimum.

b. Ceiling grid: T, H, or Z in section, galvanized painted steel, No. 25 gauge minimum.

c. Cross-runners: T, H, C, J or Z in section, galvanized painted steel, No. 25 gauge minimum.

d. Furring (for special conditions): surface mounted, light fixture 1½" channels, cold rolled steel, No. 16 gauge minimum.

e. Furring for surface mounted light fixtures, power or communication receptacles: cold rolled steel channels, No. 16 gauge minimum, 1½" and ¾".

f. Lighting fixtures: comply with U. L. "Standards for Safety, Electrical Lighting Fixtures," No. 57; prepared to receive flexible metal conduit.

g. Flexible connections: between lighting elements with grounded receptacles and caps suitable for single phase. Each element shall be provided with recessed female receptacle and portable cord with male cap.

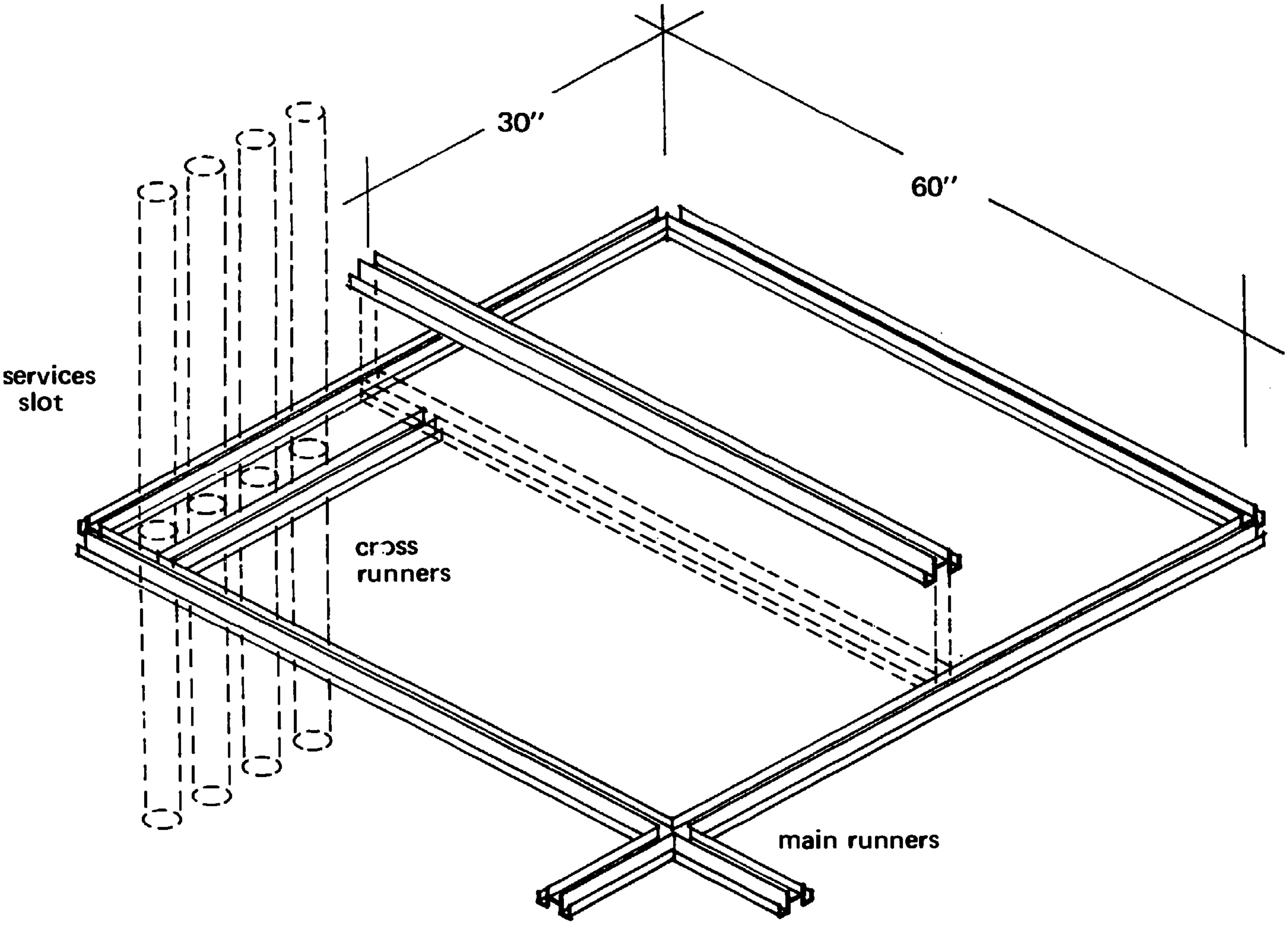
h. Coffers: factory precut and fitted; formed metal or mineral tile, listed with U. L. for a one-hour fire-resistive rating.

i. Acoustic panels: factory precut and fitted; non-combustible cellulose or mineral panels; with appropriate acoustic abosrbent material, fire proofing medium and thermal insulation between plenum return and occupied space. In fire-rated assemblies the fire proofing medium shall form a protector box for lighting fixtures.

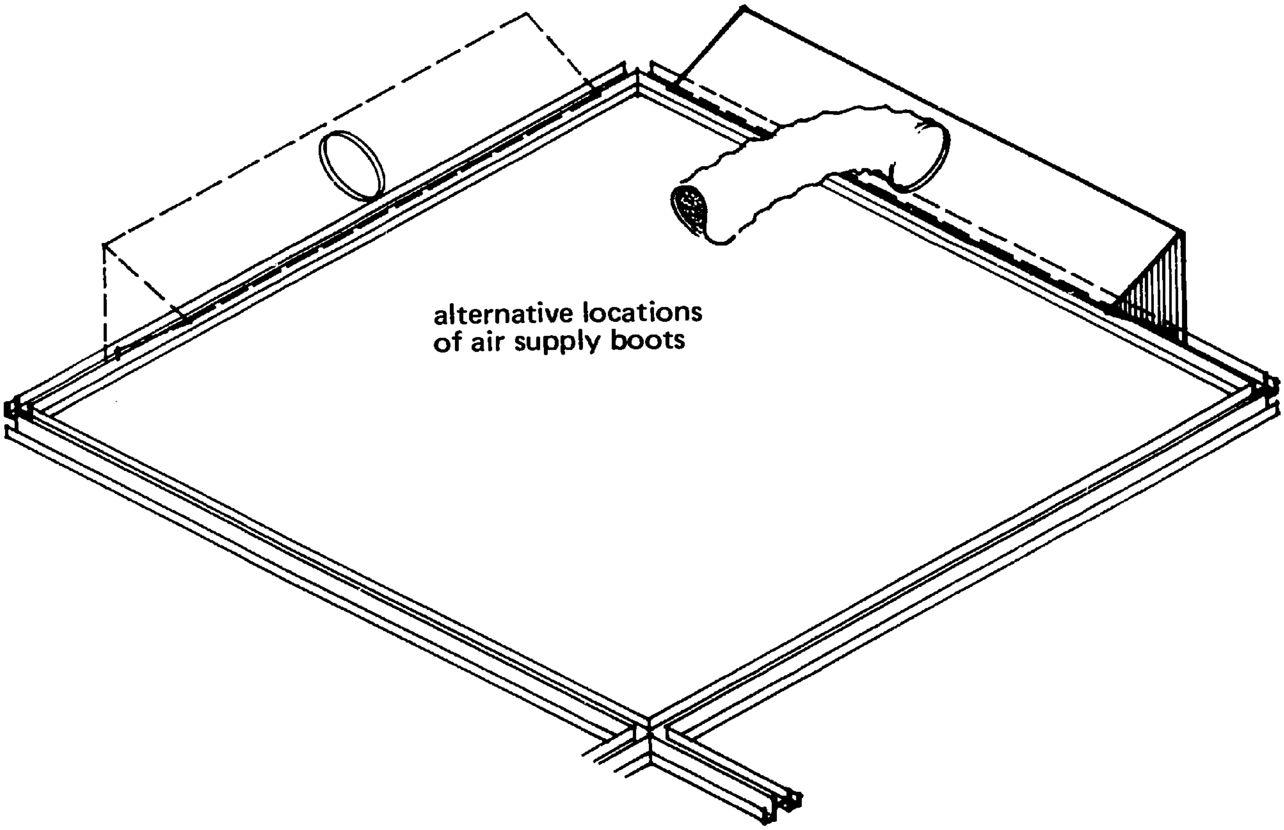
j. Air boots: formed from No. 17 gauge galvanized sheet steel; top side to receive attachment of flexible ducts; lower side to slot into air diffuser bar; with approved fire and balancing dampers as required.

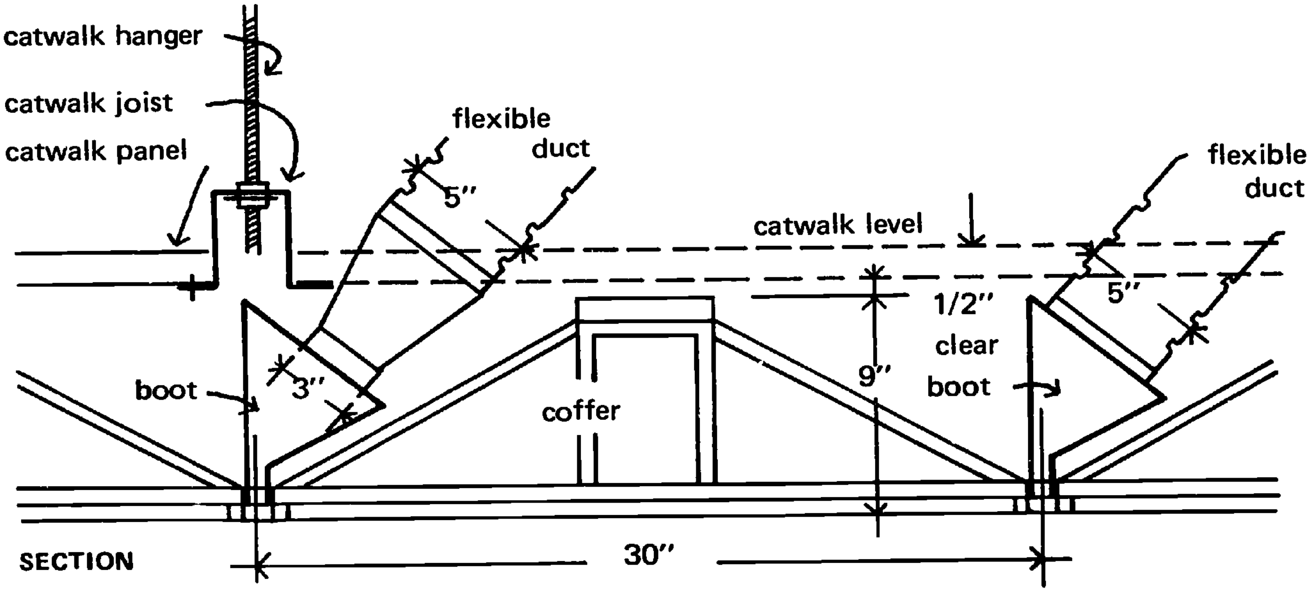
k. Air linear diffusers: formed from No. 17 gauge galvanized painted steel; to receive throat of slot on lower side of air boot, and provide support for cross runners, acoustical panels and light fixtures. Air slots shall not exceed area limitations per U. L. designation for ceiling type. Deflectors shall be adjustable pattern with volume dampers. .

H.18.3 Ceiling Grid must provide a ceiling slot permitting the penetration of vertical service runs. Ease in inserting new cross-runners, or removing unneeded ones is important.



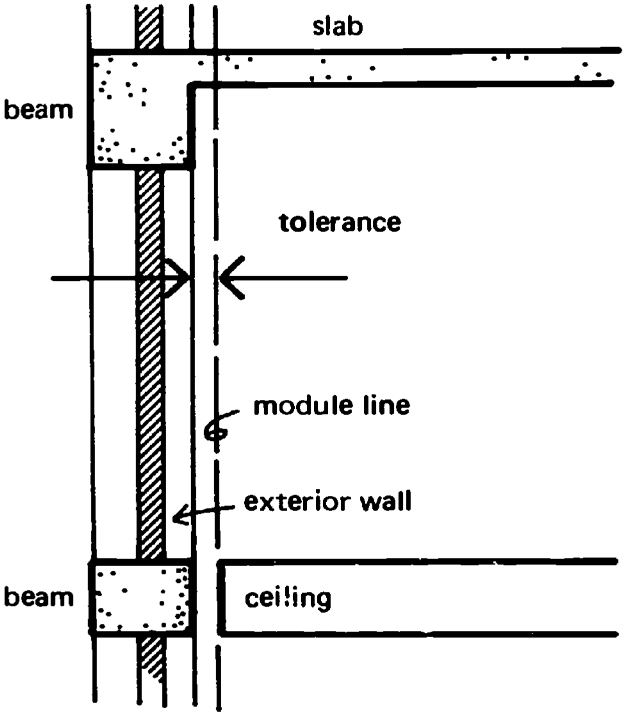
H.18.4 Air Distribution, both supply and return, occurs through ceiling, solely via the grid members providing capability of inserting air supply boots or air return openings in both directions, on 5'-0" centers. Air boots shall attach directly to grid diffuser bars, with flexible duct connection to distribution ducts. Air boots shall not increase the overall depth of 9 inches for the lighting-ceiling components.


alternative locations
of air supply boots

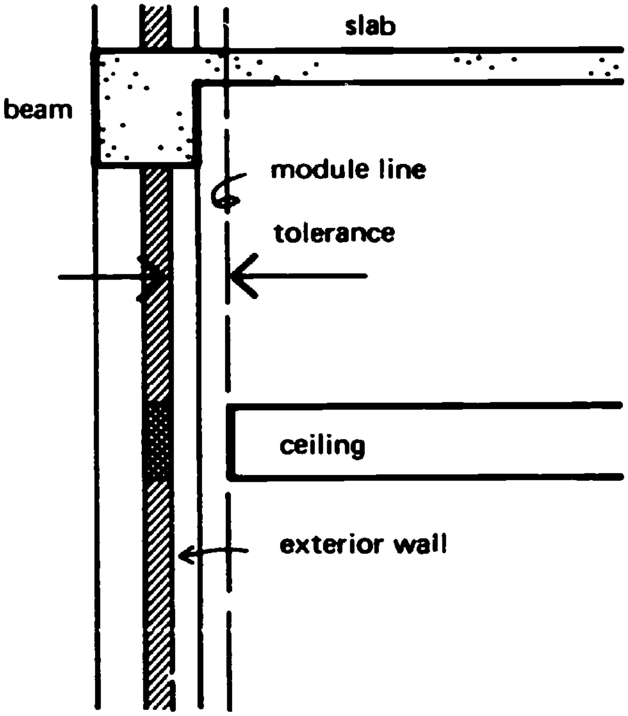

catwalk hanger
catwalk joist
catwalk panel
flexible duct
5″
catwalk level
flexible duct
5″
1/2″ clear
9″
boot
3″
coffer
boot
SECTION
30″

H.19 COMPATIBILITY WITH OTHER ABS SUBSYSTEMS

H.19.1 WITH STRUCTURE AND EXTERIOR WALLS



CATWALK CEILING SECTION

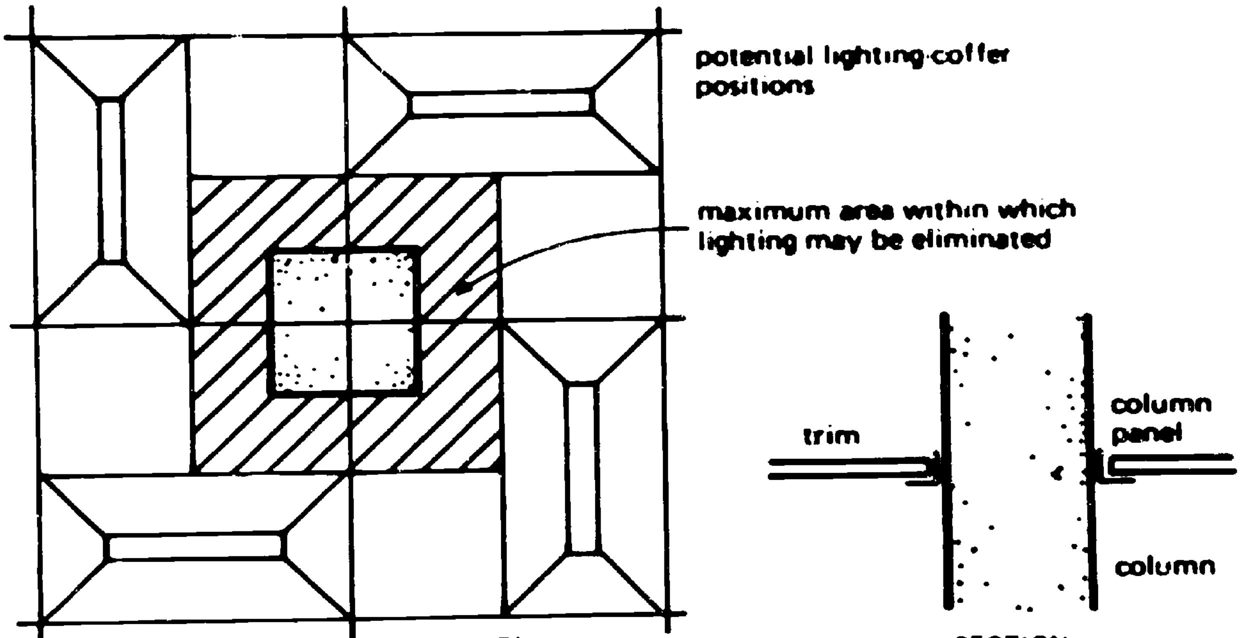


ACCESS CEILING SECTION

Both the catwalk ceiling and the access ceiling shall terminate as shown above. A tolerance may be desirable between the ceiling edge and the internal face of the structure or exterior wall, to permit a variety of ceiling edge details include blind boxes. The provision of such tolerance and its dimensions will be decided by the design professional for a specific building.

The joint detail shall conform to applicable sound transmission and fire resistance requirements, and allow for deflections due to wind, seismic and thermal loads.

H.19.2 WITH STRUCTURAL COLUMNS



SECTION

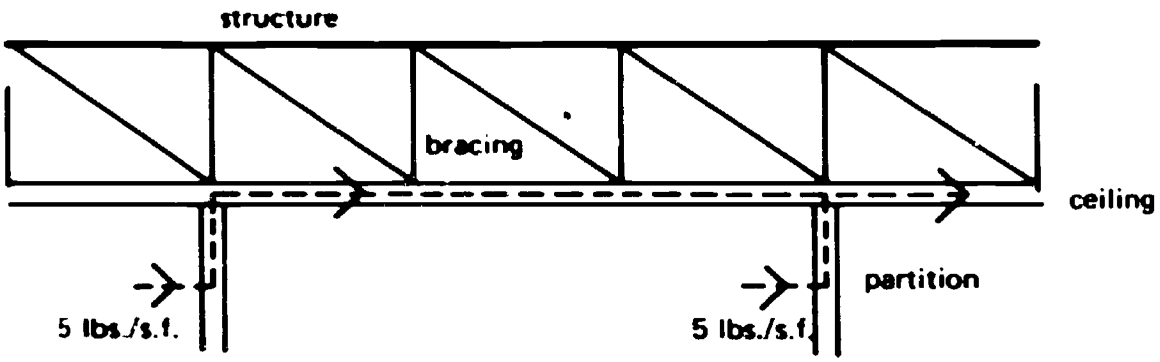
CEILING PLAN

Structural columns occur on ceiling grid intersections, thus will require visually compatible trim around them. Columns shall not eliminate lighting fixtures in an area greater than 25 square feet.

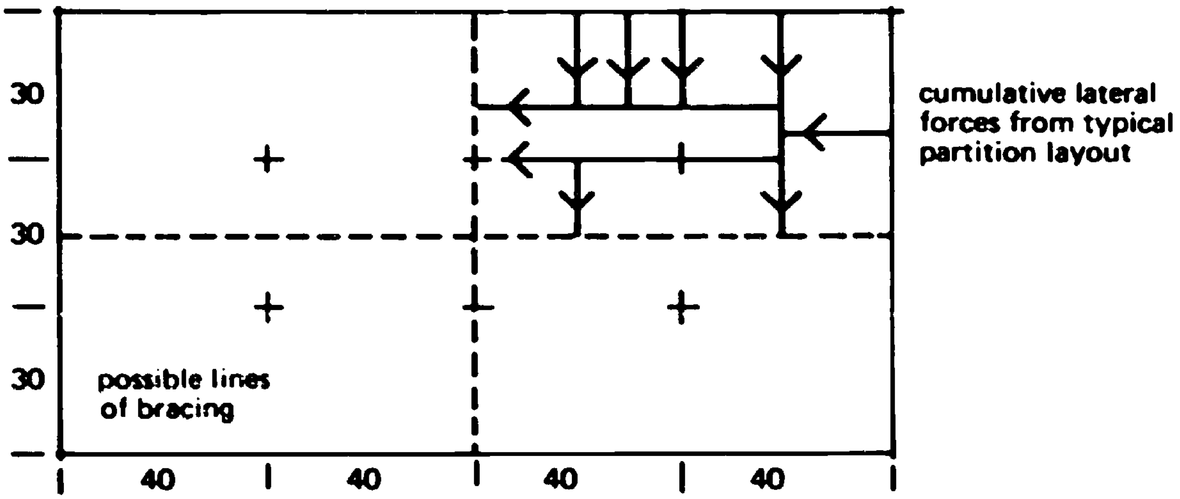
H.19.3 WITH PARTITIONS

H.19.3.1 Compatible details are required at all connections between the lighting-ceiling and the partitions, whether on or off the ceiling grid module. Secure partition heads to the steel ceiling grid with self tapping screws 30 inches on center, except where partitions occur off module where attachment shall be 60 inches on center.

H.19.3.2 Lateral loads from partitions (5 lbs./sq.ft. on the partitions) and impact such as door slam shock shall be transmitted to the structure via the ceiling. Where seismic conditions prevail, the loads from partitions shall be considered cumulative over large areas. Ceiling areas greater than 2,500 square feet shall be diagonally braced to the structure. Such bracing must not interfere with services distribution runs.



TYPICAL SECTION



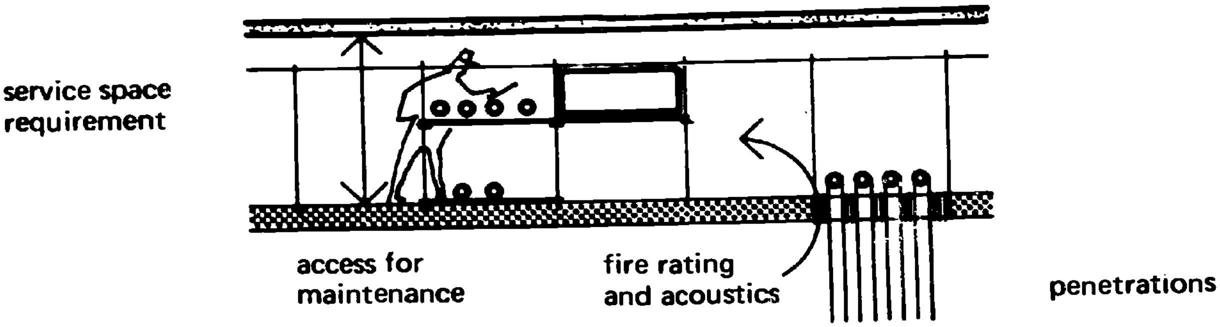
PLAN TYPICAL SPACE MODULE

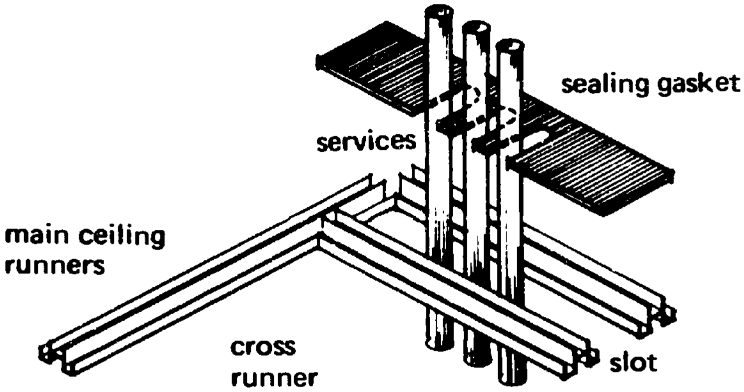
H.19.4 WITH SERVICES DISTRIBUTION

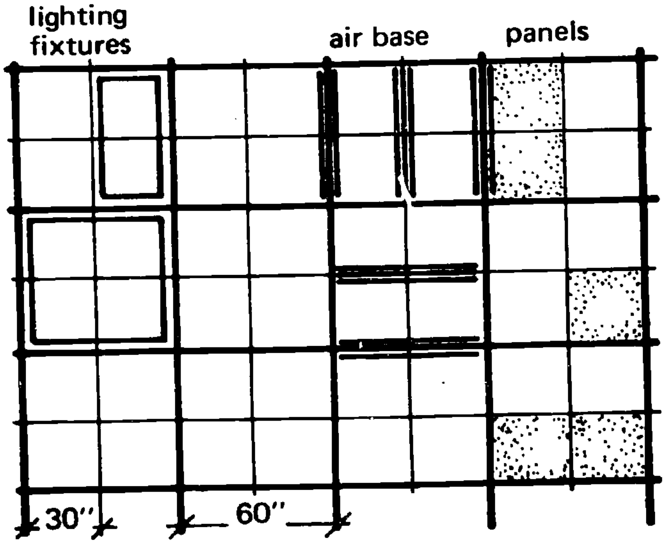
The service space requirement is determined by the density of services to be housed, and is expressed in the height of that space. Services distribution in that space must not be impaired by diagonal bracing for the ceiling. The placement of such bracing must be coordinated with the services layouts.

Access to the service space through the ceiling is mandatory only in the access ceiling type. Herein, it should be possible to move any panel or lighting fixture in order to gain access to services above.

The lighting-ceiling, whether catwalk or access type, shall permit penetrations for vertical services. A slot wide enough to accommodate such services shall be formed by the insertion of cross-runners in the ceiling grid, and be compatible with any method of encasing the services in a console. The space around the services in the slot must be sealed and insulated to maintain the acoustic and fire resistance rating required.







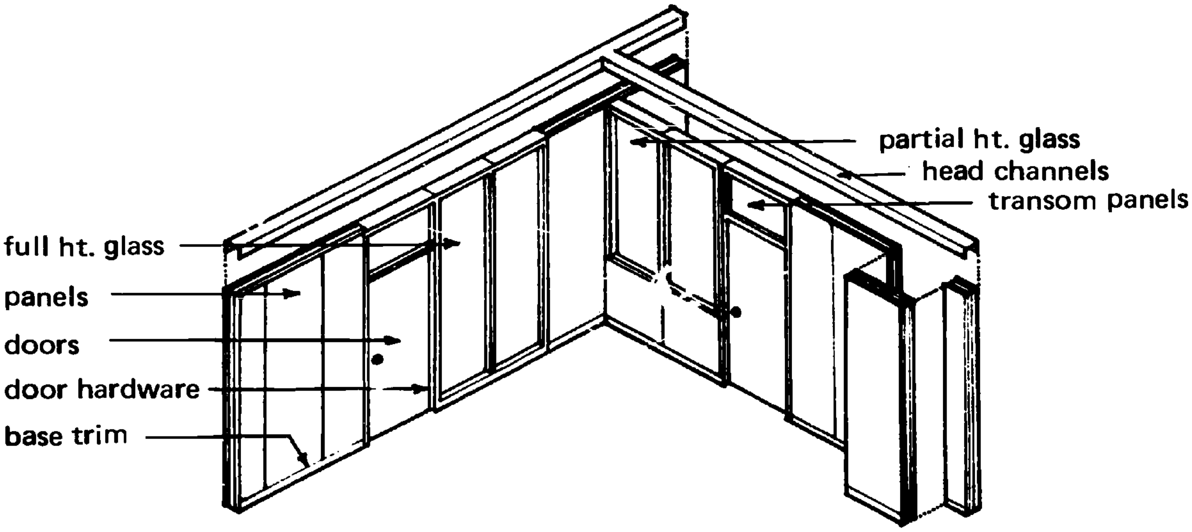
I. PARTITIONS

I.1 The ABS partitions play an extremely important role, in conjunction with the structure, in obtaining a significantly higher degree of adaptability than is available in conventional academic buildings. The partitions permit the initial plan configuration to be revised and changed as necessary, with minimum disruption to occupants and with little effort, in that the partitions are demountable and virtually free of services. As required, the partitions will provide visual separation, acoustical barrier, security, support of furniture and casework, and substantially contribute to the visual environment. All partitions within the space module, including door frames, will be installed after the ceiling grid is complete. No framing members of these partitions will penetrate the ceiling.

It is intended that the following materials provide guidance only, establishing basic criteria and parameters for the ABS partition subsystem. The architect is expected to use this information in developing details and specifications compatible with his usual format and consistent with the best practice.

I.2 This subsystem includes all elements needed to define the visual and acoustical separation of rooms, from floor to ceiling. These are:

a. Panels with optional finishes.
b. Door frames and doors, hinges, sealing devices.
c. Glass and glazing; both partial and full height panes.
d. Baseboard and trim.
e. Support for wall hung casework, utilities, and equipment such as fire extinguishers, hose reel cabinets, drinking fountains.



1.3 Excluded from the ABS partition subsystem are:

a. All exterior walls.

b. All structural load-bearing walls.

c. Walls between the space module and the service tower.

d. Any wall with special performance requirements precluding the use of ABS partitions, e.g., walls surrounding cold rooms, or 2-hour fire-rated.

e. Any special insulation or shielding that can be applied to ABS partitions to achieve a higher performance, e.g., radio active shielding.

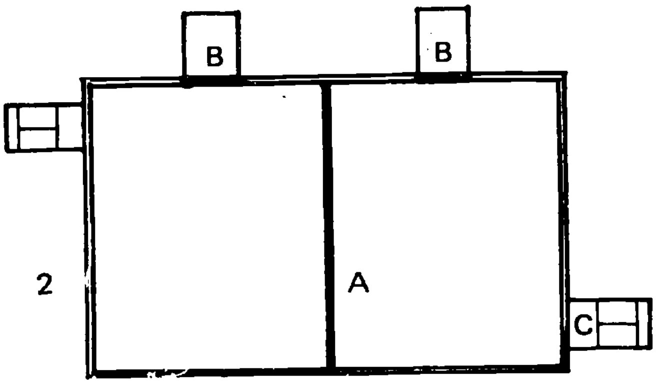
f. Chalkboards and tackboards and similar architectural specialties.

g. Door locking and closing hardware, and door louvers and fire dampers.

h. Communication, electrical, plumbing or other service distribution lines and terminals housed within or mounted on the partitions.

i. Wall-hung casework, shelving and equipment.

j. HVAC terminals, registers and grilles.

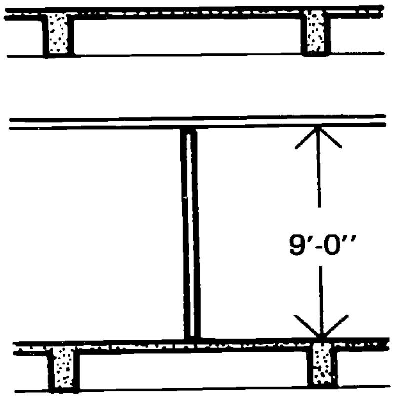


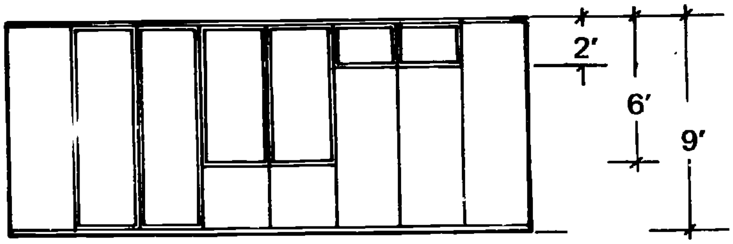
EXCLUDED:

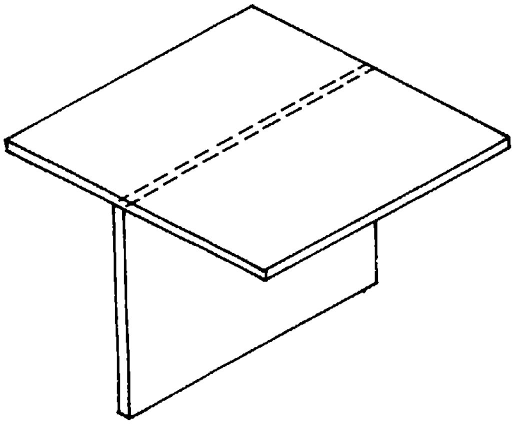
1. All two-hour partitions
   - A. between space modules
   - B shaft enclosures within service tower
   - C. stair enclosures
2. Exterior wall
3. Any walls with special performance requirements
4. Any special surfaces
5. Chalkboard and tackboards

1.4 PANEL HEIGHTS

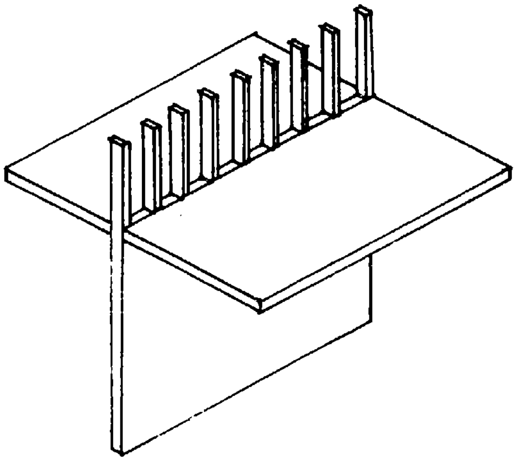
1.4.1 Height of all ABS partitions is nine feet throughout, terminating at the ceiling. Standard 7'-0" doors are installed in nine feet high frames, with a fixed transom panel above door. Glass panels in the partition should be 2'-0", 6'-0", and 9'-0" high. Portions of solid panels to be used below glass shall be 7'-0" and 3'-0" high.







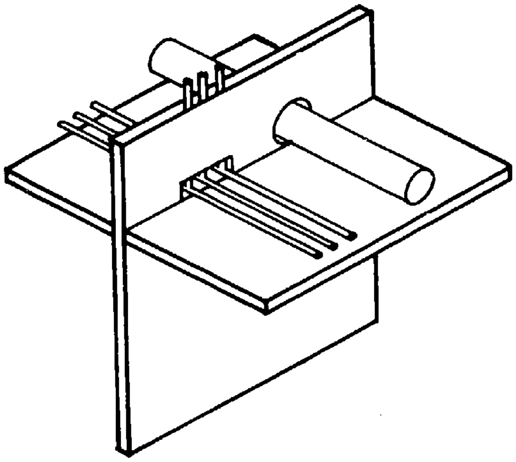
ABS Partition



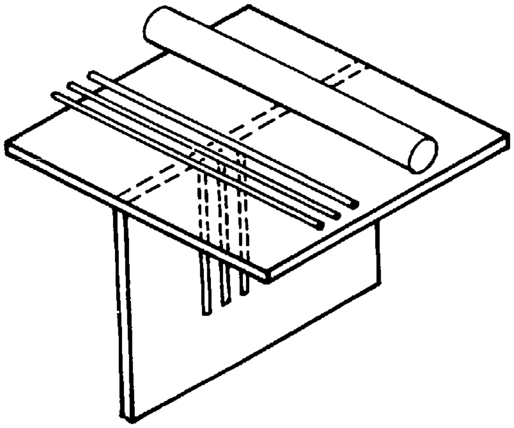
Conventional Partition

ABS partitions stop at the ceiling, instead of penetrating the ceiling.

1.4.2 A partition height of 11'-3" is possible where the 16'-10" floor-to-floor height is used with the shallow service space instead of the deep service space, as described in Section B.10.



ABS partitions permit free passage of services in service space above the ceiling.



Conventional partitions interfere with passage of services above the ceiling.

1.5 MODULE

1.5.1 Planning dimension is 5'-0" each way, or multiples thereof, coordinated with ceiling grid bars. However, if required and at extra cost, partitions may be located off the grid.

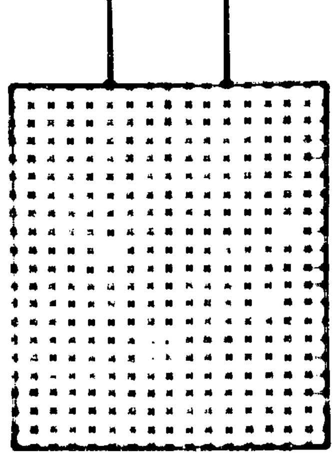
1.5.2 The design professional should provide for: maintaining modular control at all types of intersections; extensive use of a single basic panel size compatible with the 5'-0" planning dimension; and smaller standard panels to provide adaptability at intersections, ends and corners.

1.5.3 Standard panel size should provide for use of a standard door (36" wide or wider) as well as other required sizes, all related to the planning dimension, and a double door panel 5'-0" wide.

1.5.4 Partition thickness may vary as required by the performance requirements.

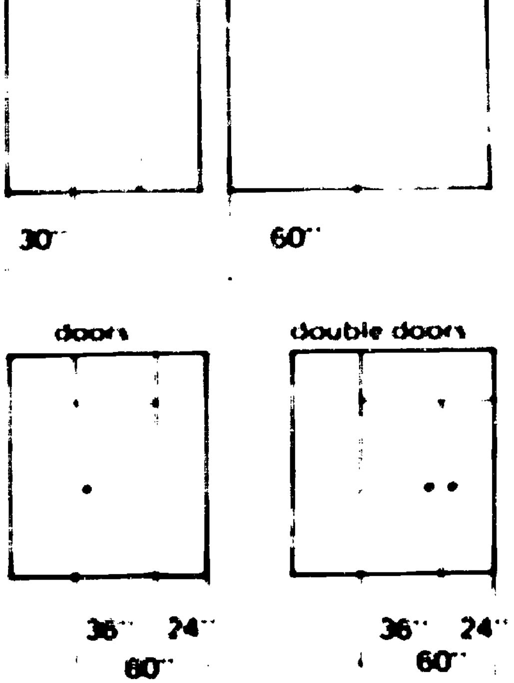
[illegible]

[illegible]



5'-0" planning dimension throughout coordinated with ceiling grid bars.

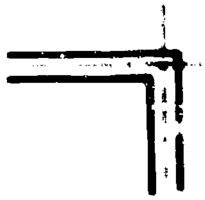
Partitions may be located off planning dimension.



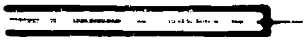
INTERSECTIONS

Intersection conditions need careful coordination. Consistency and simplicity of detailing are essential. The following types of intersections on a 90-degree basis should be provided

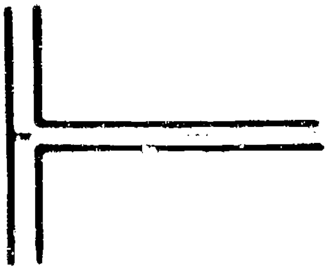
straight line



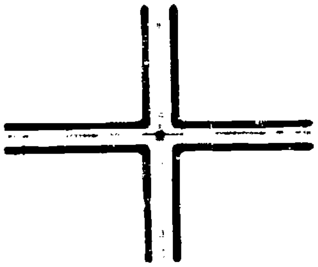
two way corner on and off point



finished end



three way intersection on and off panel



four way intersection on and off point

end against other component

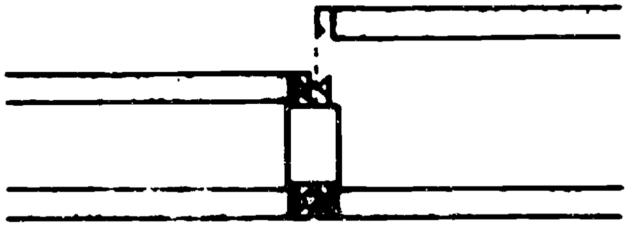
1.6.2 The ABS partitions should permit:

a. Any panel type to receive another panel at any intersection and between intersections, excepting those at mid-panel of door or glass.

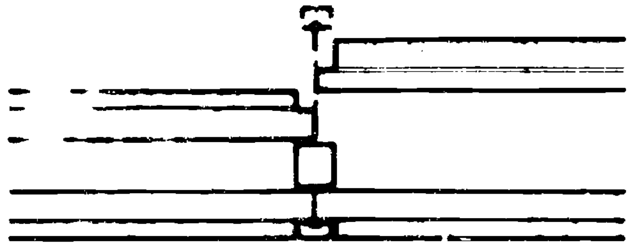
b. A single coherent detail for all joint conditions. The visual importance of the joint shall be deemphasized; no protruding battens are acceptable.

1.7 PANEL TYPES

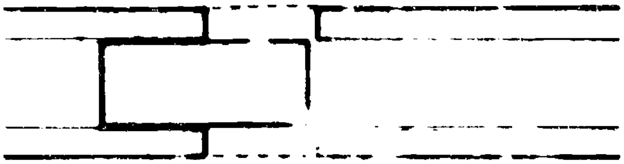
1.7.1 Three basic design alternatives are available for ABS partitions:



classic



batten



progressive

1.7.2 The finish shall cover the entire panel face except as noted. Different panel finish surfaces shall be available for opposite sides of a partition. Opposite panels shall be independently removable. Surface finishes in three types of performance shall be available:

Type I: Smooth or textured finish; painted or factory-applied vinyl fabric; conventional level of surface durability for use in classroom and offices.

Type II: Smooth finish; epoxy paint or medium density vinyl; high resistance to stains and corrosion for use in general science laboratories and their service spaces, and animal rooms.

Type III: Smooth or textured finish; epoxy paint or heavy duty vinyl; high resistance to abrasion for use in corridors, lobbies and circulation spaces.

A particular space use may require higher special performance demands.

1.7.3 Backup panel shall be available to receive non-system veneers and special surfaces; for example, electrostatic shielding, adhesive mounted semi-rigid veneers, chalkboard and tackboard. The backup panel shall be exempt from all surface durability requirements.

1.7.4 Glass panels 2'-0", 6'-0", and 9'-0" high and 2'-6" wide shall be available with heads always at the ceiling. Glazing details shall accommodate the minimum glass thickness required by applicable codes.

1.8 DOORS

1.8.1 Door width will be 36 inches generally. Other narrower widths may have to be accommodated. A wide double door opening requirement may be satisfied within the 60" planning dimension when made up of a 36-inch leaf plus a 24-inch leaf. The 24" leaf may be a minimum activity, bolted installation.

1.8.2 All door frames will be full height of partition, so detailed as to receive special doors of same dimensions and thicknesses as the ABS partition subsystem doors. Door frames shall be capable of receiving door closers, silencing strips, and acoustical gasketing.

1.8.3 Four types of doors are required for both non-rated and fire-rated partitions:

a. Solid core door.
b. Viewing panel door (± 10% glass).
c. Glass panel door (± 50% glass).
d. Louver door. Louvers and fire dampers are not part of this subsystem.

Doors may be either 7'-0" or 9'-0" high. Transom panels shall be available with either glass or door panel infill over 7'-0" doors.

1.9 FIRE RESISTANCE

All ABS partitions shall be non-combustible.

1.9.1 Each panel type shall provide for:

Nonfire-rated demountable partition
One-hour fire-rated demountable partition

1.9.2 All panels and doors shall have a maximum flame spread of 75 or less, and a smoke developing rate of 50. (ASTM E84-68 Tunnel Test shall be used for flame spread determinations. The ASTM E119-69 test procedure shall be used for determining all fire resistive construction standards.)

1.9.3 Glass panels shall be limited to 1,200 square inches in the one-hour fire-rated partitions.

1.9.4 Doors in one-hour fire-rated partitions shall meet the applicable code requirements.

1.10 ACOUSTIC PERFORMANCE

The interface conditions with the other subsystems should be carefully coordinated and detailed.

1.10.1 All solid panels shall provide an STC rating of 40 minimum. Panels containing glass shall provide an STC rating of 20 minimum.

1.10.2 Doors shall be available both non-sound rated, and with STC 24 minimum. Glass panel doors shall provide STC 20 minimum. Gasketed doors are recommended to provide acoustical continuity with STC 40 wall panels. Door latching hardware with precision construction should be selected to maintain acoustical seal of gasket. All ordinary use doors should have full length silencer strips. (STC ratings shall be determined by laboratory test ASTM E90-66T.)

1.11 LOADING AND IMPACT

1.11.1 Lateral load to be resisted by all panel types, doors, and connections is five pounds per square foot.

I.11.2 Vertical loadings to be resisted by all panel types and connections are:

a. One load of 110 pounds, minimum, per linear foot applied 12 inches out from the face of partitions.

b. Eight loads of 40 pounds, minimum, per linear foot on shelving 12" apart vertically. Assume loading is applied 6 inches out from the face of partition.

c. Both the above types of loadings should be applicable on either or both sides of a partition. (The partition subsystem should sustain test loadings of the above with a safety factor of three.)

I.11.3 Impact loads to be resisted by all panel types and doors, except glass, are:

a. Conduct test per ASTM E72-68, Section 12 or 13, to be on doors and panels nine feet high, using the widest stud spacing available. Impact shall be over the studs, and between studs. In five drops of two feet each, the panel shall not fracture; temporary deflection shall not exceed one inch; and permanent set shall not exceed 1/16 inch.

b. No cracking or chipping shall occur from impact of an 8-ounce, 1½ inch diameter steel ball dropped 18 inches.

I.12 SURFACE DURABILITY

Panel Surface Types I, II, and III (described in section I.7) shall provide different performance characteristics, as tabulated hereafter.

Door surfaces should meet the test requirements of the appropriate panel surface type.

1.12.1 TEST DESCRIPTION

Abrasion Resistance	For paint: Gardner Model 105 Washability and Abrasion machine. Change in gloss not greater than 5% on a Gardner 60° gloss meter. For vinyl: Wyzenbach method, CCC-T-191B, Method 5304. No exposure of backing or base.
Humidity Resistance	Exposure to atmosphere with 100% humidity of 70°-75°. No appreciable deterioration.
Washability	Brush wetted by a 5% solution of trisodium phosphate in a Gardner 105 Straight Line Washability machine. No softening, color change or more than slight surface abrasion. Test performed over joints of laminated surface materials.
Repair of Surface	Marks due to cutting or scratching of the surface shall be easily repairable in the field by the university custodial staff.
Ultraviolet Resistance	No appreciable color change after 150 hours at approximately 150° in the Atlas Fadeometer.
Resistance to Stains	Surfaces shall not be permanently discolored or damaged by the application and removal 24 hours later, of not more than one third of the materials listed hereinafter.
Resistance to Solvents	At least two-thirds of the listed solvents must be usable on panel surfaces without permanently discoloring or damaging the surface if used according to manufacturers' instructions.
Resistance to Chemical Reagents	When exposed to splash, spillage or fumes from the listed chemical reagents left on for 24 hours and removed according to manufacturers' instructions, there must be no noticeable effect in 80% of the cases, and may be only a trace of a stain in the other 20%.

1.12.2 **PERFORMANCE REQUIREMENTS**

TYPE I	TYPE II	TYPE III
100 cycles	100 cycles	150 cycles
200 double rubs	200 double rubs	300 double rubs
100 hrs.	100 hrs.	100 hrs.
15,000 brush strokes	50,000 brush strokes	100,000 brush strokes
Yes	Yes	Yes
Yes	Yes	Yes
Group 1	Group 1	Group 1
	Group 2	
	Group 3	

I.12.3 LIST OF STAINS, SOLVENTS AND REAGENTS

Group 1: Stains

Ballpoint ink
Carbon tetrachloride
Cellulose tape
Coffee
Household bleach
Lipstick
Permanent fountain pen ink
Tea
Wet detergent

Group 2: Solvents

Ethanol
Hydrogen peroxide
Methanol
Mineral spirits
Petroleum ether
V.M. and P. naptha

Group 3:

Acids

Acetic acid 2% and 10%
Hydrochloric acid 2% and 10%
Lactic acid 85%
Nitric acid 2% and 10%
Phosphoric acid 2% and 10%
Sulphuric acid 2% and 10%
Tannic acid 50%

Alkalies

Ammonium hydroxide 2% and 10%
Potassium hydroxide 2% and 10%
Sodium hydroxide 2% and 10%

Miscellaneous

Bromine water
Chlorine water
Glycerine
Latex
Motor oil — 10W
Phenol 10%
Sodium chloride 25%
Sodium hypochlorite Cl. 6%
and Cl. 10%
Water-deionized

I.13 DEMOUNTABILITY

ABS partitions shall be so designed that campus maintenance personnel can demount, move and re-erect them. The demountability method shall not be obvious; fasteners shall be concealed. Progressive solutions shall provide a key panel at each door and intersection.

I.13.1 The partitions will be made, generally, of several parts (panels, head and base channels) assembled at the job site. Commercially available components permit partitions to be taken down, moved and re-erected with more than 90% salvageability of components. Obviously, the higher the salvageability, the more successful in terms of cost of adaptability; the easier to move, the more successful in terms of adaptability.

I.13.2 The weight of any element shall not exceed 200 pounds.

I.13.3 The minimum standard of demountability, for both fire-rated and non-fire-rated partitions, should be as follows:

a. A single panel in the center of a 12-foot run is to be demounted, moved and reinstalled in one hour by two men.

b. 100 linear feet of partition is to be demounted, moved and reinstalled in 80 man hours.

c. Minimum refurbishing of adjacent surfaces should be required as a result of the demounting and reinstalling.

I.13.4 The actual cost of moving a partition can be obtained in the bidding process, by requiring a bid for moving 5% of the partitions after initial installation.

I.14 COLOR

I.14.1 Partition colors are to be designated by the architect for the specific project. Colors in academic spaces should not be drab or dull nor lacking the variety responsive to occupancy.

I.14.2 Surfaces in laboratories and classrooms should have a light reflectance of 40-60%; and have a maximum gloss rating of 20 as measured by a 60-degree Gardner Gloss Meter.

INSTALLATION

All attachments shall be concealed.

2 Partition head attachment to ceiling shall be to support points located as required for lateral stability and sound attenuation. The supports are included in the lighting-ceiling subsystem. Partitions located other than on the 5'-0" planning grid shall have head attached to ceiling grid bars on 5'-0" centers, at grid intersection with partition. In this case, head also may be fastened to ceiling panels for hold-down but not for support or stability.

Head details shall provide for passage of electrical conduit and HVAC control conductor, and a continuous light and sound seal; trim shall include method for receiving picture hooks. The head channel should be in 10-foot lengths, minimum, so that each channel section can be attached to ceiling grid bar in at least two locations.

3 Partition base shall be designed for installation over finish flooring, including carpet. Attachment methods that avoid damaging the floor are desirable and should be used if structural, fire safety and deflection tolerance requirements are satisfied.

Base details should accommodate differences in flooring thickness occurring at boundaries between two different materials.

A resilient base should be reusable when partitions are moved or services installed. Base details shall accept resilient cove or carpet bases projecting a maximum of 3/8" from panel surface and a minimum of 2½" to a maximum of 4" in height.

Base shall adjust to floor variations, and provide a continuous light and sound seal at floor contact. A recessed base is acceptable.

4 Partition corner details shall provide required strength, whether located on planning grid or elsewhere. A channel or cover strip, not exceeding 2 inches face width and 1/8" thick, is acceptable if details are consistent with other subsystem details, and visually acceptable.

TOLERANCES

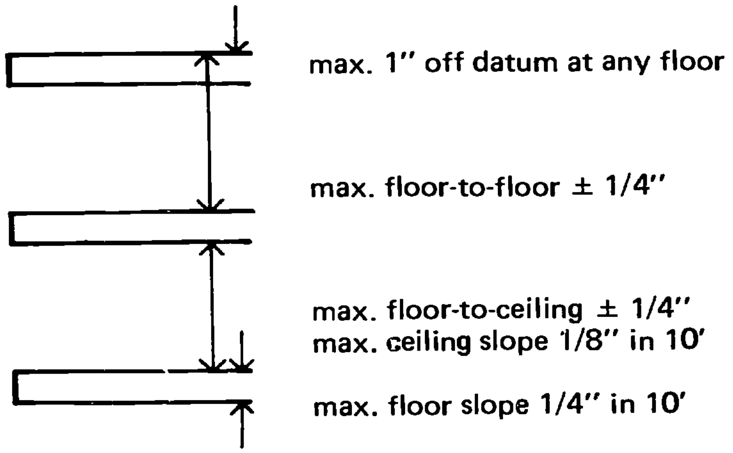
1 Excluding finished surface textures, surface irregularities such as warp, camber, and oil canning shall be ± 1/16-inch with a slope less than 1 in 10. Slope of all joints and exposed edges shall be less than 1/8-inch in 10 feet.

2 Head and base members shall be adjustable to accommodate the ± 1/4-inch construction tolerance from floor-to-ceiling, the maximum slope in floors of 1/4-inch in 10 feet, and the maximum slope in ceilings of 1/8-inch in 10 feet.

I.16.3 The maximum theoretical structural vertical live load deflection for floor-to-ceiling distance is +0, -1 inch, or L/360. The partitions shall have a minimum live load deflection tolerance of 3/4".

I.16.4 Intersection of an ABS partition with a non-ABS surface may have a ± 3/8-inch variation, and a maximum slope of less than 1/4-inch in 10 feet.

I.16.5 TOLERANCES



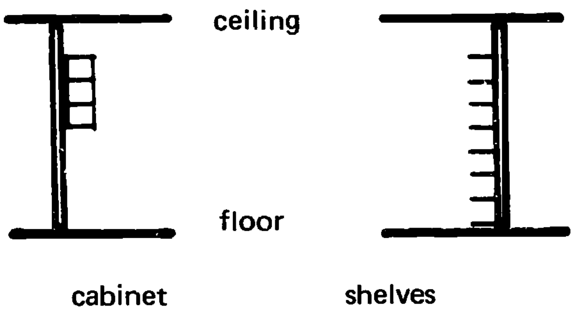
Partitions: minimum live load deflection tolerance 3/4"

I.17 SUPPORT

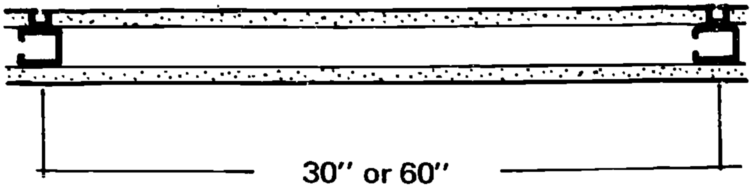
I.17.1 It shall be possible to attach casework, furniture and utilities to the partitions. Both flush mounted and surface mounted hangers are required. Loading requirements are stated in Section I.11.2.

I.17.2 CASEWORK AND FURNITURE

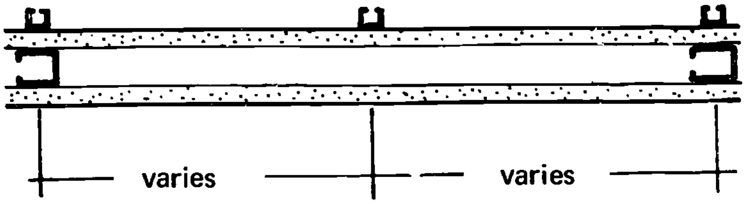
Objects to be supported on the partitions may not fit the planning or panel dimensions. They will consist of such varied items as: book shelves, wall hung cabinets, storage units, map rails, screens, special lighting, miscellaneous laboratory equipment, chalkboard and tackboard. The attachment devices must accommodate all these, and shall be designed so that when removed, no visible mark shall be left on the partition panels. Supporting channels or rails are permitted as part of the attachment devices. Special care shall be taken in selection of finishes so as to be compatible with the partition trim, including surface durability characteristics required in laboratory conditions.



flush, built-in hangers



surface-mounted, strut-type hangers

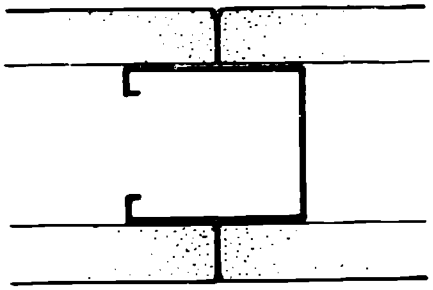


a. The width of the joint detail shall be minimized. Where the hanger is integrated with the partition, it shall not protrude beyond the panel face. Hangers shall permit maintaining the 5'-0" partition planning dimension. This may imply cutting the surface panels, as shown below, and so requires a visually and functionally acceptable detail of the interface between hanger and cut panel.

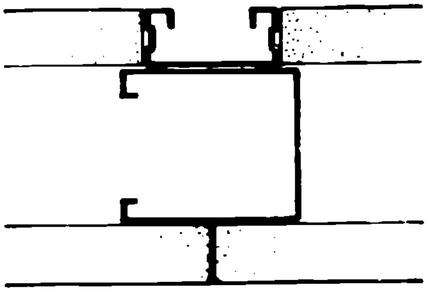
b. Where flush, built-in hangers are used, the required fire and acoustic provisions shall not be degraded. With gypsum board on steel studs, this may imply additional layers of fire-resistant material to back up the metal hanger strip, separating it from the steel stud. Alternative solutions are shown on the following page.

c. Details: Furniture Attachment

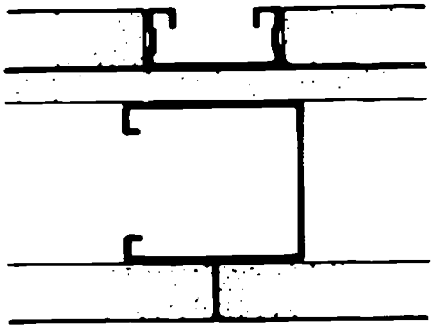
steel stud



STC 40
one hour and non-rated

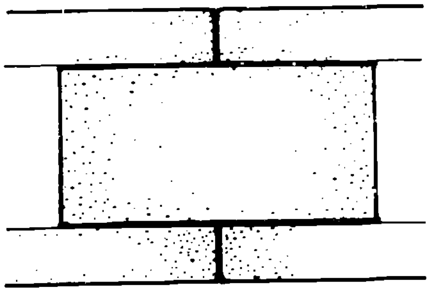


STC 40
non-rated

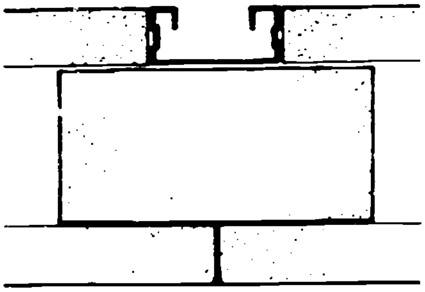


STC 40
one hour

gypsum stud



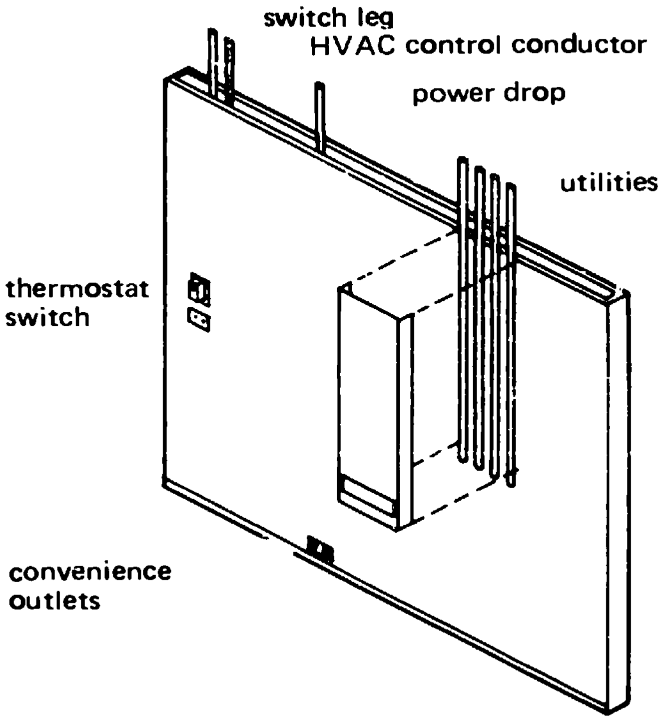
STC 40
one hour and non-rated



STC 40
one hour and non-rated

1.17.3 UTILITIES

Utility services penetrate the ceiling to serve spaces below. Generally, they do not run within the partition but are surface-mounted on it. Casework hangers noted in 1.17.2 should be utilized to support this distribution. The exceptions can be: convenience outlets, switches, and HVAC controls requiring simple connections to the ceiling and not affecting the partitions demountability.



a. Convenience outlets and switches are not part of the partitions subsystem. Space for them shall be provided within the partition to permit vertical and horizontal passage of 3/4-inch electrical metallic tubing and its conventional change of direction bend, and the termination or junction with conventional outlet and switch boxes. Provide for at least one conduit in each panel or panel joint. As horizontal passage should be available in head and base, horizontal runs within the partitions may be minimized.

b. Each panel or panel joint should provide approximately one square inch vertically for low voltage communications cable and HVAC control conductor, in addition to the space provided for conduit. HVAC thermostats may be either surface mounted or contained within the partition.

c. Space for two grounded 125V-20A convenience outlets should be provided in each panel width, at the partition base.

d. Panels adjacent to doors should accommodate a duplex low voltage switch and box.

e. Partition should be able to receive electrical boxes 2-1/8 inches deep; and with furring, items such as electrical panel boards and fire extinguishers.

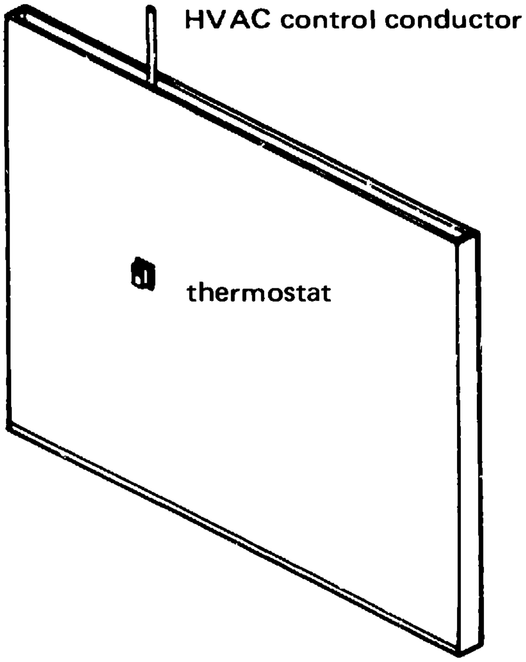
1.18 COMPATIBILITY WITH OTHER SUBSYSTEMS

1.18.1 WITH STRUCTURE

Partitions are non-load bearing, referring to support of floor loads from above. Partitions must transmit both lateral and vertical forces to the structure from doors, wall-hung items, and impact. Since few partitions, except those with a two-hour fire-rating, will be fastened to the structure, lateral forces must be transmitted to the structure via the ceiling grid bars.

1.18.2 WITH HVAC

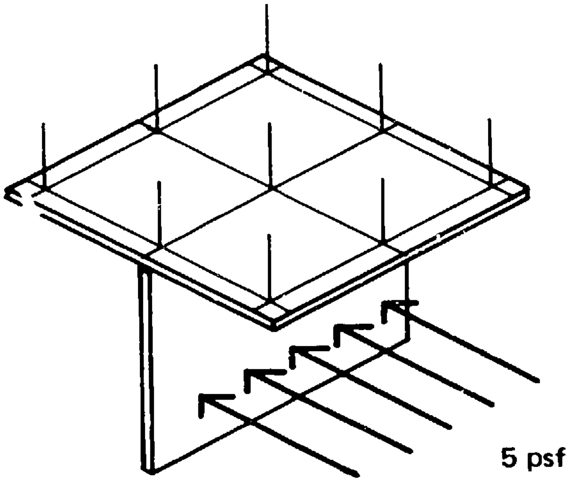
No mechanical components should be mounted on or contained within the partition, except HVAC room thermostats. If contained, the HVAC control conductor should pass within the partition to the service space above. The partition should provide for space, attachment and all other requirements so that the services penetrating through the partition can meet all applicable electrical, HVAC, and other codes.



1.18.3 WITH LIGHTING-CEILING

Compatible details are required at all connections between the partition and the lighting-ceiling.

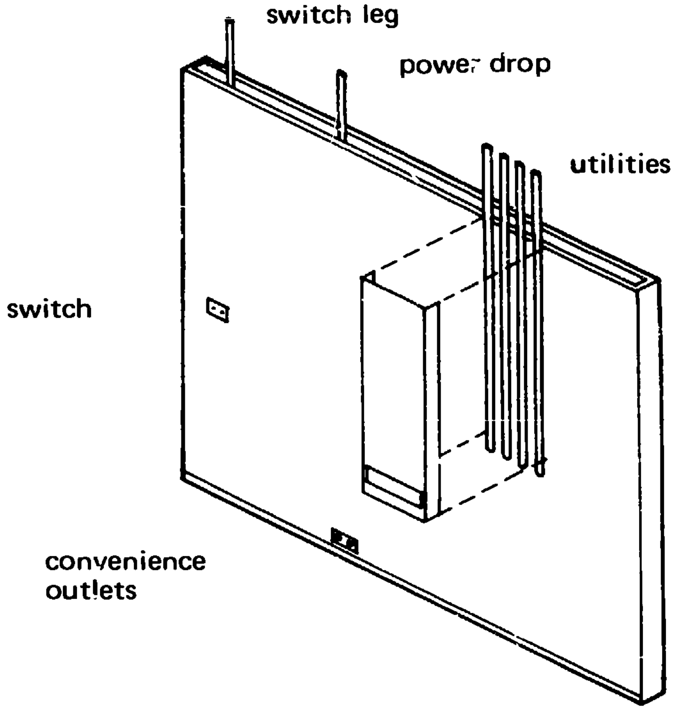
Partitions stop at and transmit lateral loads to the ceiling. Head details must accommodate ceiling deflection, construction tolerances, door slam shock, and must not degrade the sound attenuation of the partition or ceiling.



1.18.4 COMPATIBILITY WITH UTILITIES

To facilitate door relocation, other partition alterations, and alteration to services, all service distribution lines should be kept out of the partition cavity excepting switches and convenience outlets. When these are contained, they should run upward as directly as possible to the service space above, rather than horizontally. No services will run down into the floor, except plumbing drain lines. Rigid horizontal distribution should occur in the service space above the ceiling.

a. Most utilities within a room should be surface mounted. Covers concealing the services (forming a service console) are optional.

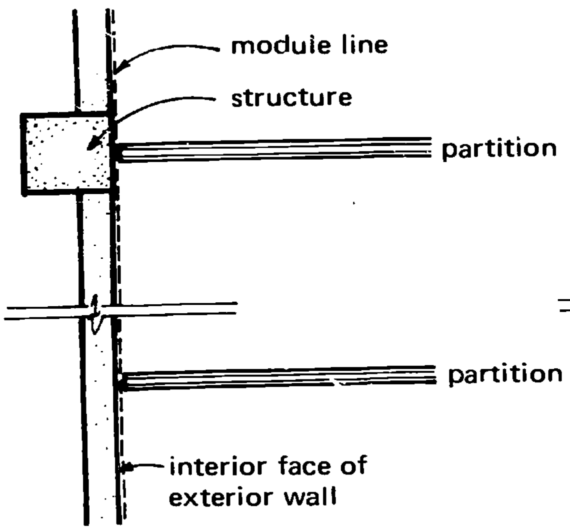


I.18.5 WITH EXTERIOR WALL

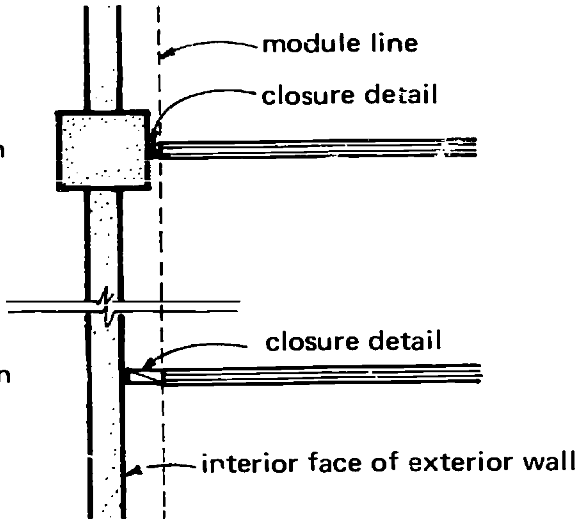
The joint detail between a partition and exterior wall shall conform to applicable sound transmission and fire-resistance requirements; accommodate construction tolerances of both partition and exterior wall subsystems, and allow for deflections and vibrations in the exterior wall due to wind loads without loss of other required characteristics.

The exterior wall shall provide for partition attachment no greater than on 60" centers corresponding to the lighting-ceiling grid.

There are several alternative ways the partition may meet the exterior wall; all are determined by the lighting-ceiling subsystem. The inner face of the structure may or may not coincide with a module line. The partition may include a closure detail to accommodate this discrepancy.



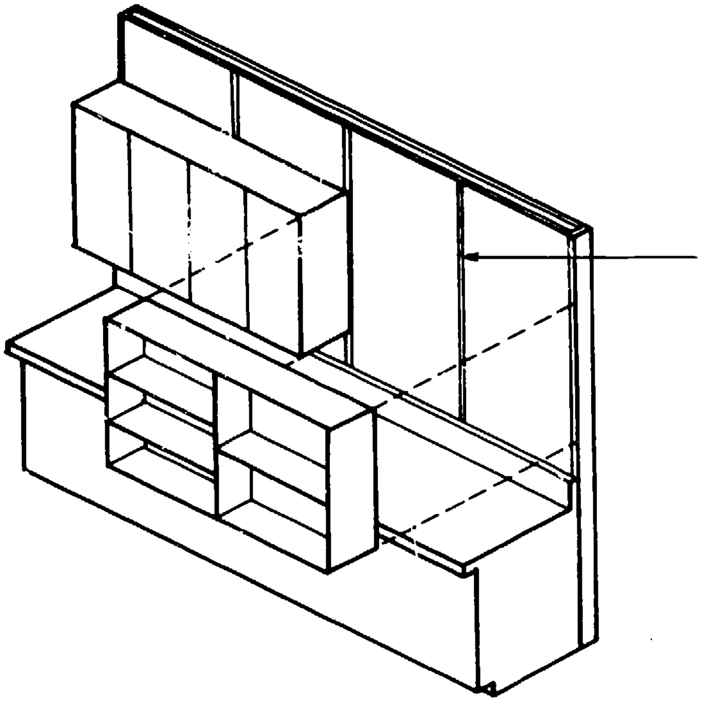
Structure on Lighting-Ceiling Module



Structure off Lighting-Ceiling Module

I.13.6 WITH CASEWORK

Some casework units are required to be wall-hung. The partition shall provide attachment hardware for wall-mounted casework, and a means of fixing laboratory experiment frames over large areas from floor to ceiling. Laboratory casework shall be mounted so as to permit utilities to run vertically between the partition and the back of the casework.



hanger strips at 30″ spacing for supporting casework and utilities.

J. UTILITIES DISTRIBUTION

J.1 GENERAL

J.1.1 The information in this section is provided as a guide to the design professional, whose responsibility must include its interpretation and application. Local condition, preferences and less stringent code requirements for a specific project may suggest to him economies and variations which he is encouraged to investigate. When the design professional's requirements differ from the defined relationships, careful appraisal of the interface with the other subsystems will be required.

J.1.2 This ABS subsystem provides criteria for the distribution of plumbing, communication and electrical services in the service space above the ceiling of the space module. The organization of the service space establishes the locations of all horizontal mains and all lateral branches, coordinating these with locations of HVAC services. All utilities should be installed within their designated zones to avoid interference with each other and with other subsystems, thus maintaining the optimum relationships among t. .m.

J.1.3 Special emphasis has been place; on laboratory facilities and those utilities most often required for a science laboratory building. Some utilities will not be required in every building; some additional services occasionally may be required. From study of existing laboratories, the maximum *probable* spatial demands and a pattern of utilities usage has been established. It is unlikely that more than the total number and volume of utilities shown herein will be required in any single building.

J.2 This subsystem provides for the distribution of utilities from the service tower into and within the service space above the ceiling of the space module, as follows:

a. Liquid and gas supply piping
b. Sanitary and laboratory waste and vents
c. Roof drainage
d. General power
e. Laboratory power
f. Lighting power
g. Emergency power
h. Communications
i. Controls and signals

J.3 This ABS subsystem does not include the following:

a. The dry standpipe for the building.
b. Steam supply and condensate return lines.
c. The vertical sanitary plumbing mains outside of the space module.
d. All utilities in the occupied space below the ceiling of the space module.

J.4 DESIGN CRITERIA

J.4.1 The demand for each of the several utilities, and the pattern of points of usage, cannot be predicted with certainty. Moreover, engineering and code requirements allow less freedom of choice in the methods of installation of utility piping and electrical service.

J.4.2 An acceptable level of performance has been based upon the usage observed in existing buildings. The intensity of utility services was recorded for each of the six science and engineering buildings studied in the ABS research effort. The data was tabulated in terms of square feet of floor area per utility flow rate or load factor. From this, the probable flow rate or load factor was determined for a building consisting of ten 12,000 square foot space modules, each containing a laboratory assigned space of 5,400 square feet. The probable flow rate and load factor requirements derived are summarized herein.

J.5 PLUMBING SERVICE

J.5.1 Piping of one size larger than that determined from the calculated flow rates noted in Sections J.5.6 and J.5.7 was used to develop the clusters shown in Section J.7. The pipe spacing is based on the actual pipe size plus the minimum separation to permit insulation where required, and installation.

J.5.1.1 One elevation is established for all horizontal utility mains and a different one for all laterals. Elevations and zones must be respected to minimize interference.

J.5.1.2 Spacing criteria and code dictated slopes must be maintained for waste, vent and rainwater drain lines. Therefore the horizontal mains have thoroughfares occupying the full depth of the available service space. Lateral drain branches run above the mains within the space between the structural beams.

.2 SUPPLIES

Vertical main risers in the service tower have shaft spaces as shown in Section G. These permit risers of sufficient size to serve ten stories of the assumed typical, large space modules. Space is available to permit required piping anchors, guides and expansion loops, and access clearance in front of electrical equipment. Utility services include: domestic sanitary and laboratory water, hot and cold; hot water return; natural gas; compressed air at 80 psig; vacuum at 15 inches hg; distilled water; sea water or other "special" liquids; and wet standpipe.

.3 WASTES AND VENTS

.3.1 Sanitary wastes and vents for toilet rooms are located outside of the space module and within the service tower. They are kept separate from the acid-resistant waste and vents until outside the building.

.3.2 Wastes and vents for the space module are entirely acid-resistant, to accommodate laboratory sinks, floor drains and the like. Random fixtures in the space module area, such as drinking fountains and eye-wash fountains, are connected to the acid-resistant lines. Space requirements are based upon piping sizes shown, with a minimum slope of 1/8-inch per foot. Each row of structural bays is served by one waste main. The architectural design must provide space by a column or wall for a vent to roof at the end of each run and at 100-foot centers, maximum, along the length of each drain main. A vent riser adjoins the waste riser in the service tower. All waste lines and traps shall be two sizes larger than code minimum for an individually vented design. Each vent shall have a cross-sectional area one-half the area of the waste line it serves.

5.3.3 Individual floor drains and sinks on lateral branches longer than fifteen feet shall have separately vented traps. These vents will be run up through the ceiling, then sloping horizontally in the service space to connect to one of the vent stacks. Horizontal vent mains should not be required.

5.3.4 The acid-resistant waste main is to join the sanitary main outside the building. Special treatment of the acid waste, such as a dilution tank, is to be provided as required. The design professional should review local codes and costs, as well as acid concentration and volume, to determine cost benefits of acid waste dilution and neutralization at the source and then feeding into building sanitary waste.

5.4 RAINWATER DRAINAGE

Roof water is handled by two horizontal mains in the service space just below the roof. The mains connect to roof drains spaced as required by the roof area and design.

J.5.5 GAS SUPPLY

J.5.5.1 Location of a gas supply line in the service space above the ceiling may be at variance with local requirements. The suggestion is made that this is possibly a more desirable, and safer, installation than would be the case in a closed shaft or furred enclosure. In a tightly closed space, leaking gas could accumulate undetected until an explosive mixture was reached. However, using the return plenum above the ceiling in a recirculating cycle, strongly suggests the gas odor would soon be detected by occupants, prompting remedial action.

J.5.5.2 If special piping installation methods are required, the use of all welded joints, wing-cap packed stem valves, or gas piping installed in a vented sheet metal conduit with sealed joints are design possibilities.

J.5.5.3 Some locations may require that the gas main entering the building have an earthquake safety shut-off valve.

J.5.6 Plumbing capacities for a 12,000 square foot space module with 5,400 square feet assigned to laboratories are

J.5.6.1 SUPPLIES

Service	Flow Rate	Pipe Sizes Calculated	Pipe Sizes Layout
Domestic CW Sanitary	39 F.U. - 45 GPM	2"	*
Lab	34 F.U. = 24 GPM	2"	2½"
Domestic HW Sanitary	7 F.U. = 5 GPM	1"	*
Lab	27 F.U. = 18 GPM	1½"	2"
DHWC		¾"	¾"
Gas	102 CFH	1½"	2"
Compressed air (80 PSI)	1000 CFM free air	2"	2½"
Vacuum (15" HG)	32 CFM	1¼"	2½"
Distilled water (gravity)	10 F.U. = 7 GPM	1¼"	1½"
Sea water (S & R)	4 F.U. = 4 GPM	¾"	1"
HVAC reheat water supply and return	18 GPM	1½"	2"

J.5.6.2 DRAINAGE

Sanitary	4 WC, 4 Lav, 3 Ur, 1 SS, 1 DF, 39 F.U.	4" W, 4" V	*
Acid-resistant	72 F.U. total; two horizontal mains, each 36 F.U.		
Each main-vented system		4" W, 3" V	
Each main-combination W & V		6" W 5" V (2 or 3)	
Rainwater	12,000 sq.ft., 3" rainfall, 2 mains, each	6"	

F.U. = Fixture Units

* = Not included in space module layout.

J.5.7 PLUMBING CAPACITIES UTILITY RISERS FOR TEN SPACE MODULES

J.5.7.1 SUPPLIES

Service	Flow Rate	Pipe Size
Domestic CW Sanitary	390 F.U.	
Lab	340 F.U.	
	730 F.U. = 200 GPM	4"
Domestic HW Sanitary	70 F.U.	
Lab	270 F.U.	
	340 F.U. = 100 GPM	3"
DHWC		1½"
Gas	1020 CFH	3"
Compressed air (80 PSI)	10,000 CFM free air	5"
Vacuum (15" HG)	320 CFM	4"
Distilled water (gravity)	100 F.U. = 45 GPM	3"
Sea water (S & R)	40 F.U. = 25 GPM	2"
HVAC reheat water supply and return	180 GPM	4"

J.5.7.2 DRAINAGE

Sanitary	390 F.U. total	6" W, 5" V
Acid-resistant	720 F.U. total, 2 runs each 360 F.U.	
Each waste drop		6"
Each vent riser		5" (2 or 3)
Rainwater	12,000 sq.ft., 3" rainfall	
Each riser		6"
Combined		6"

F.U. = Fixture Units

J.5.8 SPECIAL PLUMBING CONSIDERATIONS

J.5.8.1 The provision described in this subsystem generally meet the requirements of the National Plumbing Code and the Uniform Plumbing Code. However, the design professional is expected to comply with the local requirements governing a specific project.

J.5.8.2 Pipe support trapezes are to be installed at uniform levels in each direction. Trapezes shall attach to hangers located as described in Section H. Install circulating services to permit air to vent out in direction of flow. Use eccentric reducers to keep the tops of these pipes level; shim pipe supports as required.

J.5.8.3 Provide pipe stubs every twenty foot pipe length in each service, to permit adding branches for future needs with minimum disruption to service.

J.5.8.4 Install pipes with adequate loops, anchors and guides to accommodate expansion. Install hot piping on rollers.

J.6 ELECTRICAL UTILITIES

J.6.1 Provision for the distribution of the following electrical sercices is made in the service space above the ceiling of the space module. The space requirements for conduits, bus ducts and cable trays allow for spacing and access consideration as indicated in Section J.7. Optimum size of conduits, bus ducts, and cable trays have been determined from capacities noted in J.6.5.

J.6.1.1 Power and Lighting:

a. 277 volt power for lighting
b. 208/120-volt power for laboratory
c. General use outlets
d. Equipment for fan room motors
e. 208/120-volt power for emergency lighting and laboratory outlets
f. 24-volt wiring for remote switching of lighting

J.6.1.2 Communications and Signal:

a. HVAC control
b. Public telephone
c. Master antenna and/or closed circuit television
d. Program clock
e. Intercom and public address
f. Fire alarm
g. Computer systems

J.6.2 **DISTRIBUTION**

J.6.2.1 Lighting: one centrally located panel board fed from a vertical bus riser is provided in each space module.

J.6.2.2 208/120 volt power: from six to eight branch circuit panel boards are in each space module, supplied from one distribution panel board in each mechanical room as shown in Section G. This distribution panel board also supplies power to fan motors in the mechanical room and to a panel board within the space module for computer equipment power. The distribution panel board is fed from a vertical bus riser through transformers located on alternate floors.

J.6.2.3 Emergency power: one centrally located panel board in each space module fed from a conduit riser

J.6.2.4 Public telephone, master antenna and/or closed circuit television, program clock, intercom and public address, and fire alarm systems: terminals for each are located on each floor, fed from conduit risers.

J.6.3 **ELECTRICAL ROUTING**

J.6.3.1 Conduit and cable tray main runs in the service space are run at a fixed elevation and supported by channels spaced at ten-feet intervals.

J.6.3.2 Lateral branches from the mains are made at an elevation below the main, as shown in Section J.7.

J.6.3.3 Lateral runs for all signal system conduits emanate through condulets and terminal type junction boxes, at fixed elevations.

J.6.3.4 Lateral runs from cable trays are made by conduits terminating in the cable tray.

J.6.3.5 Lateral runs for 24-volt switching are made through junction boxes located at a fixed elevation.

All lateral conduit runs are to be supported at intervals meeting code requirements. Choose conduit sizes that do not require support spacing violating the system disciplines.

J.6.4 **SPECIAL CONSIDERATIONS**

J.6.4.1 Requirements for regulated AC voltage and in some laboratories, DC voltage, should be met by portable equipment in the laboratory.

J.6.4.2 Building power has been allocated for one computer installation per building.

J.6.4.3 Plan the location of the branch panel circuit boards to produce the minimum interference with future adaptability. The boards are to be located:

a. In the deep service space if this option is used. Ascertain that local codes recognize the adequacy of the access provided from the service tower.

b. In the occupied space if the shallow service space is used.

J.6.5 ELECTRICAL CAPACITIES

J.6.5.1

Module Power	Estimated Load (max.)	Design Factor	Design Load
Lighting	5.0 watts/sq.ft.	1.25	6.3 watts/sq.ft.
208/120-volt power	10.5 watts/sq.ft.	1.25	13.1 watts/sq.ft.
Emergency power	0.75 watts/sq.ft.	1.25	0.9 watts/sq.ft.

J.6.5.2 Additional Power Loads

a. Fan load on each floor: 36 HP x 1.25 = 45 HP
b. Computer power load - one per building: 84.0 KW

J.6.5.3 Low Voltage Switching

Thirty (30) rooms per space module with relays centrally located in module at lighting panel; 2" conduit per space module.

J.6.5.4 Public Telephone

Two (2) terminals per space module with cable tray interconnection.

J.6.5.5 Master Antenna and/or Close Circuit Television

Service to selected rooms with 1½" conduit per space module and 2½" conduit for building riser.

J.6.5.6 Program Clock

Thirty (30) rooms per module, 1½" conduit per space module and from one to three 3" conduits for building riser.

J.6.5.7 Intercom and Public Address

Thirty (30) rooms per module, 1½" conduit per space module and from one to three 3" conduits for building riser.

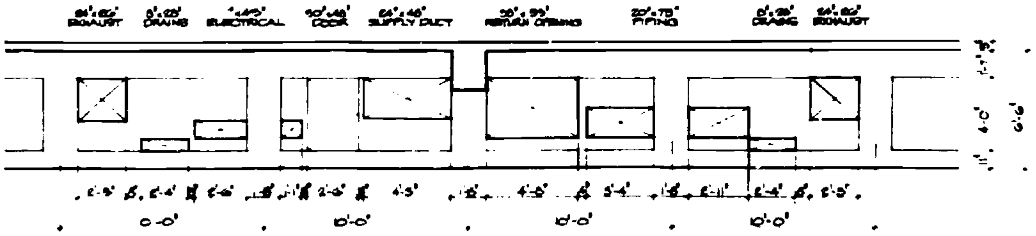
J.6.5.8 Fire Alarm

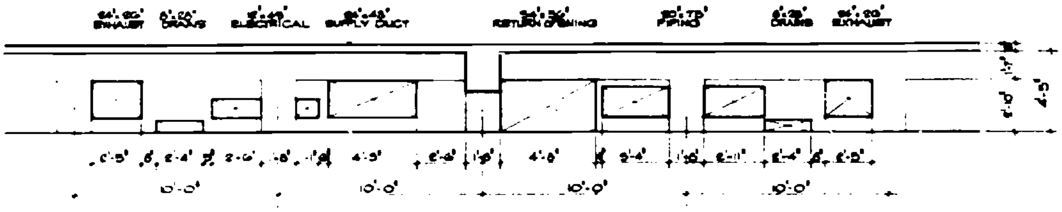
Manual stations and signals in each space module, with each space module in separate annuciator zone. One-inch conduit per space module and 1½" conduit for building riser.

J.6.5.9 Computer Control Cable

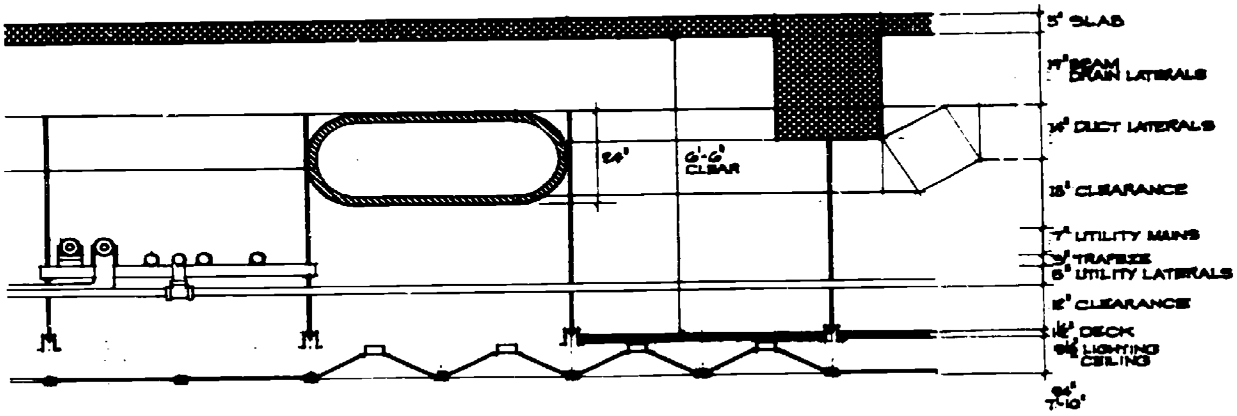
Cable tray interconnection between locations within space module. Computer component interconnection requiring laid-in installation may be accomplished with raised computer floor and special short partitions or planned structural floor penetrations and cable trays in service space below.

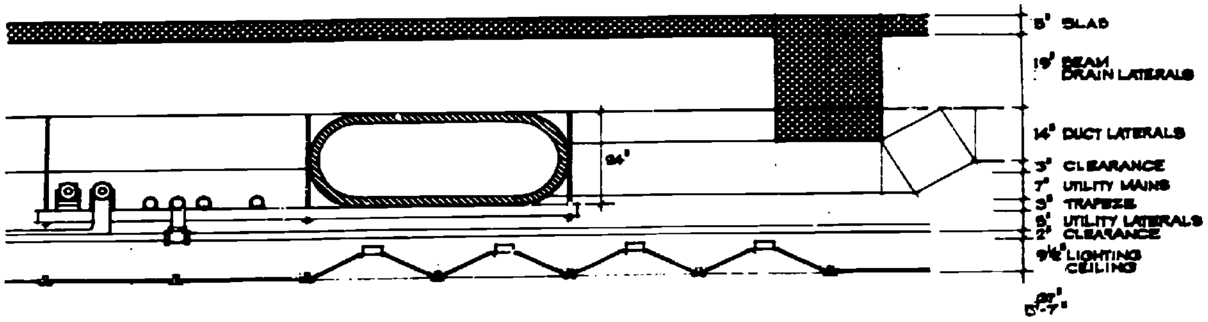
J.7 ELEVATIONS: MECHANICAL ROOM WALL FROM SERVICE SPACE

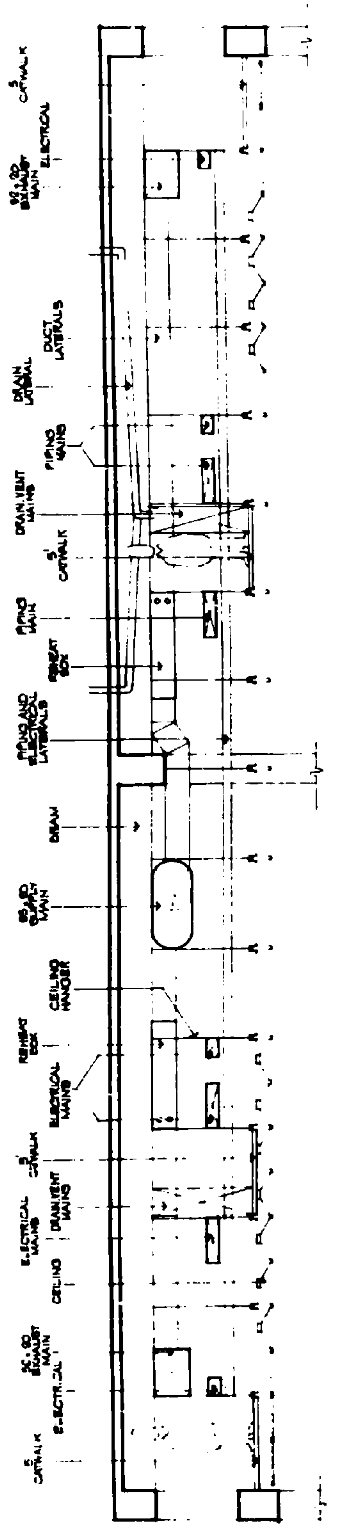


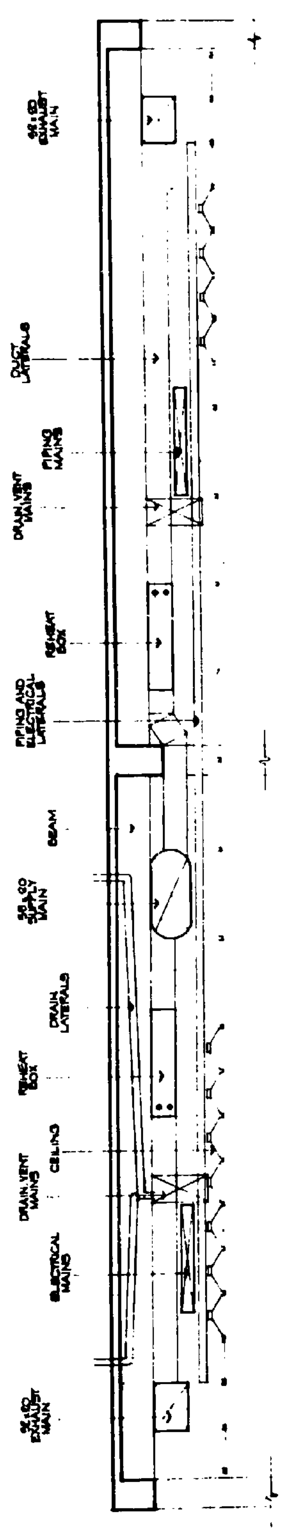


J.8 VERTICAL SECTIONS: SERVICE SPACE ZONING






5' CATWALK
ELECTRICAL
92 x 30 EXHAUST MAIN
DUCT LATERALS
DRAIN LATERAL
PIPING MAINS
DRAIN, VENT MAINS
5' CATWALK
PIPING MAIN
REHEAT BOX
PIPING AND ELECTRICAL LATERALS
BEAM
58 x 30 SUPPLY MAIN
CEILING HANGER
REHEAT BOX
ELECTRICAL MAINS
5' CATWALK
DRAIN, VENT MAINS
ELECTRICAL MAINS
CEILING
92 x 30 EXHAUST MAIN
ELECTRICAL
5' CATWALK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BEAM
58 x 30 SUPPLY MAIN
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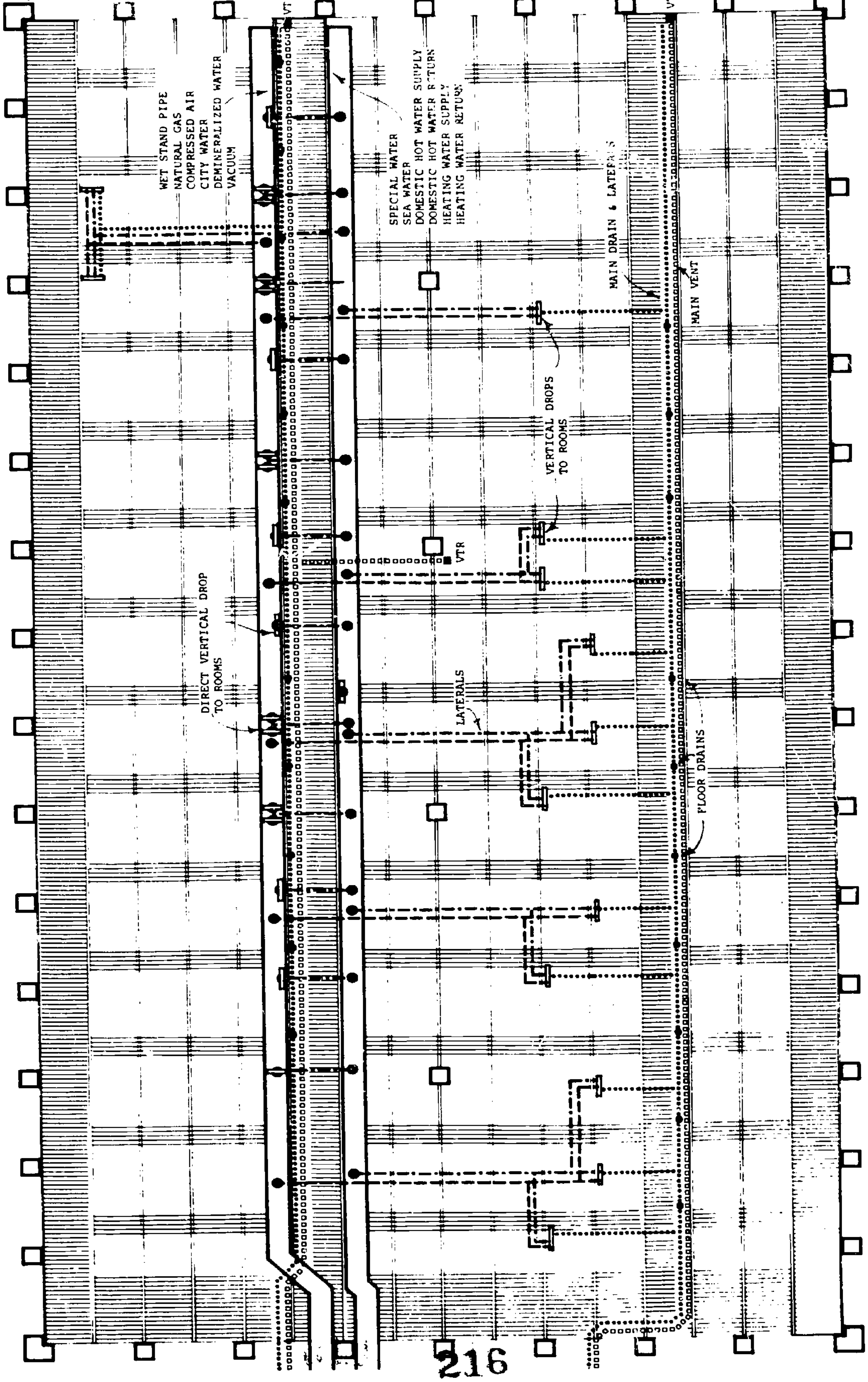
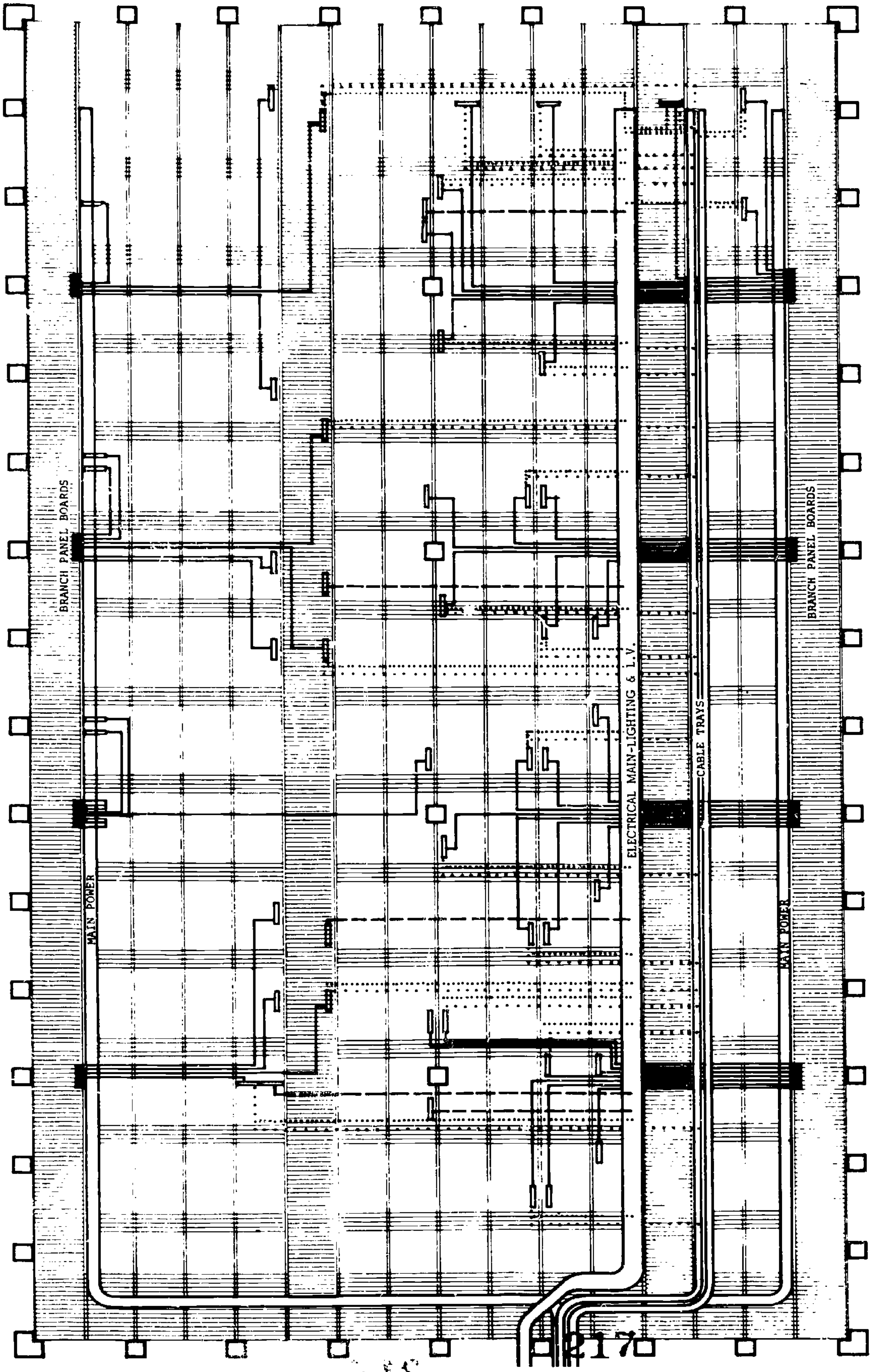
92 x 30 EXHAUST MAIN

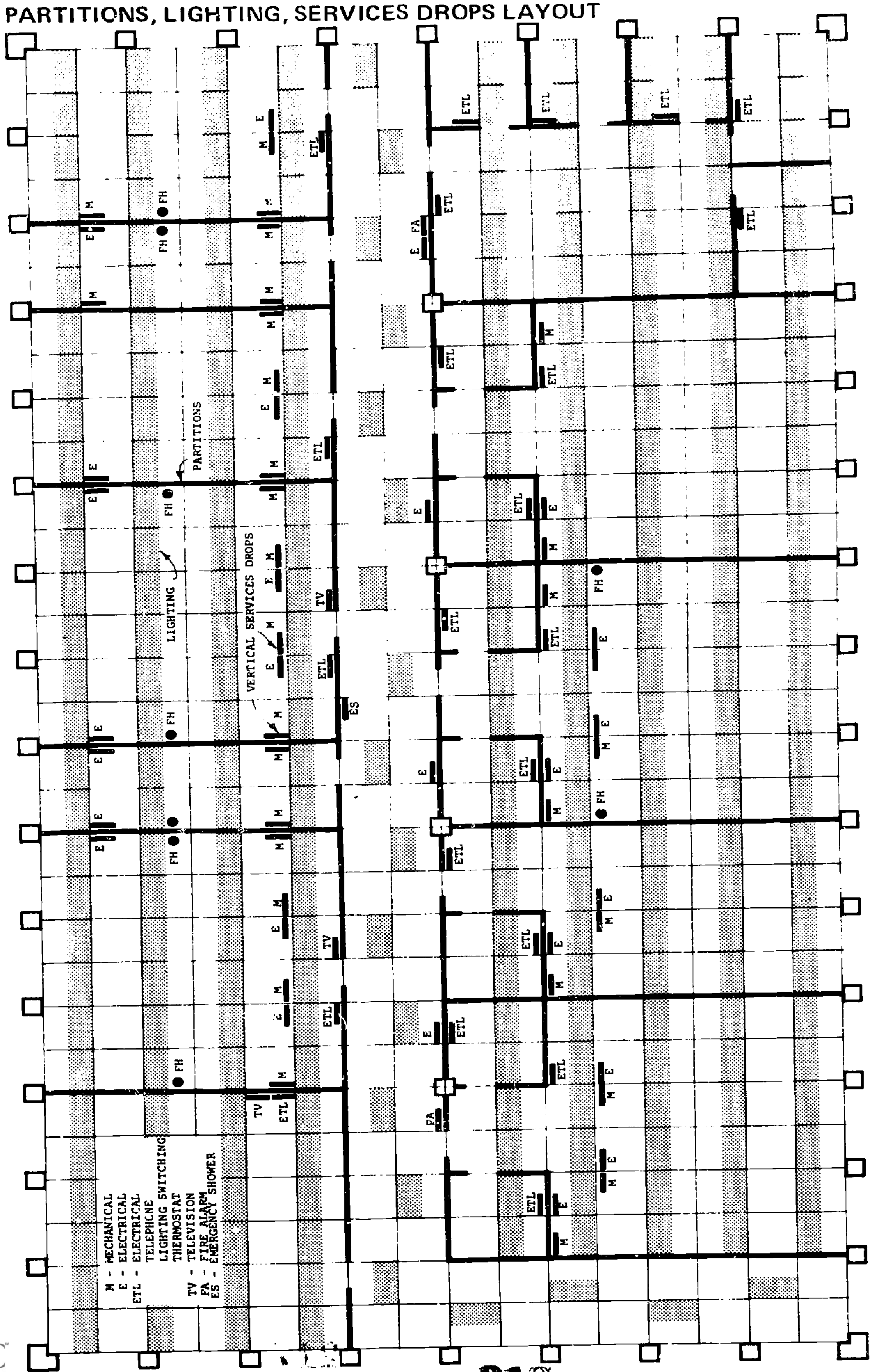
J.9 PLUMBING DISTRIBUTION



J.10 ELECTRICAL DISTRIBUTION



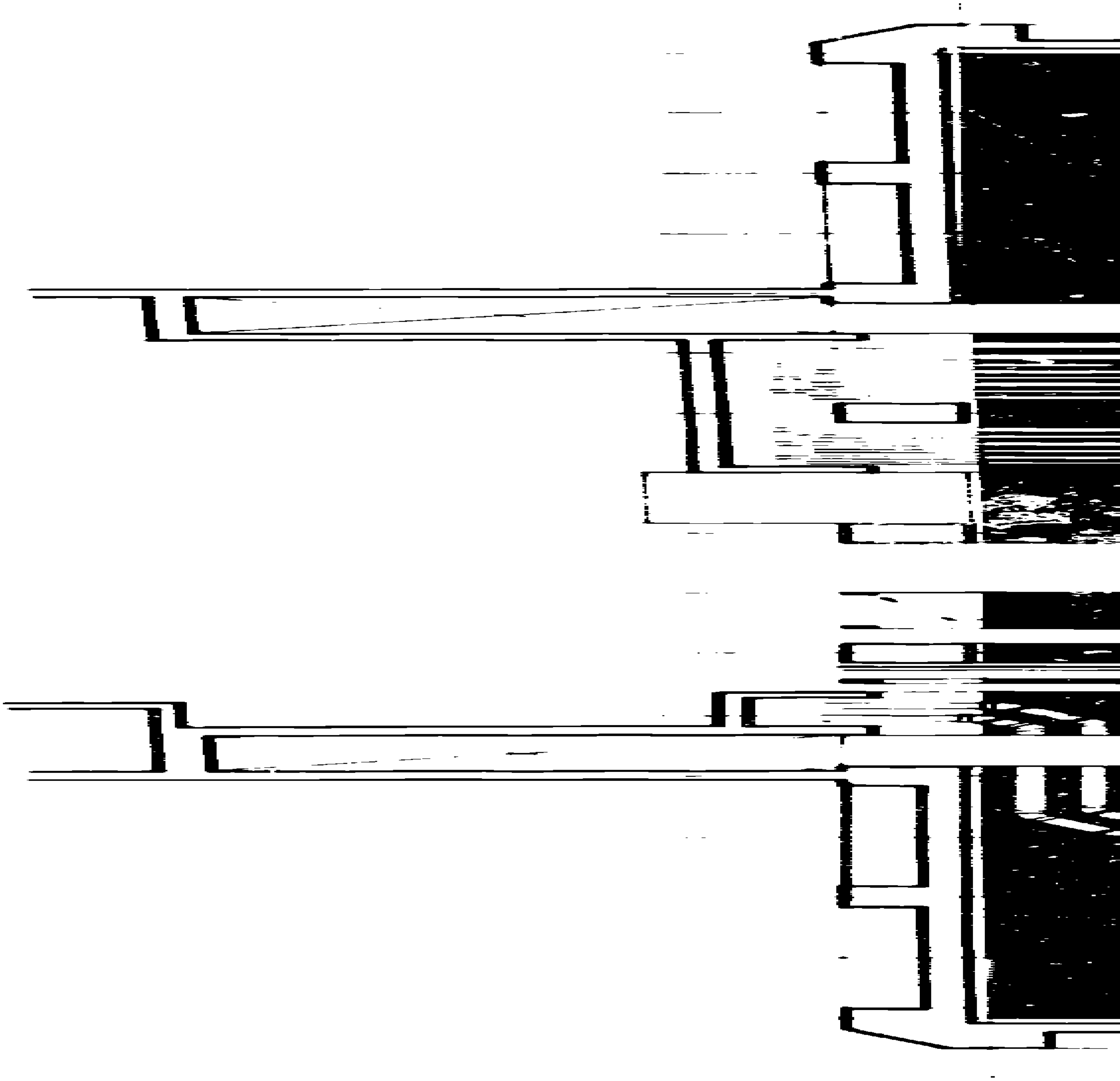
.11 PARTITIONS, LIGHTING, SERVICES DROPS LAYOUT



J.12 SERVICE S

HVAC, UT

CATWALK



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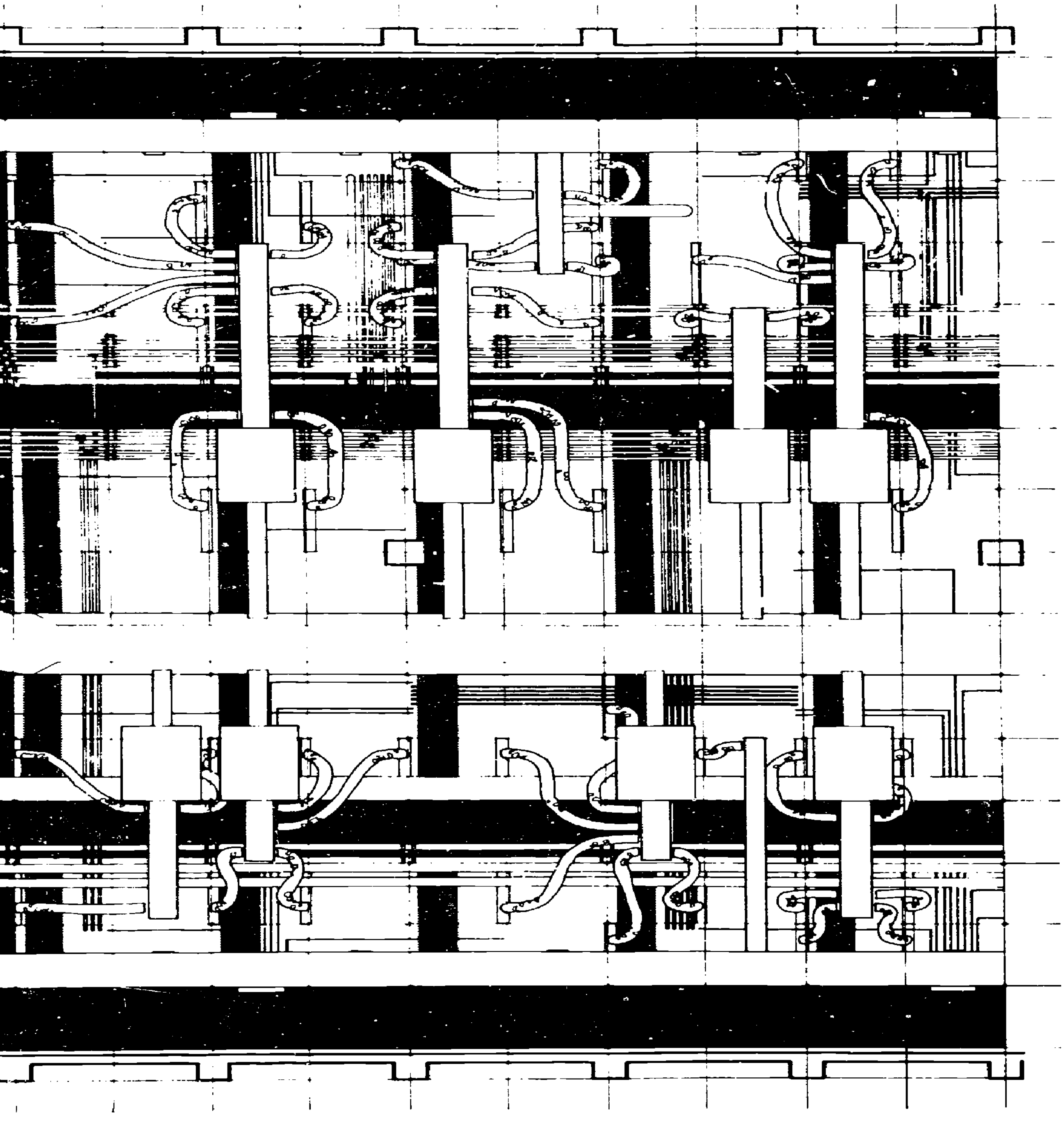


K. RELATED NON-ABS SUBSYSTEMS

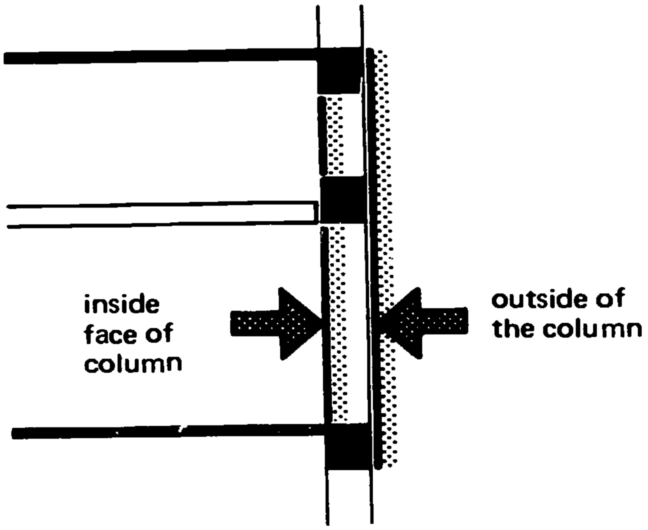
K.1 The choice of the ABS subsystems was limited to those improving the quality and/or reducing the costs of construction and alterations. Because of their relationships to the ABS subsystems, two related non-ABS subsystems were analyzed. The intent is for the building as a whole to remain effective during its total life-time, able to undergo periodic renewal of its adaptable components.

K.2 EXTERIOR WALLS

An exterior wall has two distinctly different functions: its performance and its visual appearance. The performance aspect is composed of those items required to ensure proper interface with, and functioning of, the several ABS subsystems, and those items determined by local conditions. Local conditions include availability of various skills and materials, climate, available budget, and campus architectural vocabulary.

K.2.2 COMPATIBILITY WITH STRUCTURE SUBSYSTEM

The inside face of the exterior wall may be located at any position between the inside face and the outside face of the column. Space dimensions are measured to the inside face of the column—moving the wall out returns "bonus space."



K.2.2.1 The exterior wall must be compatible with the dimensional characteristics of the perimeter grid frame described in Section F, Structure. Tolerances for structural movements of creep, earthquake and thermal expansion are required for the exterior wall. The allowable tolerance for the vertical intersection of exterior wall and structure is 3/4"; for the horizontal intersection is 1/2".

K.2.2.2 The allowable dimensional tolerance for the intersection of the ABS partitions with the non-system vertical surface is 3/8"±, with a maximum slope of less than 1/4" in 10 feet.

K.2.3 COMPATIBILITY WITH HVAC SUBSYSTEM

Energy transference through the exterior wall should not exceed 377 BTU/hr./lineal foot in summer, or 845 BTU/hr./lineal foot in winter. This requirement is to define the loads expected in the operation of the HVAC subsystem. The implications on the design of the exterior wall for some climates will be severe, limiting the glass area and requiring high "U" factors.

a. Early in the design stage, the design professional should provide interpretations of energy transfer to suit the local conditions.

b. Windows should be non-operable to the occupants.

K.2.4 COMPATIBILITY WITH LIGHTING-CEILING SUBSYSTEM

Spandrel panels enclosing the service space above the ceiling may be left off for access during construction. They should be removable for access during major alterations.

The exterior wall should accept the ABS Lighting-Ceiling subsystem with no loss of performance at the joint.

K.2.5 COMPATIBILITY WITH PARTITIONS SUBSYSTEM

The exterior wall must be able to accept partition termination on both the 60-inch planning grid and intermediate locations.

K.2.6 DESIGN PROBLEMS

New materials and construction techniques are producing a number of new exterior wall solutions, implemented with only partial success. Well known problems experienced in exterior walls are:

a. Condensation on windows, frames, and wall and column surfaces.

b. Corrosion of metal connections attaching the exterior wall to the structure. This is of particular concern in seismic regions, for the shear resistance in the attachments may be greatly reduced.

c. Glass breakage caused by partial shading of windows in intense heat or cold, and insufficient tolerance to allow thermal movement.

d. Rain pentration due to failure to joints, and by outside/inside pressure differentials.

K.2.7 DESIGN SUGGESTIONS

Some of the above problems could be avoided in ABS buildings by consideration of the following suggestions:

a. Provision of the air barrier on the warm side of the wall's insulation, preventing condensation forming within the wall. Warm air movement from inside the building through the wall to cold spaces within the wall reduces the temperature difference.

b. Provision of an air chamber, sealed on the inside and ventilated to the outside, to prevent rain penetration by neutralizing the pressure differential which draws the moisture through.

c. The window and window frame should be insulated from the structure so as to reduce condensation forming because of temperature differences between exterior surfaces and interior structure.

d. In intensely cold climates, the provision of insulation on the exterior of the structure may be appropriate to reduce the load on the HVAC subsystem and to prevent expansion and contraction of structural members. Tolerances should permit movement between the exterior wall and the structure.

K.3 CASEWORK

K.3.1 Casework is defined as those interior furnishinge interfacing with the ABS subsystems. Included are the laboratory fumehoods and cabinetwork, and wall-mounted office and classroom equipment—such as shelving and storage units.

The casework contributes materially to the visual environment. Its general appearance, proportions and colors are important considerations. Research for ABS showed, for example, that users objected to having only the black color bench and counter tops found in many laboratories. Although the users recognized that the black tops were generally of higher chemical resistance, they felt that the black color was not justified in many cases, and they preferred lighter, more colorful tops and furnishings.

Casework may play an important role in enhancing or obstructing ABS emphasis on adaptability. One of the greatest obstructions to changing activities is in fixed casework. Casework should be modular, coordinated where possible with the ABS 60-inch planning module, movable, and its parts interchangeable.

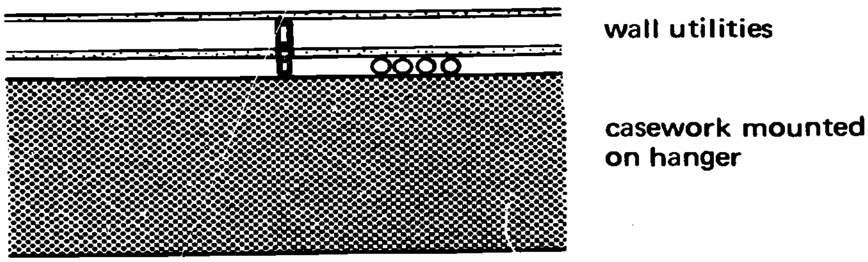
The ABS research indicated that many users would prefer more free wall and floor space for equipment and for setting up experiments as needed. Wall-hung cabinets for storage were preferred over base cabinets which, in some cases, went unused.

K.3.2 COMPATIBILITY WITH HVAC SUBSYSTEM

The HVAC subsystem will exhaust fume hoods. These should be provided with automatic constant volume bypass dampers, in order to allow HVAC air balance to be maintained.

K.3.3 COMPATIBILITY WITH UTILITIES DISTRIBUTION

The utility drops within rooms should be located on the surface of the partitions and behind the wall-mounted casework. Casework attachments should facilitate rapid relocation of exposed utilities.

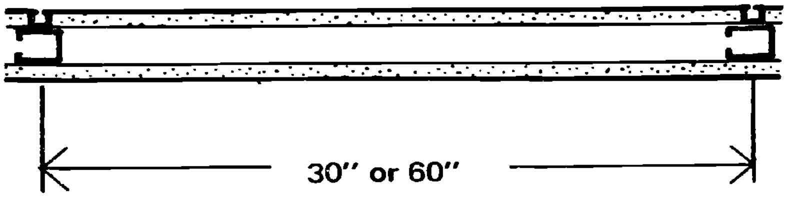


K.3.4 **COMPATIBILITY WITH PARTITIONS SUBSYSTEMS**

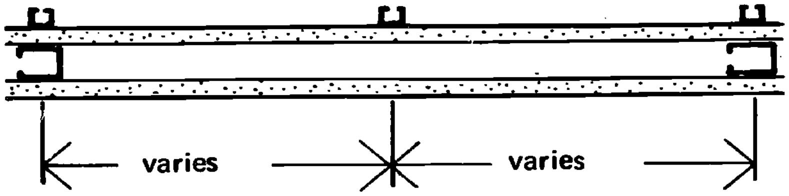
The partitions will provide support for wall-mounted caswork in accordance with loading capabilities stated in Section I, Partitions.

Partitions shall include attachment hardware for wall-mounted casework. The attachment hardware shall be of the following types:

a. Flush, built-in hanger: spacing coordinated with partition module.



b. Surface-mounted hanger: location varies.



L. ABS DEMONSTRATION PROJECTS

L.1 GENERAL

L.1.1 The ABS program consists of three basic phases: the research phase, the system development phase, and the demonstration phase. Until tested in actual demonstration projects wherein academic buildings are planned, designed, and built with the coordinated ABS procedures, planning concepts, and subsystems, ABS remains a "paper" system.

L.1.2 Recognizing ABS' potential, each of the two sponsoring universities—Indiana University and the University of California—plans to initiate the demonstration phase with a major academic building project. The first specifically designated ABS demonstration project is the Science/Engineering/Technology (SET) Building for the Indiana University/Purdue University campus at Indianapolis. A description of this building is included in this section, together with drawings. The University of California has completed a study of the application of ABS to the basic and clinical sciences laboratory of its new medical school at the Davis campus. The significance of this ABS' application to the health sciences is discussed in this section, and schematic drawings are included. Final selection of the demonstration project will be made by the University of California from a list of candidate projects pending funding of its capital outlay program.

L.1.3 The two demonstration projects by Indiana University and the University of California, because of the diverse geographical locations, present a broad spectrum of criteria for the ABS system. A major problem in the development of a building system with nationwide applicability was to provide for this broad spectrum, while including a sufficient number of options appropriate for different situations involving geographical areas where lesser requirements would be indicated.

To illustrate this point, in California the structure must withstand high seismic loading, whereas in Indiana this is not required. In Indiana, high summer humidity and low winter temperatures require greater HVAC capability than in California. The alternative options available in the ABS structure and HVAC subsystems adequately respond to such diverse requirements.

L.1.4 In 1970, the Illinois Building Authority appraised the development of ABS and elected to extend the demonstration by allocating two projects from a list of candidates in Illinois to the effort: a science building for the University of Southern Illinois, and a library building for the University of Illinois. This latter facility could widen the applicability of ABS to the library disciplines. These two projects are awaiting funding in order to proceed.

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L.1.5 The value of the ABS system will be increasingly demonstrated as projects are completed, and data from actual installations are collected and evaluated. Comparisons of ABS demonstration buildings with conventional buildings, such as the six from which the cost/performance data was derived, will provide a unique opportunity to further analyze academic building costs, performance characteristics and building production methods. An expanded information base will provide solid assistance to all interested institutions and should generate additional input from them.

L.2 INDIANA

L.2.1 The initial ABS building in this state will be on the new campus known as the "Indiana University-Purdue University at Indianapolis" (IUPUI). The IUPUI campus will centralize the academic programs conducted for many years by the two universities in widely scattered facilities in Indianapolis. The current enrollment is approximately 17,000 students, and is expected to be 22,000 students by 1975. The ABS demonstration facility will house science, engineering and engineering technology disciplines. With enrollment in these disciplines projected to be 10,000 students in 1980, the required facilities ultimately will involve a half million square feet of floor area, developed through an almost continuous building program.

L.2.2 The IUPUI campus is centrally located on the banks of the White River, near the Indiana State Capitol, and adjacent to the Indiana University Medical Center—as shown on the location plan. The ABS demonstration building is the initial project of an academic superblock, and will be known as the Science/Engineering/Technology (SET) Building.

L.2.3 The space need summary for the initial phase of the SET Building is:

%	DEPARTMENT	TEACHING LABORATORY*	FACULTY OFFICE	FACULTY RESEARCH	CLASS-ROOMS	STUDENT SERVICES	LIBRARY	STORAGE	ASF	OGSF
10.2	Computer Technology	5,400	2,800		1,620	785	420	221	11,246	18,139
12.4	Construction Technology	9,700	2,250		352	692	369	274	13,637	21,995
9.0	Electrical Engineering Technology	5,000	2,400		1,331	650	348	194	9,923	16,004
1.7	Industrial Supervision		650		1,003	128	69	37	1,887	3,044
17.0	Mechanical Engineering Technology	12,950	2,500		1,874	648	347	383	18,702	30,165
11.3	Engineering	4,400	2,500	2,200	2,080	658	351	255	12,444	20,071
6.0	Geology	4,200	950	800	131	332	177	78	6,668	10,755
23.1	Math-Computer Science		8,400		13,356	2,077	1,108	499	25,440	41,032
9.3	Physics	3,300	2,600	2,000	1,280	846	113	185	10,324	16,651
	TOTAL	44,950	25,050	5,000	23,027	6,816	3,302	2,126	110,271	177,856
100%		25.2	14.1	2.8	12.9	3.9	1.9	1.2	62.0	100.0

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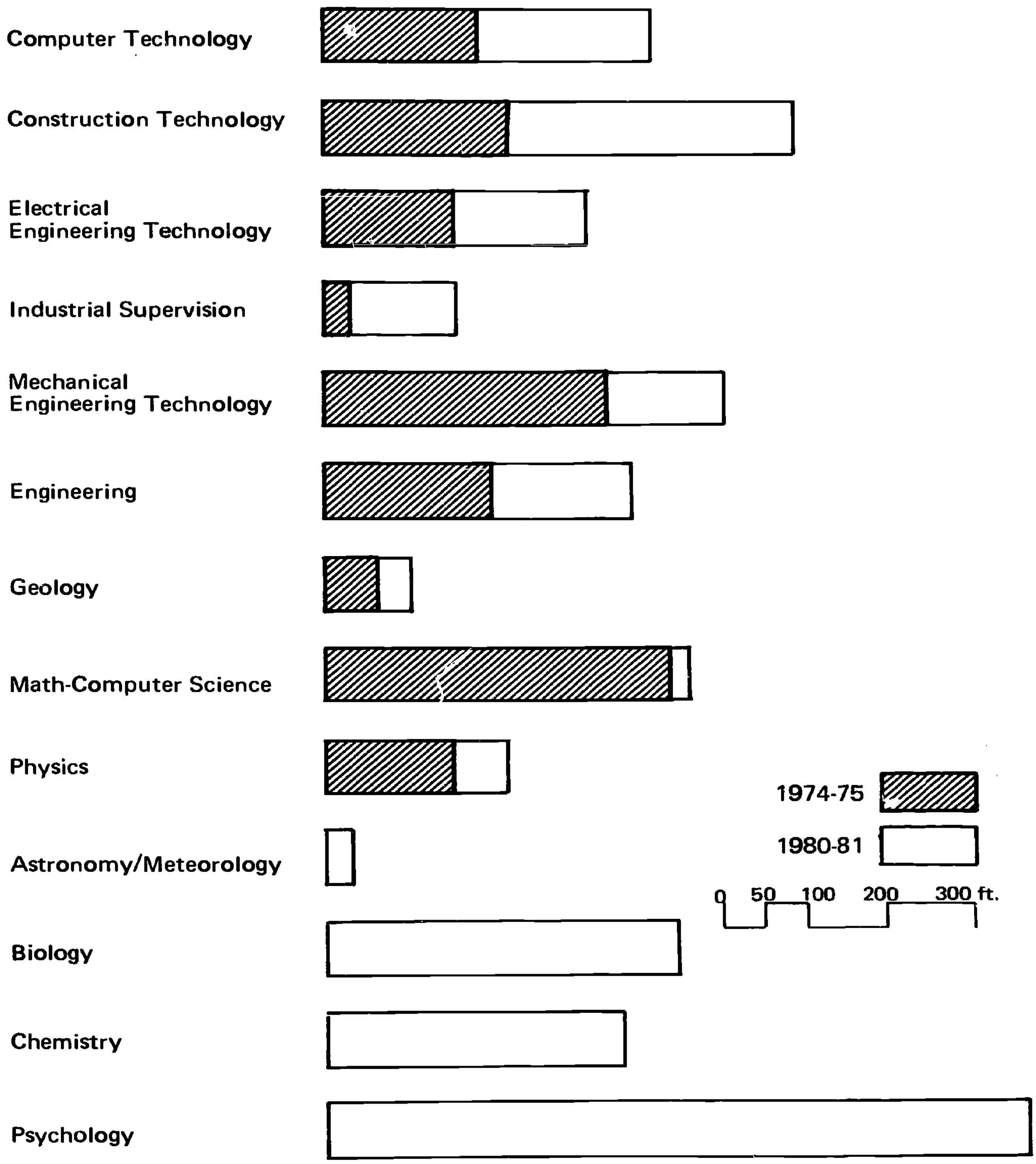
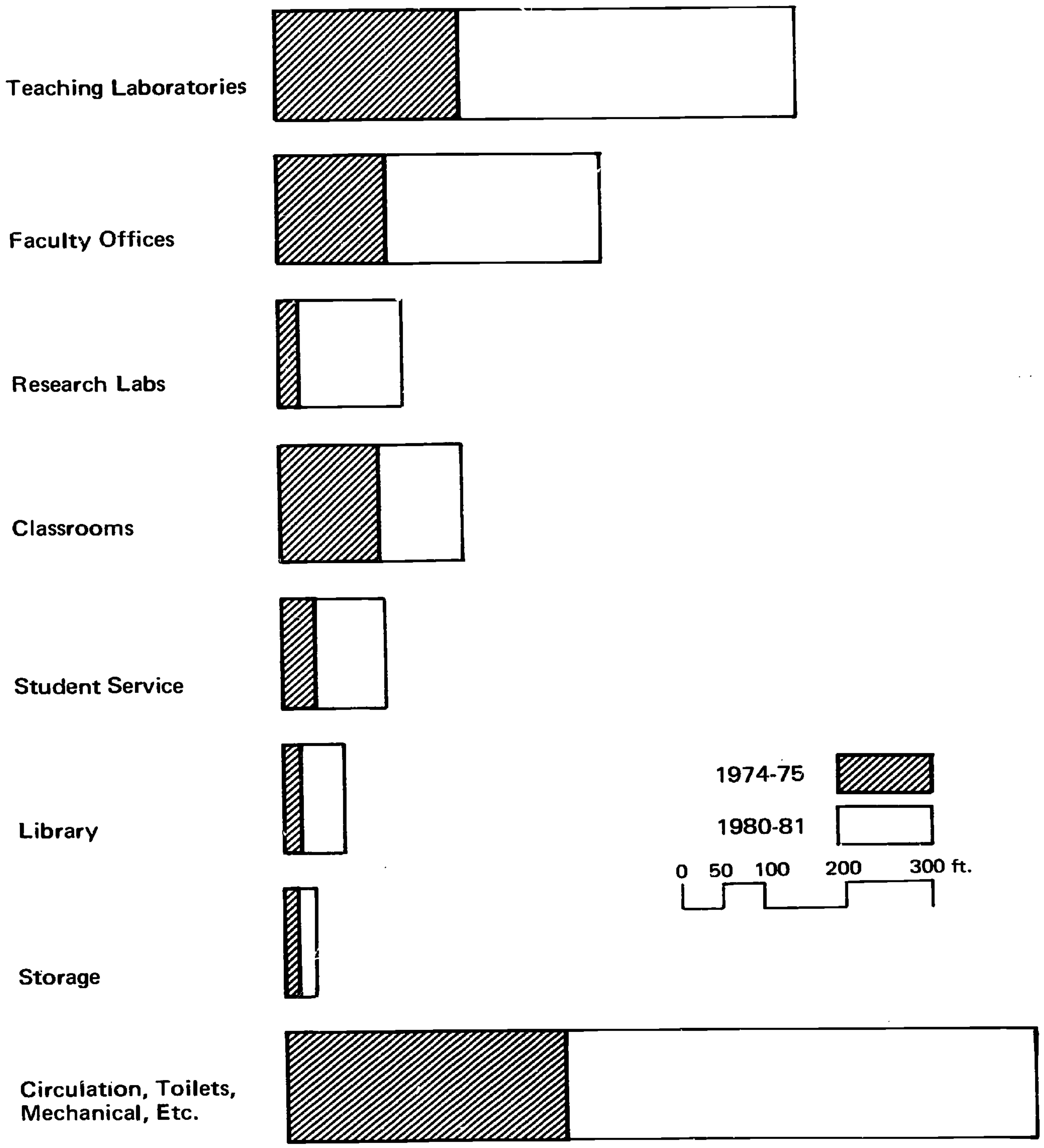
*This column represents each department's share of the total laboratory area; the total represents the amount of laboratory area within the building. Technology departments provide for extensive multi-discipline utilization of laboratories made available by the adaptability of the ABS system.

L.2.4 The space needs by departments within the SET Building are graphically shown below.



L.2.5 The space needs by space type within the SET Building are graphically shown below.



L.2.6 The SET Building design provides two 3-story wings, each wing having two space modules per floor. Deep service space is used throughout to permit initial and future relocation of services and laboratory space as programs change. The service towers, grouped at one end of the wings, with a full basement below, form a vertical service and circulation spine. As additional wings are added to the building, the spine can be extended. Horizontal distribution of service mains from the basement to the base of each service tower provides for rapid building modification and expansion.

The maximum size space module was used to provide: large general space allowing maximum interior configuration adaptability; minimum exterior wall surrounding the enclosed area (to minimize exterior wall costs and HVAC operating costs); and maximum repetition of structural frame.

The exterior design is a direct expression of the concrete structure option selected by the architects. The exterior skin is precast concrete with bolted attachments, permitting building expansion and access to the deep service space.

The schematic design drawings hereafter delineate the project:

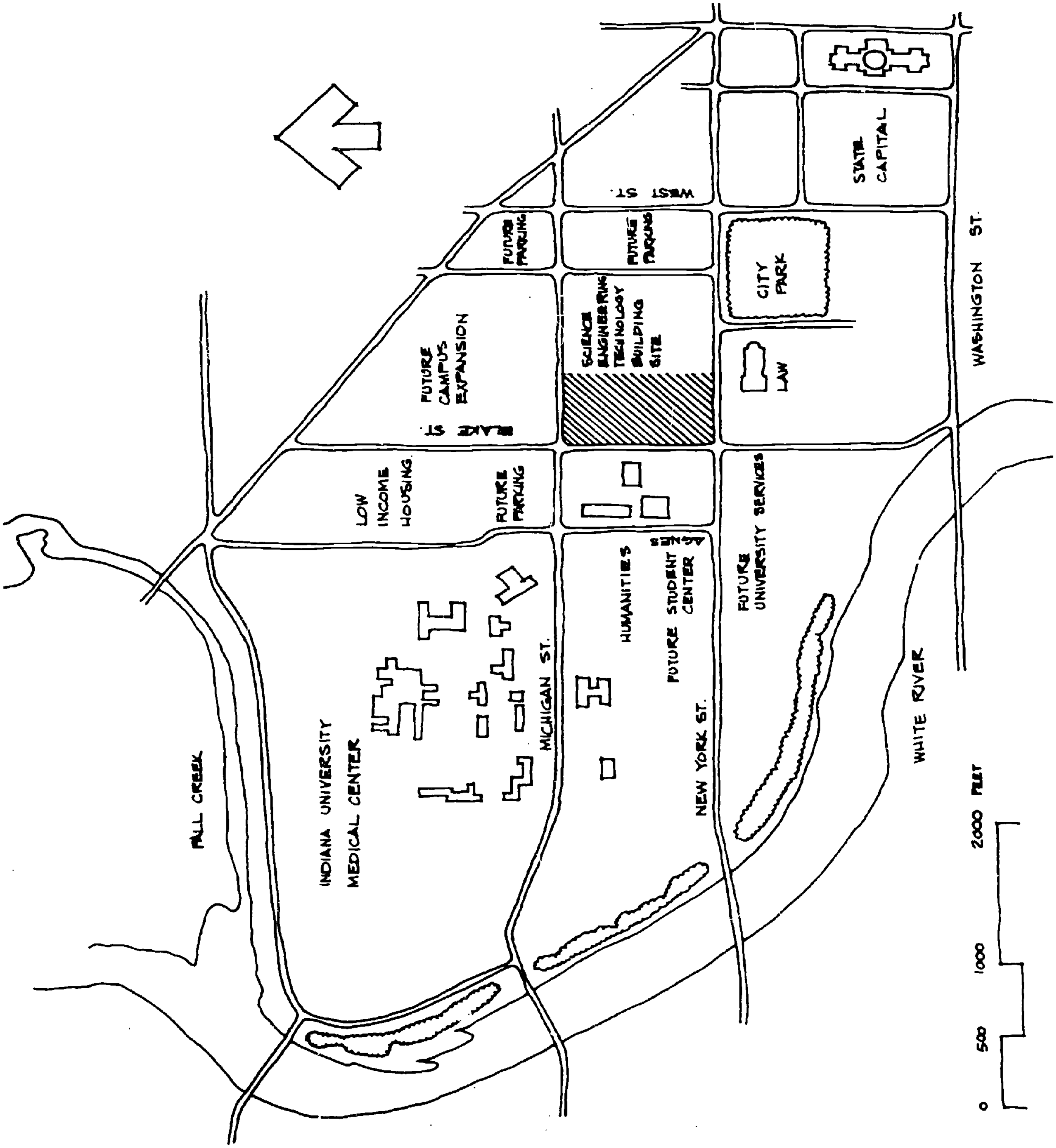
Location Plan
Basement Plan
Floor Plan
Perspective

L.2.7 ABS data and procedures have proven valuable in the user's understanding of his facilities—what they will do for him and what they will cost. For example, users concurred that application of ABS programming data supporting an approximately thirty percent reduction in their original request will not impair academic programs. Also, use of ABS procedures permits a scheduling reduction in total elapsed time of approximately ten months as indicated in the charts following the schematic design drawings.

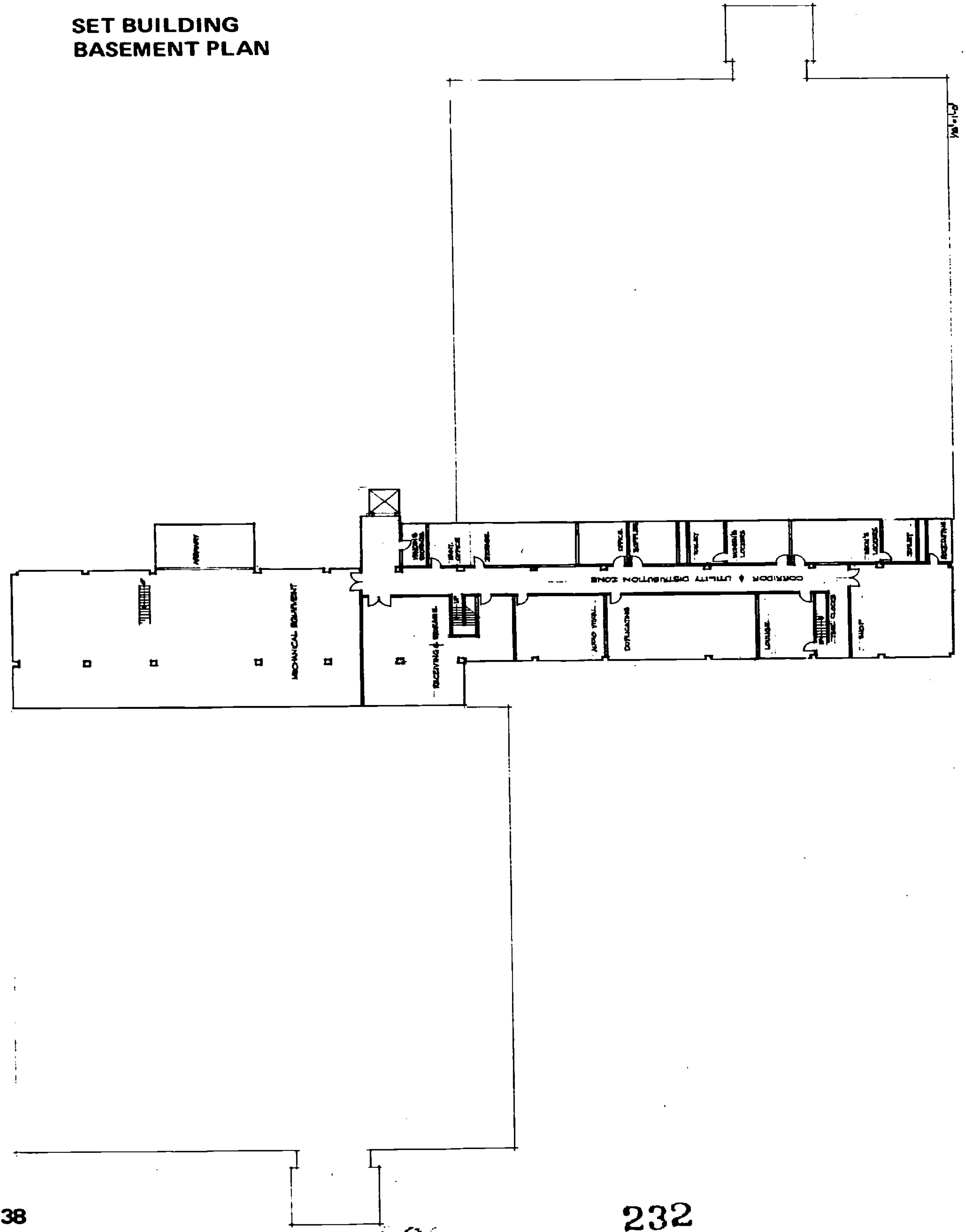
L.2.8 The SET Building design is by a joint venture team of three firms:

Building Systems Development, Inc.; San Francisco
Fleck, Burkart, Shropshire, Boots, Reid & Associates; Indianapolis
James Associates; Indianapolis

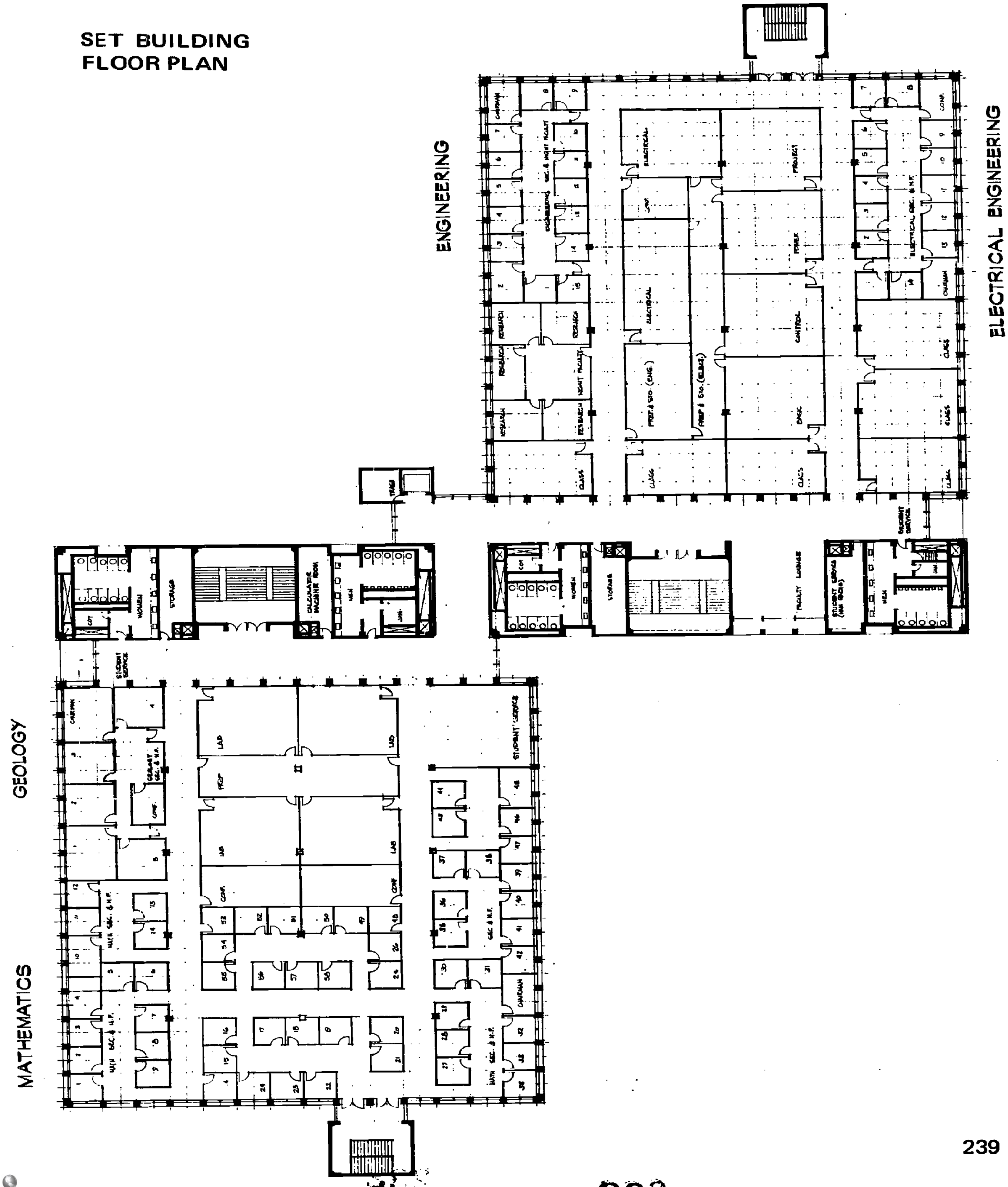
IUPUI CAMPUS



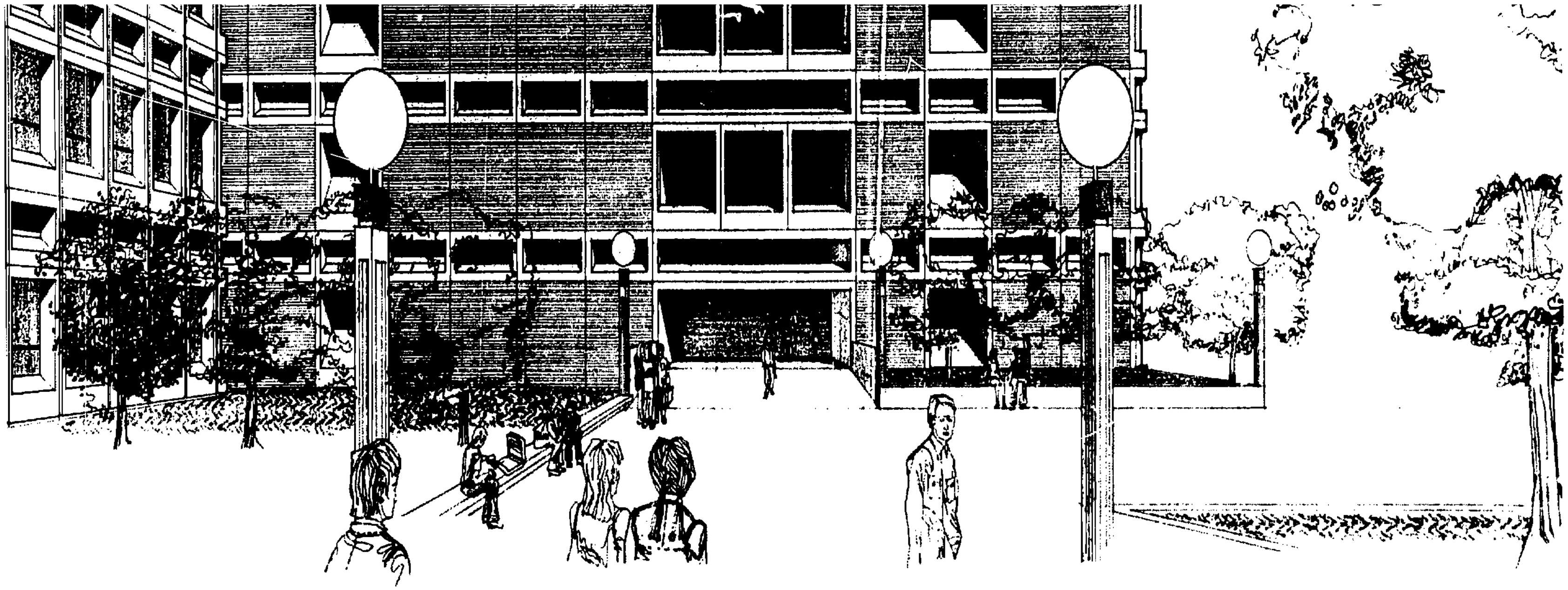
SET BUILDING
BASEMENT PLAN



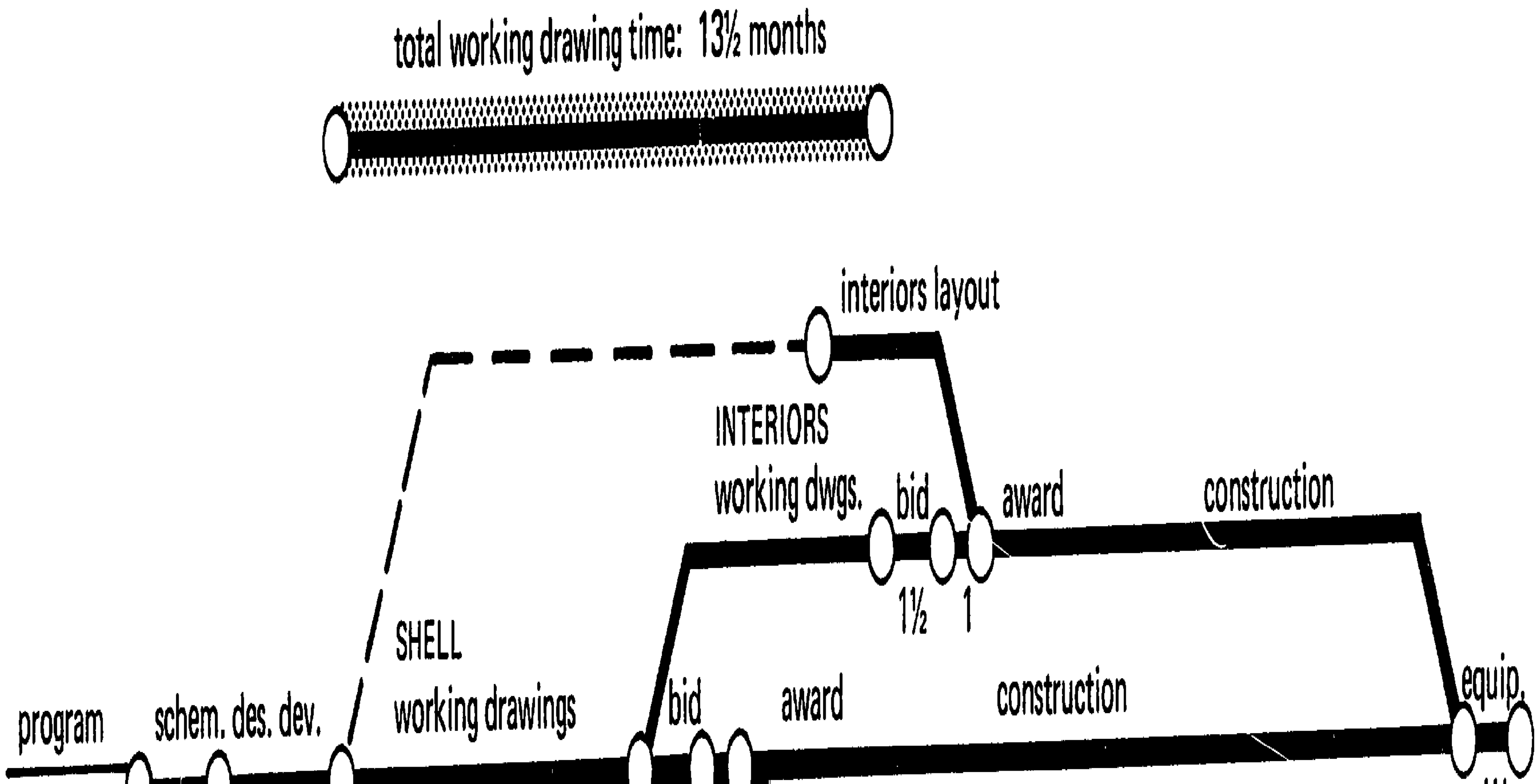
SET BUILDING
FLOOR PLAN

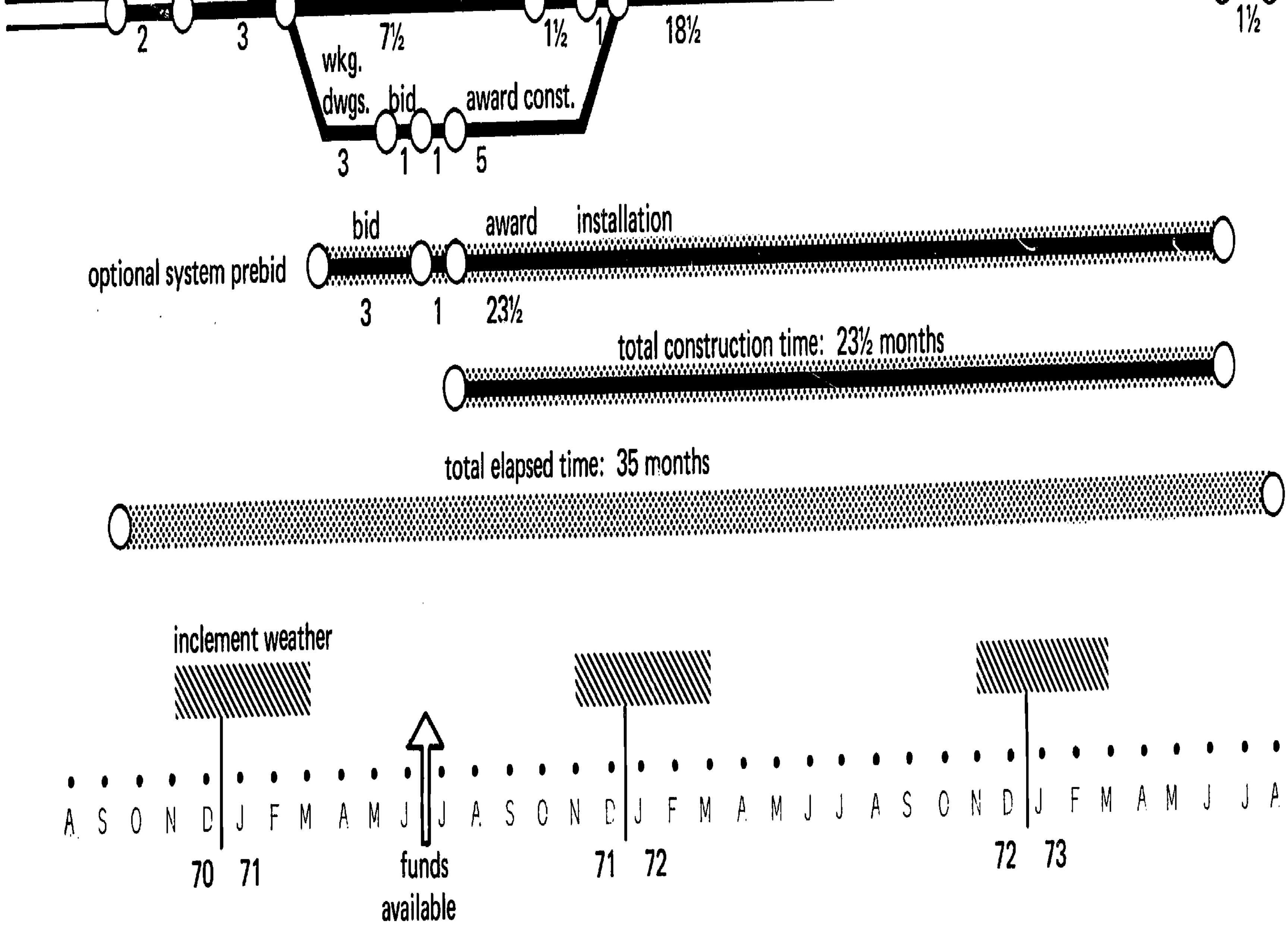


SET BUILDING PERSPECTIVE

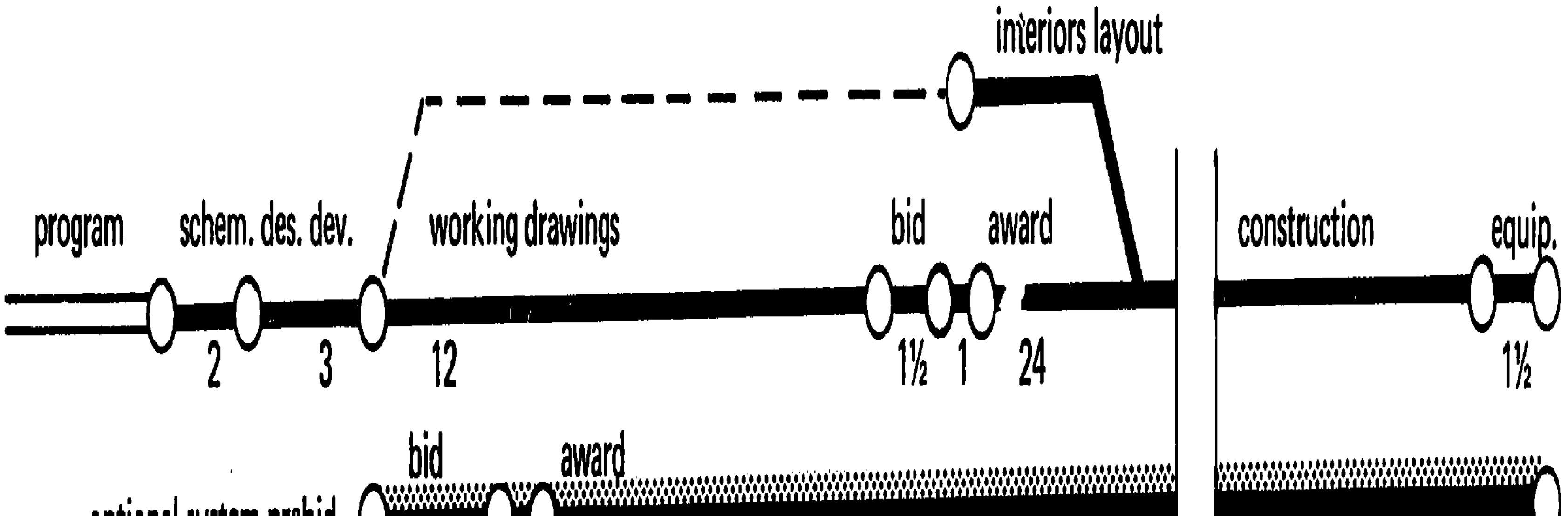


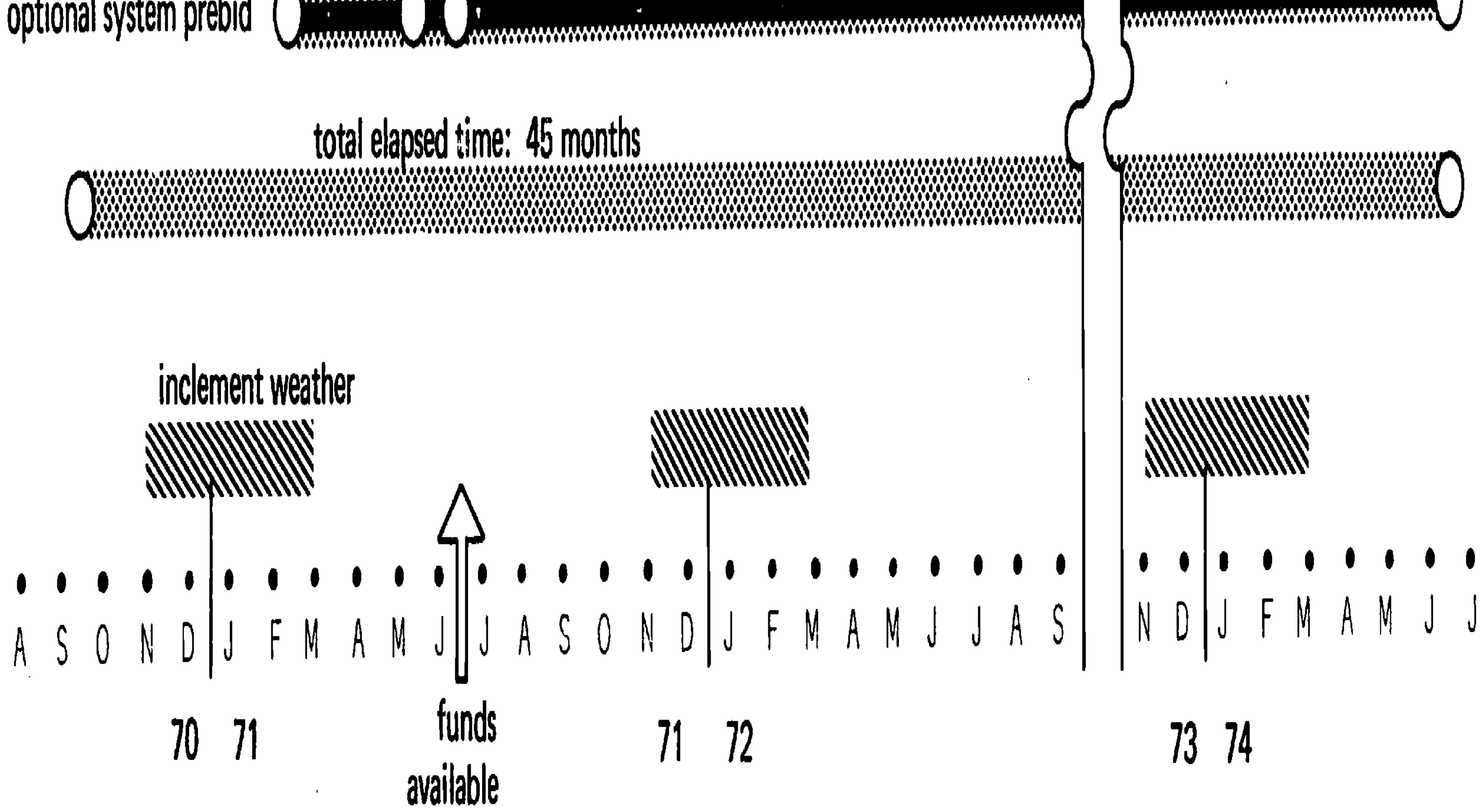
ABS/SET: PHASED DESIGN AND CONSTRUCTION




2
3
7½
1½
1
18½
1½
wkg. dwgs.
bid
award const.
3
1
1
5
optional system prebid
bid
award
installation
3
1
23½
total construction time: 23½ months
total elapsed time: 35 months
inclement weather
A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
70 71
funds available
71 72
72 73

ABS/SET: SCHEDULE 1 CONVENTIONAL




optional system prebid
total elapsed time: 45 months
inclement weather
A S O N D J F M A M J J A S O N D J F M A M J J A S N D J F M A M J J
70 71
funds available
71 72
73 74

L.3 CALIFORNIA

L.3.1 Due to current capital outlay funding limitations in this state, an ABS demonstration building has not yet been selected. One of the candidate projects is the initial building for the basic and clinical sciences of the new medical school at the University of California campus at Davis. The University commissioned an independent appraisal of the ability of the ABS system to accommodate the program for this building project—the appraisal, completed in April 1971, was made by the architectural firm which had previously developed an acceptable design for the building.

L.3.2 The Davis campus, one of nine in the University of California, is situated about twelve miles from Sacramento, the State Capitol. Enrollment is currently about 12,000 students, with a planned growth to about 19,000. Originally devoted to the agricultural sciences, the Davis campus was designated a "general campus" shortly after World War II when the enrollment was less than 2,000 students. Definition of the health sciences program at Davis includes veterinary sciences and the medical sciences joined in a new building complex. Enrollment in the School of Medicine is approximately 310, with a projected enrollment of 1,500 students by 1980.

L.3.3 The ABS system was applied to the building housing the basic and clinical sciences for the new medical school. The space program, in terms of net assignable floor area required for this building is as follows.

NET AREA SUMMATION:

		Sq.Ft.
a. Basement:		
Physical Plant	1,393	
Receiving and Storage	4,270	
Central Instrument Facility	2,497	
Experimental Animal Facility	2,350	
Radioisotope Control Center	1,041	
Constant Environment Facility	1,456	
Electron Microscope Suite	2,322	
Basement Total		15,329
b. First Floor		
Multi Discipline Laboratories	32,600	
Support Facilities—Morgue	2,031	
Support Facilities—Aministration	8,661	
Experimental Animal Facility	2,217	
First Floor Total		45,509

		Sq.Ft.
c. First Floor Mezzanine:		
Experimental Animal Facility		2,450
d. Second Floor:		
Biochemistry	10,544	
Behavioral Science	5,683	
Glassware Facility	900	
Biomedical Communication	7,927	
Pharmacology	8,583	
Physiology	9,719	
Experimental Animal Facility	2,151	
Second Floor Total		47,507
e. Second Floor Mezzanine:		
Experimental Animal Facility		2,151
f. Third Floor:		
Pathology	12,252	
Animal Tissue/Fermenter	563	
Glassware Facility	563	
Anatomy	9,991	
Microbiology	9,603	
Group Facilities	5,975	
Information Science	4,690	
Experimental Animal Research	2,111	
Third Floor Total		45,748
g. Third Floor Mezzanine:		
Experimental Animal Research		2,111
Total Laboratory Building Area		**160,805 sq.ft.**

L.3.4 The Medical Sciences Unit 1 building, as designed in the ABS appraisal, is a massive three-story building using four maximum size space modules on each floor. The building is designed for major expansion, typical of health sciences complexes. The deep service space is used throughout to provide for the particularly high relocation and modification rates anticipated, especially in the medical research laboratories. Services distribution is expected to be near the maximum provided by the ABS system. Those functions and special facilities advantageously located outside the space module are in enlarged service towers grouped at opposite ends of the building. Two stories in the service tower correspond with a single story space module. For example, animal quarters requiring special finishes, extensive waterproofing and drainage are functionally placed in the lower (8'-0") headroom of the service tower.

Just as in Indiana's SET Building, a horizontal distribution of services is from a basement area connecting the service towers. Use of the maximum size space modules provides the large uninterrupted (except for columns) area needed for anticipated, continual changes in space configurations.

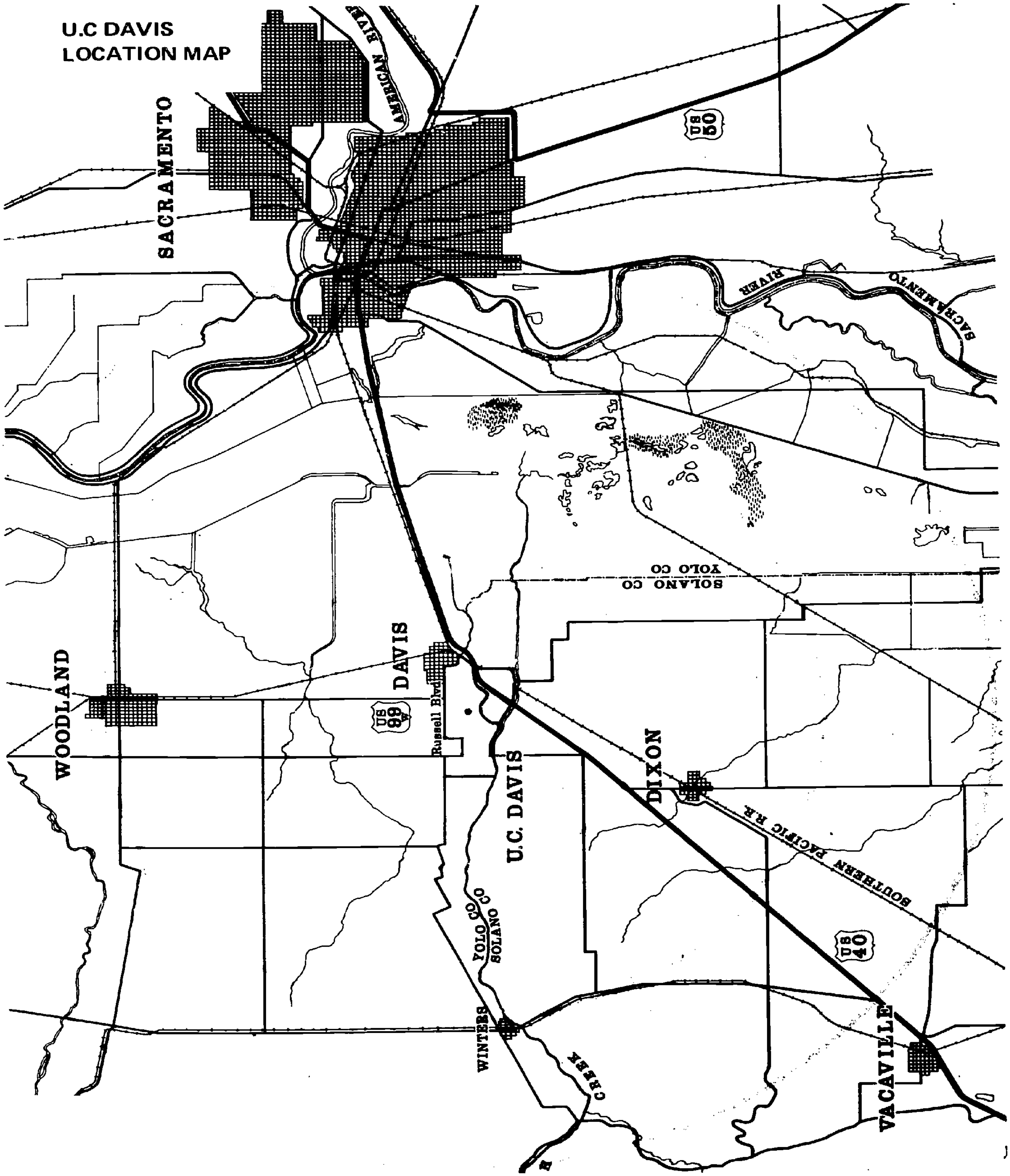
L.3.5 A steel structure was selected in response to the high earthquake risk and the low allowable, soil bearing pressure in this geographical area. The HVAC subsystem provides cooling for hot summers and filtration of dust generated by the agricultural community, but otherwise reflects the comparatively mild California climate. The exterior wall is of removable, aluminum framed glass and steel panels that permit building expansion and access to the deep service space.

L.3.6 The building design is by the architectural firm of Stone, Marraccini and Patterson, of San Francisco.

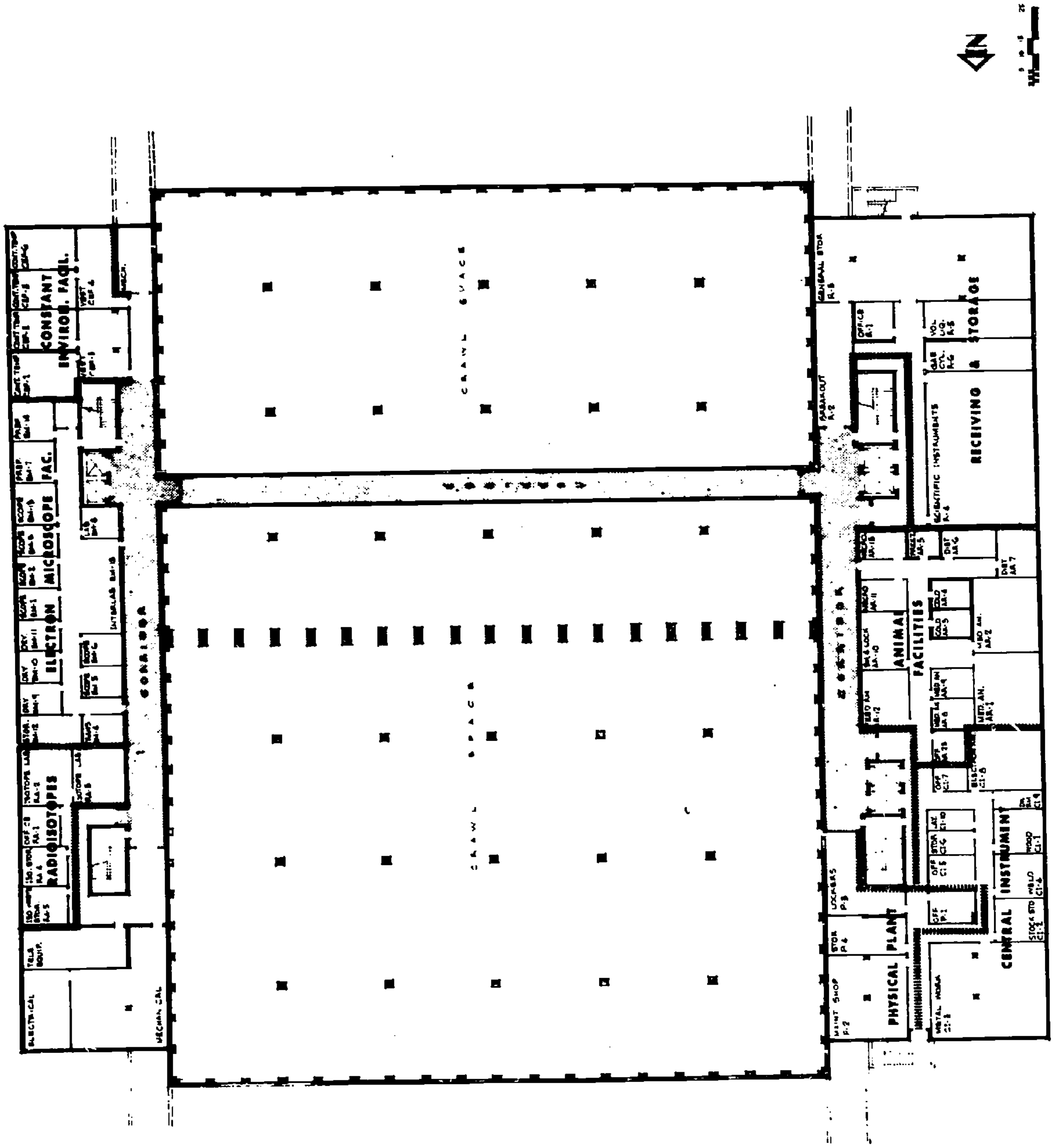
L.3.7 Drawings included are as follows:

Location Plan
Basement Plan
First Floor Plan
First Floor Mezzanine Plan
Building Sections
Expansibility Plan

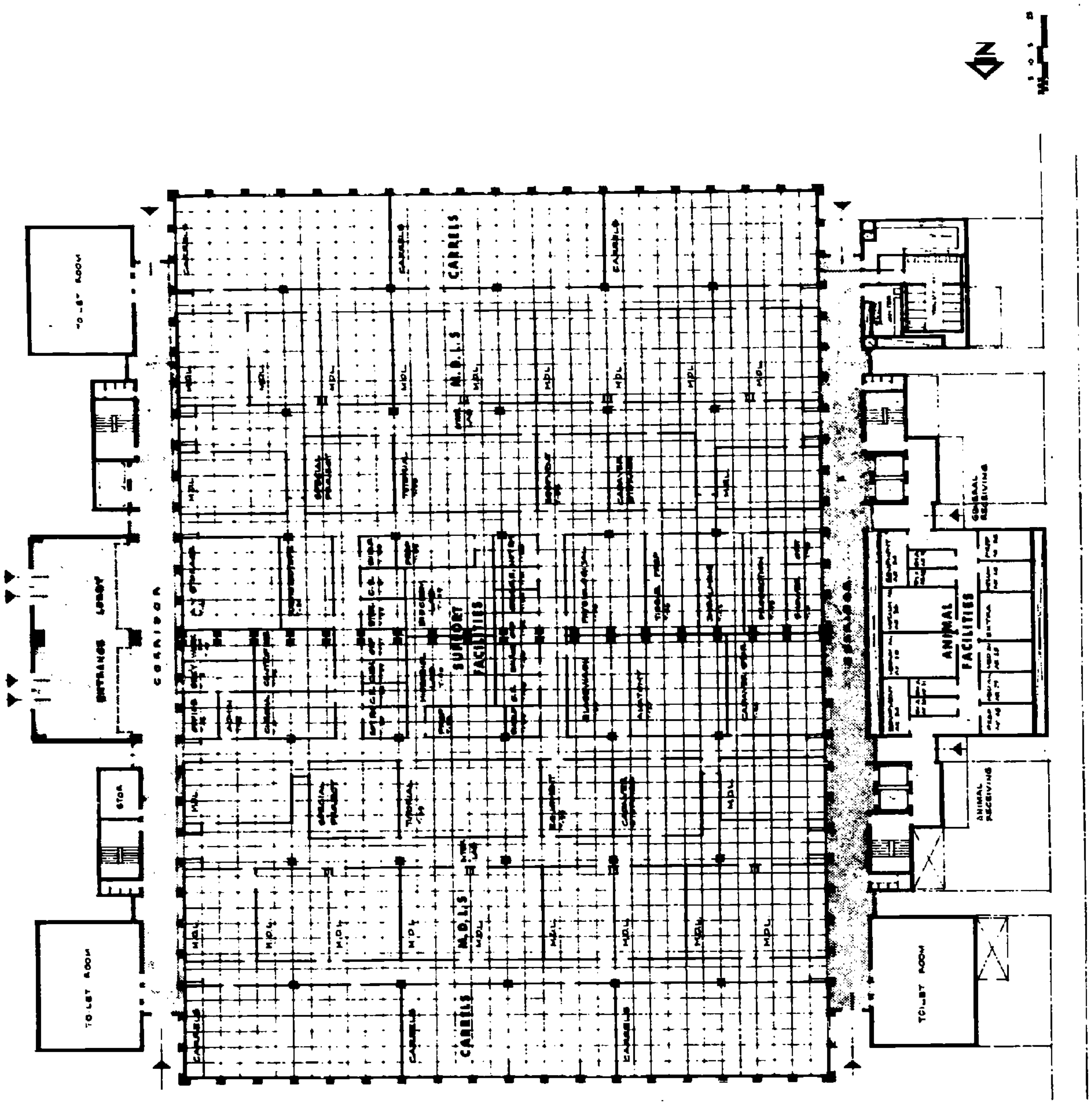
U.C DAVIS LOCATION MAP



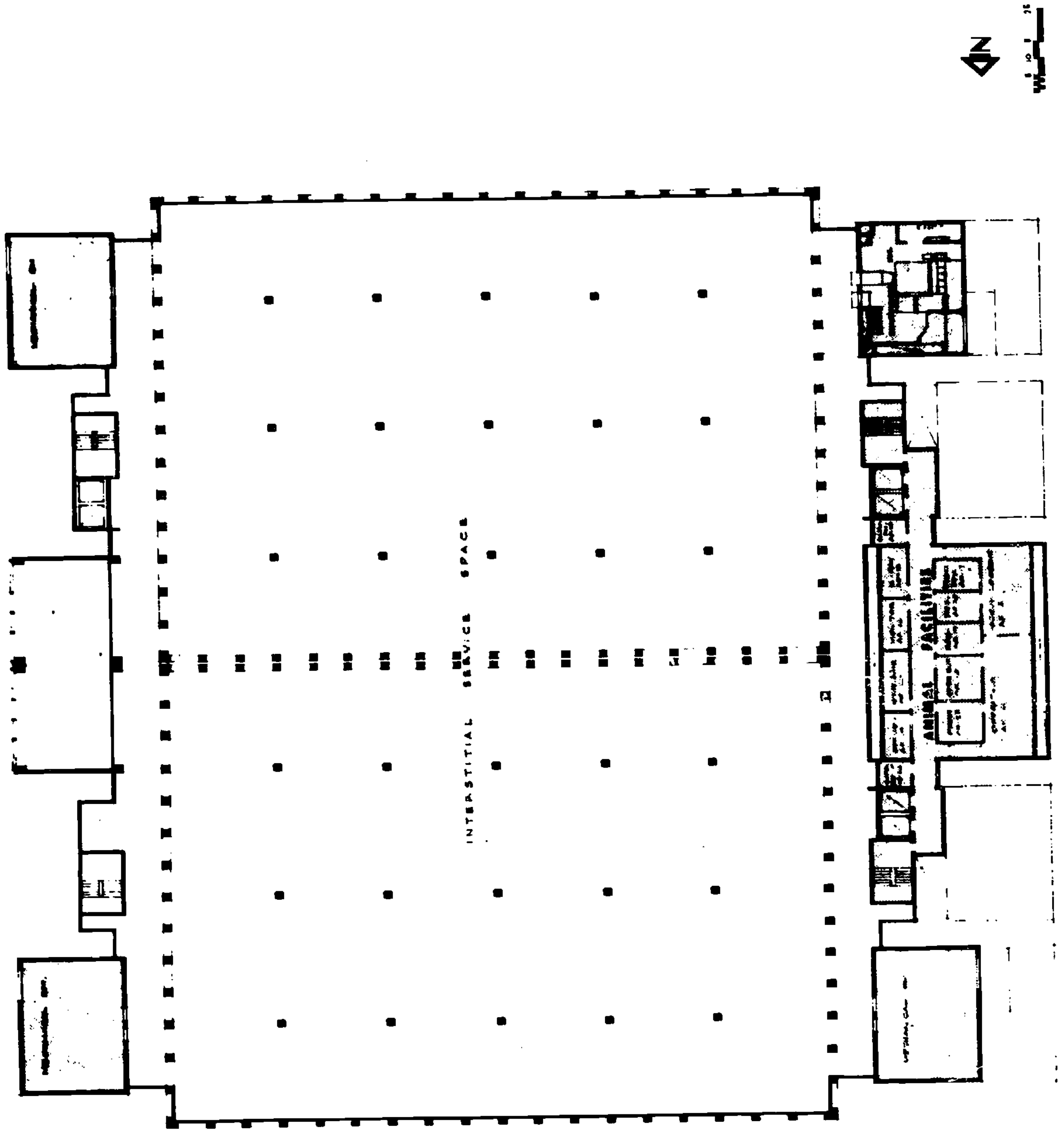
U.C. DAVIS MEDICAL SCIENCES I
BASEMENT PLAN



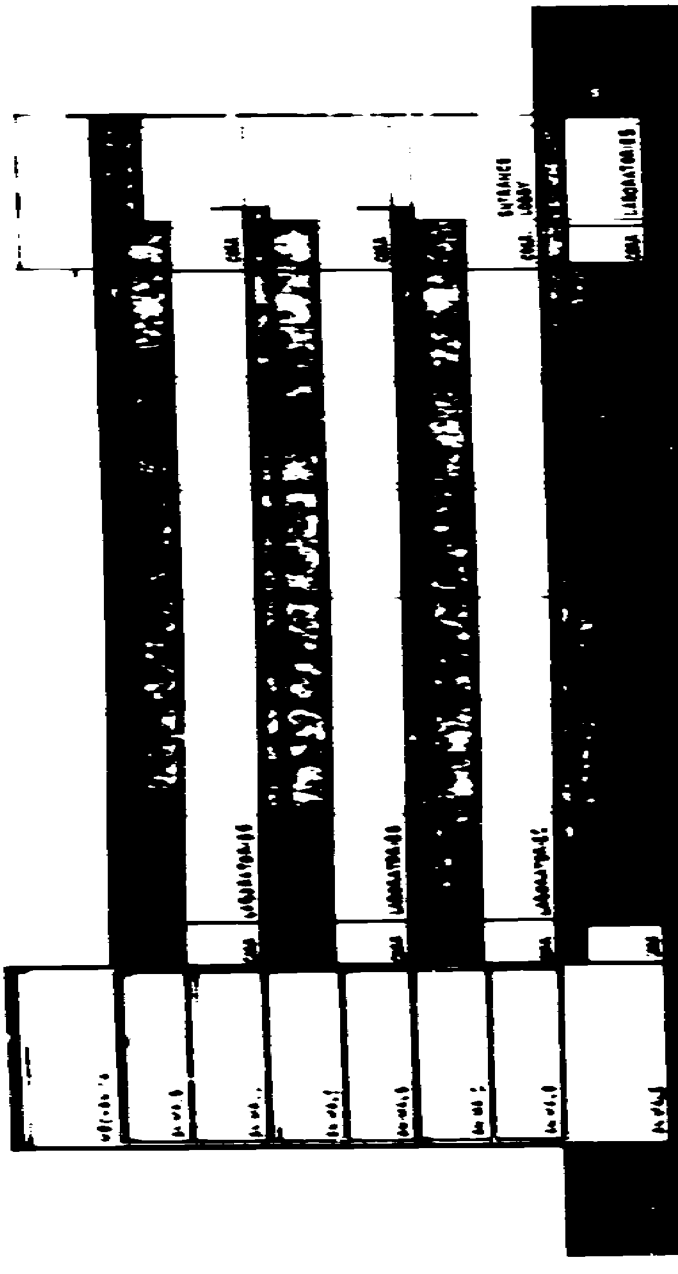
U.C. DAVIS MEDICAL SCIENCES I
FIRST FLOOR PLAN

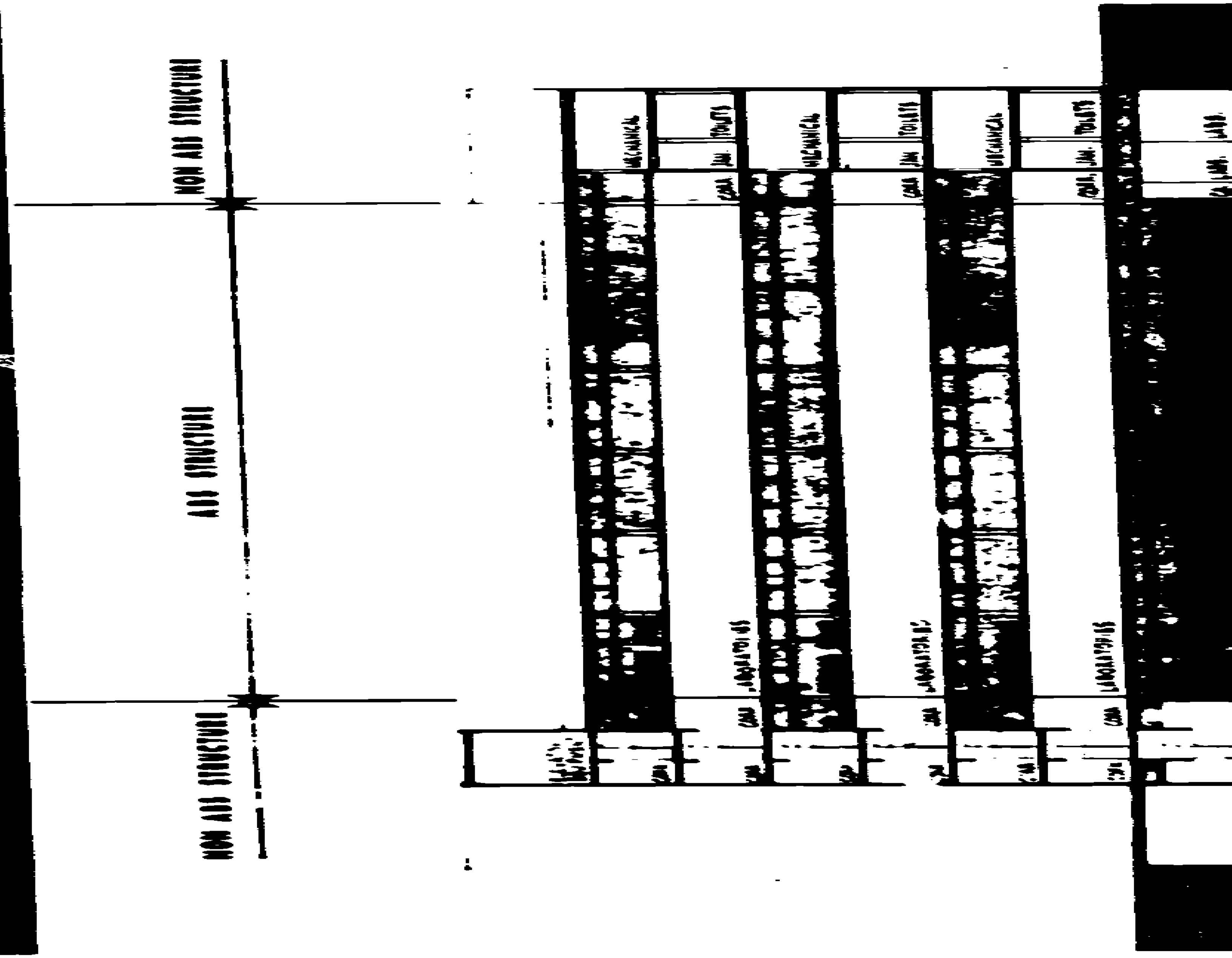


U.C. DAVIS MEDICAL SCIENCES I
FIRST FLOOR MEZZANINE PLAN

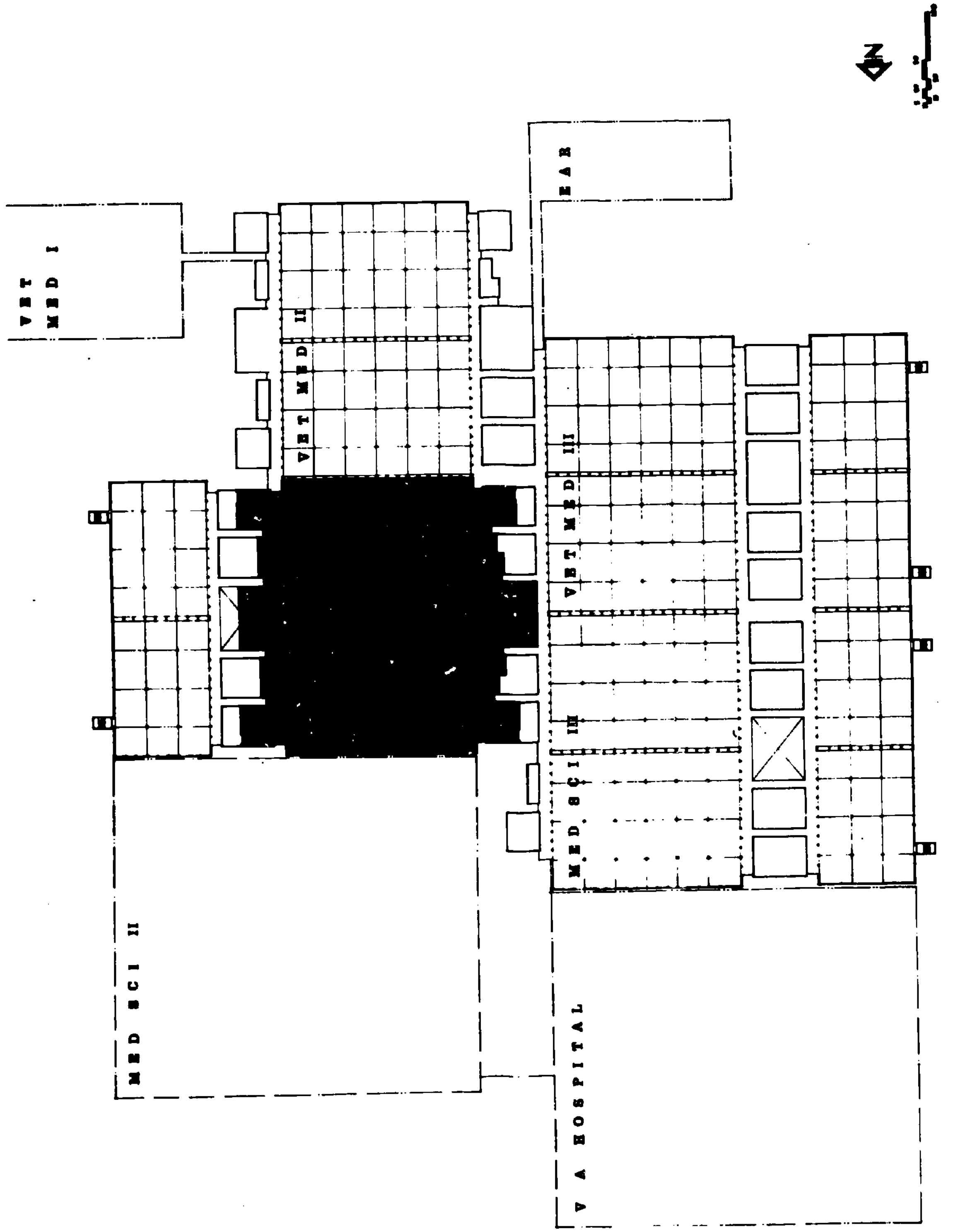


U.C. DAVIS MEDICAL SCIENCES BUILDING SECTIONS




NON ABS STRUCTURE
ABS STRUCTURE
NON ABS STRUCTURE
MECHANICAL
TOILETS
CORR.
JAN.
LABORATORIES
MECHANICAL
TOILETS
CORR.
JAN.
LABORATORIES
MECHANICAL
TOILETS
CORR.
JAN.
LABORATORIES
LABS.

U.C. DAVIS MEDICAL SCIENCES I
EXPANSIBILITY PLAN



L.4 COST COMPARISON

L.4.1 The table following is for the purpose of comparing average costs of the three sample California buildings, the three sample Indiana buildings, two separate estimates of Indiana's SET Building, and an estimate of California's Medical Sciences Unit 1 Building.

L.4.2 All costs have been projected to the Engineering News-Record Construction Cost Index of 1550. However, the cost estimates for the two ABS demonstration buildings were based on schematic design, and therefore are less detailed than the costs for the six existing sample buildings.

L.4.3 The cost variations reflect the differences among the buildings' characteristics, and to an unknown extent, the differing methods of appraising costs by the several estimators involved. In any event, the totals indicate significant construction cost savings attributable to the use of ABS subsystems.

L.4.4 Additional savings anticipated from the use of ABS procedures are not included in this comparison. However, Architects Stone, Marraccini and Patterson estimated that phased design and construction would provide an additional 6% construction cost saving for the Medical Sciences Unit 1 Building.

COST COMPARISON SUMMARY

$/OGSF—all costs projected to ENR Construction Cost Index 1550.

	UC AVERAGE[a]	IU AVERAGE[a]	AVERAGE IU & UC[a]	SET–MBM[b]	SET–BSD[c]	DAVIS MED-SCI–SMP[d]
SYSTEM						
Structure	$ 8.92	$ 6.08	$ 7.50	$ 8.26	$ 6.26	$ e
HVAC	5.43	5.40	5.41	5.17	4.20	4.99
Partitions	3.65	5.67	4.66	2.28	2.38	2.23
Lighting/Ceiling	1.92	1.78	1.85	3.65	4.17	2.49
NON-SYSTEM						
Site, below grade, basement	3.59	2.75	3.17	1.16	2.98	e
HVAC	.13	1.14	.64	1.98	1.19	.00
Partitions	.98	1.31	1.14	1.60	1.13	.56
Plumbing	5.30	3.99	4.65	3.21	3.58	3.07
Electrical	3.61	3.67	3.64	3.28	3.22	2.33
Ceiling	.04	.07	.06	.19	.06	.73
Ext. Skin	4.22	5.20	4.71	2.77	3.00	.89[e]
Elevators	1.02	.48	.76	.15	.39	1.53
Other	2.47	2.81	2.63	1.33	2.68	1.48
General Contractor—O & P	2.34	3.12	2.73	6.32	5.36	4.16
						11.17[e]
TOTAL	$43.62	$43.47	$43.55	$41.35	$40.60	$35.63
Casework	4.74	2.68	3.71	2.98	2.98	2.30
Medical Equipment						2.93
TOTAL	$48.36	$46.15	$47.27	$44.33	$43.58	$40.86

[a] Subsystem equivalent costs as shown in Section D and in ABS Publication No. 2, *Cost/Performance Study: Six Science and Engineering Buildings*, projected from ENR 1300 to ENR 1550.

[b] Cost estimate for Indiana's SET Building, prepared by McKee-Berger-Mansueto of Chicago.

[c] Cost estimate for Indiana's SET building, prepared independently by Building Systems Development, Inc.

[d] Cost estimate for California's Davis Medical Sciences Unit 1 Building, prepared by Architects Stone, Marraccini and Patterson, Inc.

[e] Elements of Structure, Site-Below Grade-Basement, and Exterior Skin = $11.17, not itemized, but included in the total cost.

M.1 THE DEVELOPMENT OF ABS

M.1.1 BACKGROUND

The Academic Building Systems program was initiated in response to the growing concern for the rising life cost of academic buildings, particularly buildings requiring a high degree of maintenance and alteration. The major ABS objective is to provide academic facilities that can accommodate both foreseeable and unanticipated requirements within a realistic cost context. In attaining this objective, a primary goal is to lower the building life cost while maintaining or improving performance. Thus, cost control relates directly to building performance.

M.1.2 HYPOTHESIS

A basic assumption of the ABS program is: an academic building during its useful life span of many decades needs to accommodate many different activities and their built-environment needs. Specifically, the areas of change that most directly affect physical facilities are:

a. Changes in university programs. In current practice, building programs are essentially determined by the requirements of the "first users" who play an immediate role in the initial programming process. As these users (both direct and indirect) change, their requirements are likely to change accordingly.

b. Changes in departments and/or disciplines. Although not predictable, changes in department size or organization can be accommodated by providing generalized space. It not only has the ability to meet the service and area requirements of a specific discipline, but generalized space also has the ability to adapt to changes in activities and methods within the discipline, or to another discipline entirely.

c. Changes in equipment. Evolutionary improvements in equipment used for research, teaching and built-environment control not only affect building services but also space sizes, configurations and circulation. Such changes may be incurred by the daily requirements of an experimental laboratory, or by future developments in teaching and research methods.

In view of present and future funding constraints, treating every academic building requirement with a customized solution is neither necessary, desirable nor feasible. Future academic buildings must be seen as structures capable of accommodating a changing variety of space types and departments. Departments must become accustomed to being tenants rather than owners of buildings. The single department building, or a building for a single discipline, is no longer appropriate to the pace of change on the campus.

M.1.3 SOLUTION

The total process of building production and utilization demands a much higher degree of internal coordination than has been achieved so far. The systems approach was selected as the vehicle for effecting improvements over conventional methods of building production. A major intent of the ABS program has been to develop a means whereby universities can construct areas of generalized space for increasingly changing academic programs, with reasonable confidence that changes in program needs will be accommodate within limited budgets.

M.1.4 METHOD

The design process for a building system differs from the traditional building design process in that although the designers must work with an indeterminate program, they must design to respond to a specific range of requirements. These requirements are determined by inputs from varied sources: tradition, user needs, costs and budgets, building techniques, and user reactions to past experience, to name a few. An academic building system must provide a university or college with options for building programming and design, which will adequately provide for criteria ranging from the most general considerations of departmental organization to the most detailed aspects of building components.

Application of the systems approach in the ABS program involved three main areas of work:

a. A research phase to establish a data base for subsystem development work.

b. A development phase to define the ABS subsystems.

c. A demonstration phase wherein the ABS system is utilized in design and construction of academic buildings.

M.1.5 RESEARCH PHASE

M.1.5.1 The ABS research phase involved four main lines of enquiry:

a. User Requirements. Defined the general nature and range of user requirements for the space types involved.

b. Performance Standards. Established specific standards of performance that ABS subsystems must meet.

c. Cost Base. Established cost targets and cost control mechanisms for the ABS subsystems.

d. Subsystems Options. Conducted studies of existing buildings leading to the establishment of basic concepts and a range of functional relationships and dimensional criteria.

Measurement of both cost and performance for subsystems is based on data from six major academic facilities,[8] selected as typical examples of science and engineering buildings.

a. These buildings were analyzed in depth, using the construction drawings and specifications, visits to each building, and interviews with the users. The documents defined the building design and performance characteristics; the interviews provided an evaluation of building performance in meeting user requirements. The characteristics of each building subsystem were then listed and measured in a form which would permit cost/performance comparisons with ABS subsystems.

b. The consultant, assisted by professional staff of the two universities, conducted a series of user studies to establish the range of activities and user requirements for which the ABS system must provide. Of prime concern in the data collection was the general nature and range of requirements for academic buildings—those built-environment requirements basic to learning, teaching and research activities.

c. Data collection covered a spectrum of space types and disciplines, but with primary emphasis on science and engineering. To provide testimony to current needs and reactions to existing facilities, users of the buildings and other academicians were interviewed in depth. In addition, a series of background studies explored academic methods and trends that would indicate a different emphasis in the way buildings may have to meet the needs of future users. The studies provided insight into the attributes and functions of the university as a complex social system of aims, values and personal relationships and validated a basic assumption of the ABS program: users of academic buildings have common attributes and environmental needs generated by similar activities, irrespective of status (faculty, staff or student), geographic location or discipline.

d. The user studies are summarized in ABS publication 1: *"Environmental Study: Science and Engineering Buildings."*

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[8] The six sample buildings are:
Jordan Hall, Indiana University, Bloomington, Indiana
Krannert Hall, Indiana University and Purdue University, Indianapolis
Civil Engineering Building, Purdue University, Lafayette, Indiana
Biological Sciences Unit 3, University of California, Davis, California
Natural Sciences Unit 1, University of California, Irvine, California
Bio-Sciences Unit 2, University of California, Santa Barbara, California

M.1.5.3 Development of System Options

Several stages were involved in the translation of the user, building, and cost data into performance criteria and options for the ABS system. In the translation, requirements were developed and expressed in several different ways:

a. Technical Criteria. User requirements are translated from everyday expressions into technical terms.

b. Space Types. Technically expressed requirements were related to space types.

c. Academic Methods. Changing teaching and research methods were analyzed in terms of new demands on support facilities.

d. Existing Facilities Analysis. Existing facilities were analyzed as to how well they support activities in terms of the performance characteristics of subsystems.

e. User Reactions. Expressions of satisfaction or dissatisfaction with present facilities were organized as they pertain to building elements.

f. Responsive Criteria Notes. All preceding items were comparatively summarized to formulate a preliminary recommendation of performance.

g. Cost. Studies of costs and subsystems performance in existing facilities included the costs of functional areas and of adaptability.

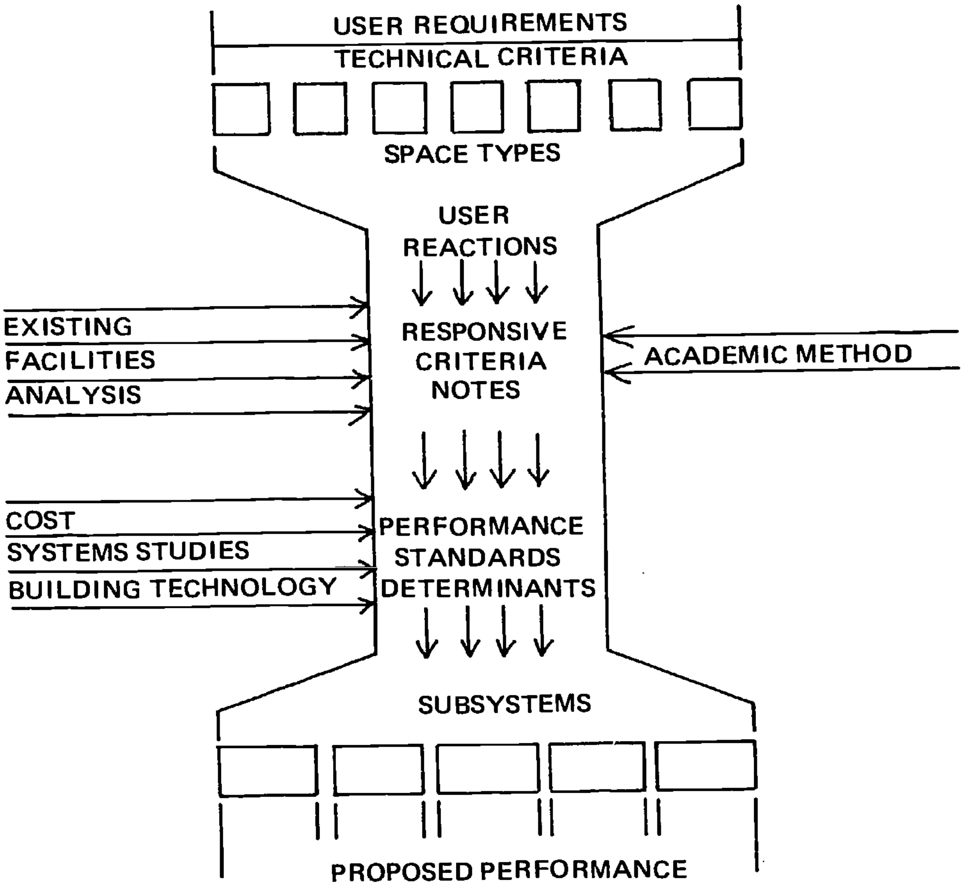
h. Systems Studies. The design requirements for coordinated building subsystems and building configuration and adaptability were examined.

i. Building Technology: The general building process was considered in terms of product availability, trade requirements, and code requirements.

j. Performance Standards Determinants. Preliminary performance recommendations were compared with compatibility and technological factors in formulating judgements about effective levels of performance.

k. Subsystems Proposed Performance. Conclusions from the foregoing studies—user requirements, translated into technical terms, subjected to tests from existing building practice and economics, considered against cost limitations and the range of choices open to user and designer—were presented as performance requirements for the ABS system.

Relationships among these stages are illustrated in the following diagram:



M.1.5.4 The analyses of the existing facilities, cost, and performance data for each of the six sample buildings were organized in the following sequence:

a. Existing facilities subsystems were described and analyzed comparatively along with user reactions.

b. Performance characteristics and unit costs for each subsystem were established and the cost/performance relationship of each was analyzed. This organization permitted comparisons between subsystems, or consideration of a package of subsystems, or the performance range of a building. The packages provide a cost/performance base for existing facilities against which the ABS subsystems, or others, may be evaluated.

M.1.6 DEVELOPMENT PHASE

M.1.6.1 In order to structure a building responsive to present functional and economic needs, the consultant conducted the following studies:

a. An adaptability study examined the effect of programmatic, disciplinary and equipment changes upon the building and service subsystems for the development of realistic guidelines for adaptability.

b. A configuration and module study established general use, circulation and service patterns, forms of incremental growth and dimensional criteria for space and planning.

c. A subsystems alternatives study, presented a broad range of solutions for subsystems, showing how design decisions narrow the range of useful alternatives. These decisions related primarily to organizing services to permit required growth and change.

M.1.6.2 Findings from the existing facilities analyses and systems studies provided the basis for final determination of the ABS subsystems. The following characteristics were sought:

a. Subsystems with a high percentage of the total construction cost, to permit maximum control of the building expenditure. Those chosen represent from 38% to 56% of the total cost of the existing buildings analyzed.

b. Subsystems with commercially available components of acceptable quality.

c. Subsystems in which coordinated design has the potential to reduce overall costs, and improve the total building environment.

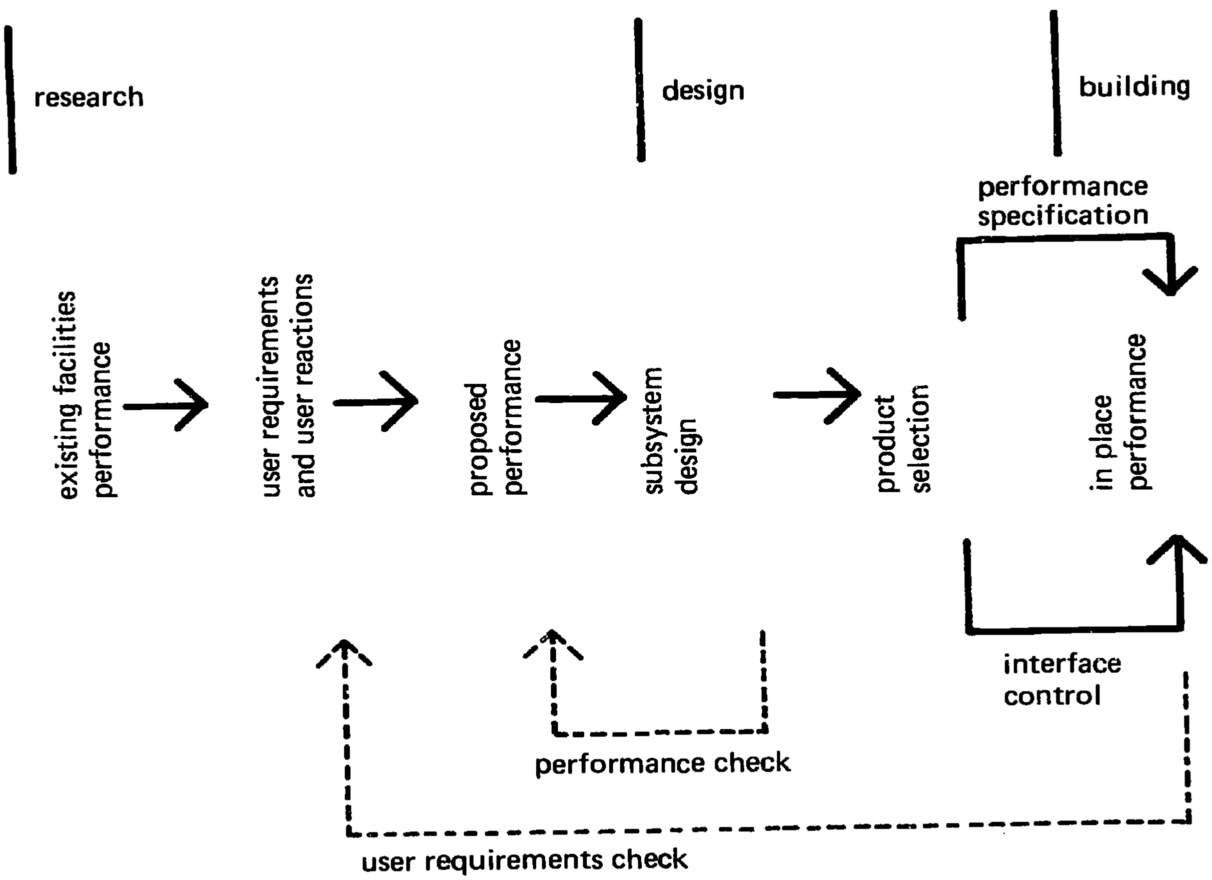
d. Subsystems that are on the construction critical path to permit more effective control of the building process.

e. Subsystems that will not result in design restraints unacceptable to either the direct or indirect users.

M.1.7 THE ABS SYSTEM

M.1.7.1 The connection between systems studies, cost/performance analyses of existing facilities and user studies is illustrated below. The strength of the ABS system lies in these connections between study stages and the over-riding emphasis on cost/performance in all stages.

PERFORMANCE CONTROL – STAGES OF PROCESS AND CONNECTIONS



M.1.7.2 A set of planning concepts were developed along with the subsystems criteria to assist the ABS user in arriving at an early design configuration. The space module, as the principal planning concept, provides broad generalized space; fixed elements, such as toilet and mechanical rooms, are on the building periphery—outside the space module. The space module fulfills an important user requirement for complex research laboratories; it is an adaptable space with potential for a variety of configurations and layouts as teaching and research needs change.

M.1.7.3 A study testing the applicability of the ABS system to actual conditions encompassed four areas:

a. The proposed subsystems were tested against comparable levels of performance in the six sample buildings, and then checked against the user requirements.

b. Planning implications of the space module were examined in terms of generic configurations, applicability to many existing building types, and growth pattern alternatives.

c. The ABS subsystems were tested for adaptability and cost of change, using a two-stage model.

d. ABS costs were evaluated and compared with existing facility costs, all at the same base.

M.2 STRUCTURE/SERVICE CONCEPTS CONSIDERED BY ABS

M.2.1 A basic decision in the development of ABS was the determination of an organizing concept for structure/services that would best accommodate the architectural design work, permit repetition in construction, and simplify subsequent expansion and alteration whether vertically or horizontally. In the user survey, adaptability emerged as the most critical of all aspects of building performance needing improvement. The adaptability of the structure/service relationship is important, not only because of stated user needs and cost considerations, but also because of the rapid rate at which technological, academic and administrative obsolescence can overtake any design configuration, no matter how carefully planned. Obsolescence becomes most acute in laboratory spaces—as distinguished from other academic space types—primarily because of the diverse and exntesive services required. Alterations to the services, consistently the most costly part of modifications in academic buildings, closely relate to the interface among structure, utilities, HVAC, partitions and lighting-ceiling subsystems. All share parallel requirements for adaptability, as all are related by physical contact or proximity.

M.2.2 In establishing the ABS utilities distribution relationship to structure, degrees of performance were considered. Whereas design for current conditions only often proves to be serious under-design for the future, highly redundant or over-designed subsystems are not necessarily implied as the answer. Far more feasible and less costly is sufficient service space providing for future changes and additions, if coordinated with all other subsystems involved.

M.2.3 In existing buildings, in general, the structure/service design found in any one laboratory was reasonably logical and efficient, and was defensible as an isolated, static solution to a defined problem. However, in the context of change, most structure/service solutions were lacking in some aspect of the design of any one subsystem and in coordination with the other subsystems.

M.2.3.1 In the conventional and unconventional laboratories examined, services had been installed according to traditional practices. That is, the engineer prepared working drawings, supplemented in some cases with exact layouts or shop drawings. During installation, subcontractors were often required to improvise considerably in order to fit piping, ductwork and equipment into the allotted space. As work progressed, each succeeding subcontractor was faced with the progressively difficult task of winding his lines over, around, under and through the others already installed. Thus, innumerable ad hoc penetrations of structure and enclosure elements occurred.

M.2.3.2 In the complexes visited, service installations generally had the following disadvantages:

a. Installation cost was high. Labor time for cutting and fitting was excessive.

b. Distribution lines were often difficult to locate for maintenance or alteration.

c. Components in service spaces blocked access to others, causing maintenance problems.

M.2.3.3 Cost studies indicated that the combined cost of structure and services are one-half the construction cost of a building, while services alone account for one-quarter to one-half the costs of alteration. Costs for services addition are higher than for modification, because the former entails large scale building disruption. As alterations to the services are consistently costly, service routes must be considered in conjunction with all decisions for subsystems.

M.2.4 ABS performance requirements call for a UBC Type I, fire-resistive building, with structural bay sizes from 20' x 20' to 30' x 40'. The following rules determined the ABS structure:

a. The structure must be simple to construct with nationally used techniques.

b. The structure must be cast-in-place concrete, precast concrete, or steel.

c. The structure must permit rights-of-way for plumbing, electrical, communication, controls, HVAC, computer cables and specialized services.

d. The depth for the horizontal structure framing and the service space depth must be highly compatible to allow each to be optimally used.

e. Vertical suspension of the ceiling must offer minimum obstruction to services distribution.

M.2.4.1 Feasible horizontal structural alternatives were:

a. Concrete flat plate
b. Concrete waffle slab
c. Concrete slab on shallow beam of either concrete or steel
d. Shallow steel truss
e. Deep steel truss

M.2.4.2 Feasible alternatives for lateral load resistance were:

a. Shear walls
b. Moment resisting frames
c. Perimeter frame

M.2.4.3 Principal reasons for selecting the shallow beam and slab and the perimeter frame were:

a. The concrete flat plate, although within the allowable target cost, was eliminated because the required 12 inch depth provides limited structural stiffness and does not permit easily made drain line relocation.

b. The concrete waffle slab, although economically feasible for the bay sizes required, places all service circulation in a layer below the structure. The cost of the added building height was the eliminating factor.

c. The shallow steel truss was eliminated because of conflicts between truss and services depth, and the cost of fireproofing the truss.

d. Attempts to achieve adaptability in laboratory buildings have utilized 60 to 80 foot structural spans, but the high cost of the required 6 to 8 feet deep truss grossly exceeded the ABS target costs. Although the idea of interstitial space[9] originated in the use of deep trusses that provided service distribution space, the ABS concept differs in utilizing shorter spans responding to user requirements and at lower cost. It was noted that deep trusses can be impediments to service runs—particularly the large HVAC ducts, and fireproofing of steel trusses is expensive. The less inhibiting Vierendeel truss is even more expensive.

e. The perimeter frame was chosen to resist lateral forces—seismic or wind—and was considered the most economical solution to the performance requirements. In general, a conventional moment-resisting frame with columns at the corners of the structural bays only, is more expensive than a perimeter frame. Although the perimeter frame costs about the same as shear walls, it is must less restrictive for interior planning and exterior wall design.

M.2.5 The number of feasible geometric relationships between structure and services distribution is limited.

M.2.5.1 Four alternatives for relating *horizontal* services to horizontal structure are:

a. Services moving horizontally below the structure.
b. Services moving around the perimeter of the building.
c. Services moving between structural members.
d. Services within a structure permitting freedom of movement in two horizontal directions.

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[9] Laboratory buildings using this concept, visited and studied by the ABS team, included:
Salk Laboratory, La Jolla (concrete Vierendeel trusses)
Veterans Hospital, San Diego (fireproofed steel trusses)
Hospital, Santa Cruz (concrete trusses)
McMasters Medical Center, Toronto, Canada (fireproofed steel trusses)
Greenwich Hospital, London, England (composite steel and concrete trusses)
Loughborough University, England (precast concrete trusses)

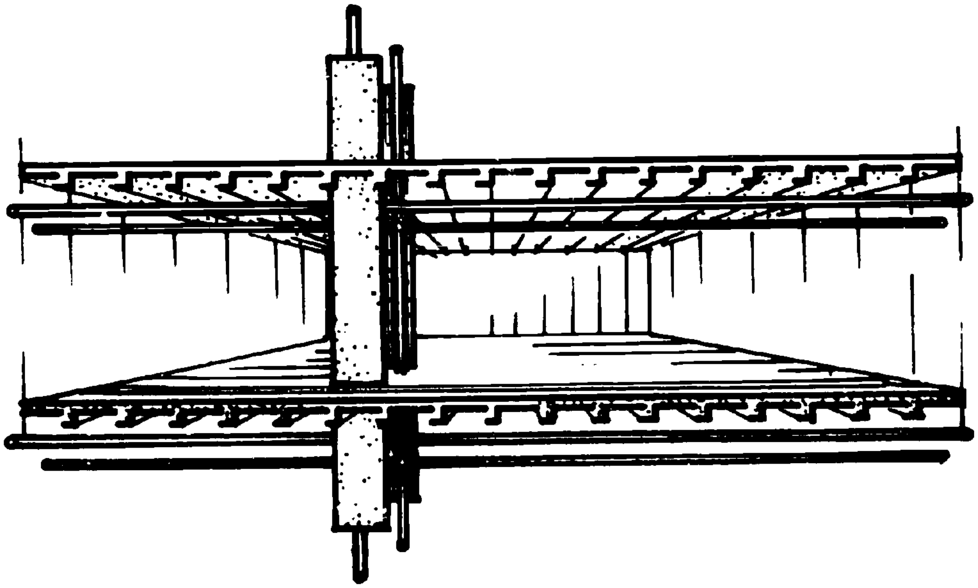
M.2.5.2 Five alternatives for *vertical* movement of services are:

a. Concentrated shafts on the perimeter of the building.
b. Concentrated shafts inside the building.
c. Dispersed vertical shafts inside the building.
d. Vertical walls of services inside the building.
e. Vertical walls of services on the perimeter of the building.

These may or may not directly relate to vertical structure; as structural alternatives they have definite implications for vertical and horizontal movements. Some vertical and horizontal combinations are not workable; for example, an interior shaft of services cannot easily connect to a horizontal perimeter movement.

M.2.5.3 The most useful structural conditions are combinations of the following:

a. VERTICAL INTERIOR SHAFT
Horizontal Below Structure

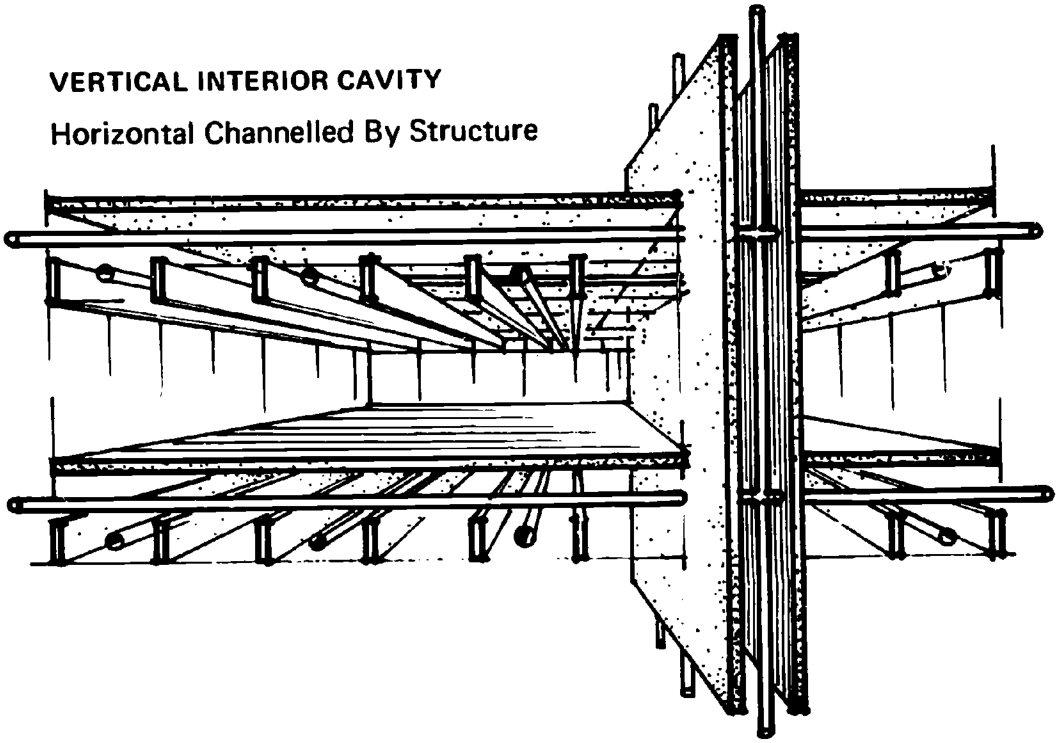


HORIZONTAL:
Entirely below structure

VERTICAL
Perimeter shafts
Interior shafts
Dispersed verticals
Interior cavity
Perimeter cavity

a. **VERTICAL INTERIOR CAVITY**

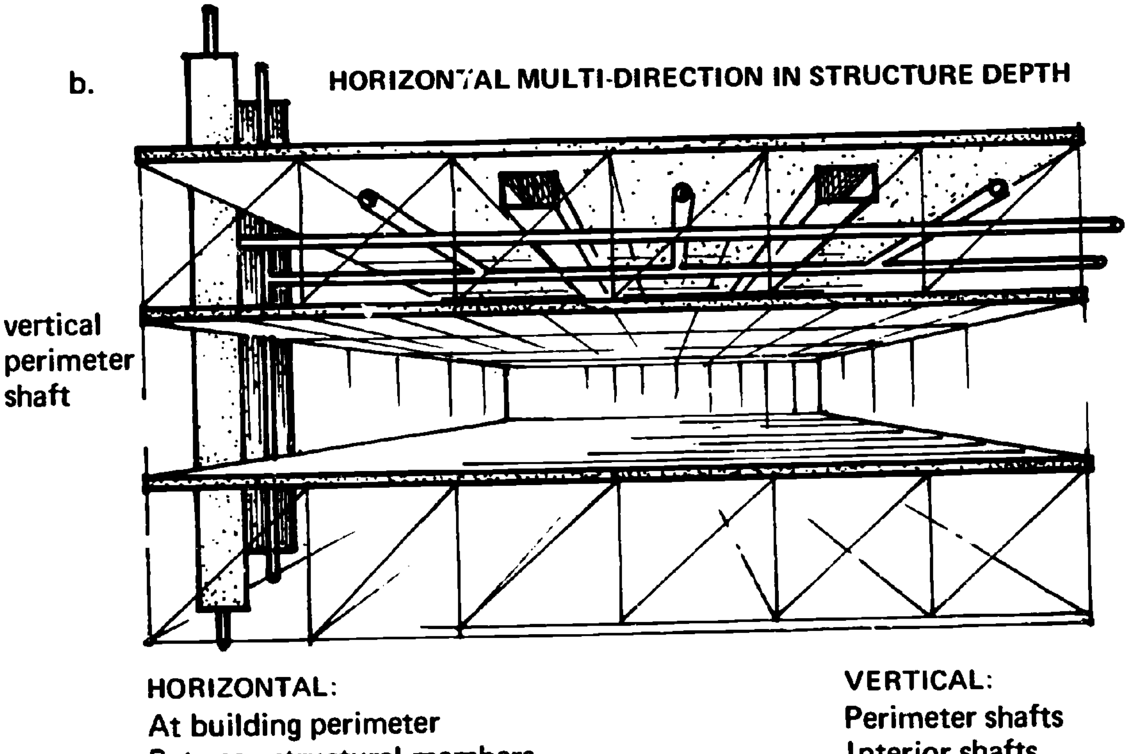
Horizontal Channelled By Structure



HORIZONTAL:
Multi-directional within structural depth

VERTICAL:
Perimeter shafts
Interior shafts
Interior cavity
Perimeter cavity

b. **HORIZONTAL MULTI-DIRECTION IN STRUCTURE DEPTH**



HORIZONTAL:
At building perimeter
Between structural members

VERTICAL:
Perimeter shafts
Interior shafts
Interior cavity
Perimeter cavity

The preceding model (b) relates structure and services both vertically and horizontally. A design decision to use a given model narrows the range of applicable building methods and implies a range of building products or hardware solutions. Conversely, the choice of a particular building method implies a range of products and a limited number of model solutions. A total services distribution pattern consists of combined patterns for different services elements. For example, the structure/services relationship involves utility services and HVAC. Combinations of distribution patterns must be well defined as to compatibility with one another and with structure.

M.2.5.4 Factors of structure/services organization considered but not selected by ABS are summarized below:

a. Vertical wall inside building provides good access to services for installation, maintenance and change; provides vertical shafts near take-off points; but does not solve disruption problems caused by changes in service laterals. Further, the interior core limits possibilities for a range of plan types.

b. Vertical walls of services on the perimeter of the building were rejected because the preference expressed in the user study was for perimeter work stations with an outside window.

M.2.5.5 Selection of vertical shafts of services (service towers) placed on the building perimeter was based on:

a. The space module should be a clear loft of space, ideally penetrated by neither vertical structure nor services, to permit freedom for internal planning and rearrangement of spaces. For this reason, the interior vertical service core, often used in science buildings, was not considered the best solution.

b. External vertical circulation of services may be concentrated to provide maximum wall area for windows.

c. Concentration of vertical shafts in mechanical rooms allows concentration of maintenance activities, and isolates functional units from fire sections and possible sources of smoke migration.

M.2.5.6 If air handling equipment is located in the service space above the ceiling, constraints are:

a. Additional floor-to-floor height is required for equipment and access thereto.

b. Ceiling must be designed for additional loading.

c. Ceiling must be designed for additional noise, vibration and fire safety demands.

d. Large areas of ceiling space (under equipment) would be inaccessible for utility drops of HVAC terminals. This would substantially reduce planning alternatives.

e. Major space renovation or relocation, removal and repairs of equipment would be difficult and costly.

The above disadvantages outweigh the cost disadvantage incurred by increased floor area for the separate mechanical rooms in the service tower.

M.2.6 UTILITIES DISTRIBUTION

M.2.6.1 ABS considered the use of horizontal drain lines run in channels in the floor, with easily removable covers. Although drains can be added or moved without disturbing the rooms below, adjacent spaces are disrupted by changes in service laterals, the channels restrict bench and drain locations, covers add to costs, and the structure required is complex and expensive.

M.2.6.2 Service zones on alternate floors were also considered for ABS.

a. The advantages are that overall building height is somewhat reduced, as is the need for horizontal runs of piping and conduit.

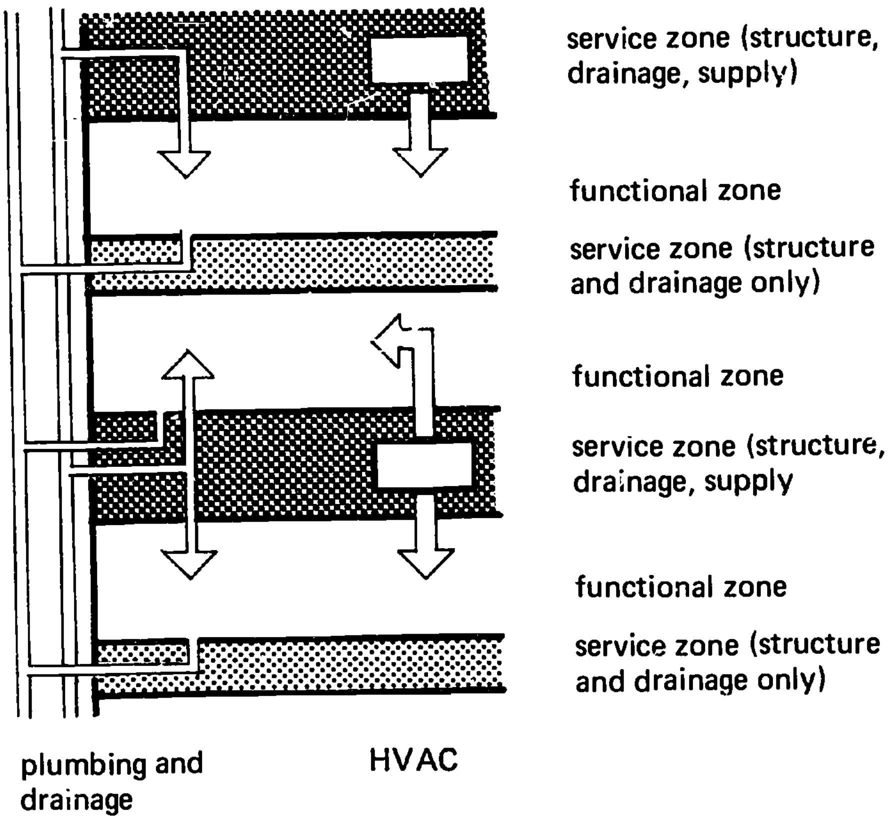
b. The disadvantages are:

- Horizontal access to the piping at alternate floors is eliminated. HVAC and piped utilities from below require numerous floor penetrations that can present problems. The drilling required for alterations is a noisy, disruptive and difficult process.

- Serving HVAC and piped utilities to floors above and below increases the likelihood of crossover conflicts.

- For reasons of fire safety, the service zone may not be a continuous space; all floor and ceiling penetrations must be carefully sealed, and all HVAC terminals to one of the two floors must have fire dampers.

c. SERVICE ZONE PER ALTERNATE FLOOR



M.2.6.3 A service zone for each floor effectively minimizes disruption in spaces adjacent to those wherein changes are made, by providing horizontal access to all service distribution components.

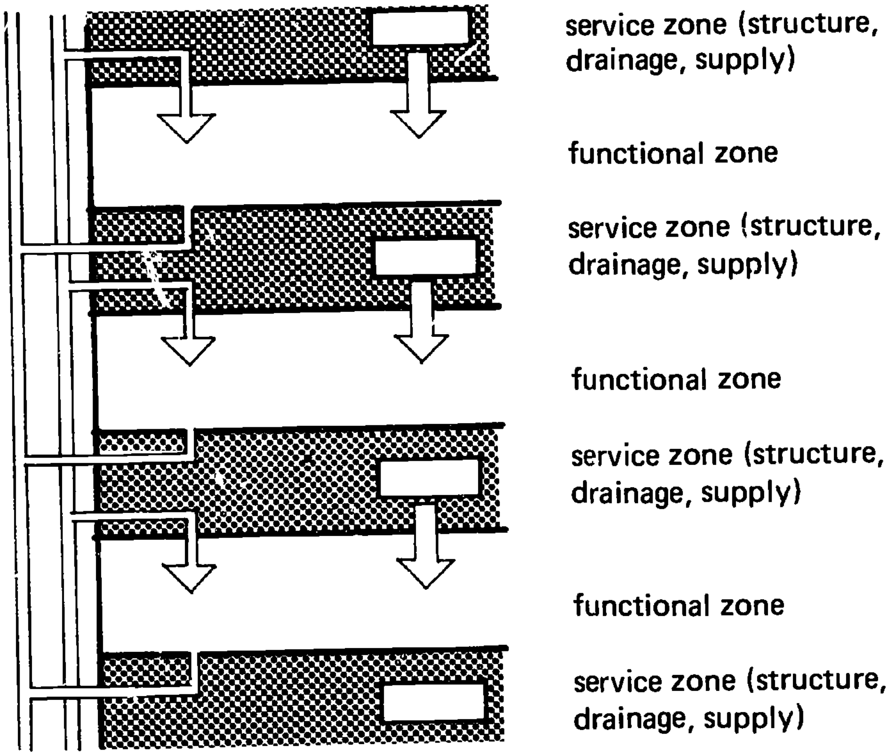
a. Each mechanical room is independent and is served by a separate air handling unit on each floor.

b. Building height increase is slight; the increase is unfinished service space.

c. All services circulate horizontally throughout the space beneath the horizontal structure, and above the occupied zone.

d. All services are supplied down through the ceiling to the occupied space. Floor penetrations are limited to waste drains.

e. SERVICE ZONE PER FLOOR



M.2.7 ABS included a ceiling throughout the space module for the following reasons:

M.2.7.1 During the user survey, ceilings were requested in research laboratories; otherwise, dust collecting on exposed piping, ductwork, and lighting fixtures falls into and ruins experiments.

M.2.7.2 Acoustical ceilings are desirable in virtually all academic areas to lessen noise transmission to adjacent areas; to facilitate communication in classrooms and teaching laboratories; and to provide privacy and quiet in offices.

M.2.7.3 A ceiling is less expensive for the average academic room than are the added costs for partition height from ceiling level to the overhead structure, with the attendant cutting and fitting required around ducts and utilities.

M.2.7.4 The ceiling provides head connection for demountable partitions. If ducts and utilities penetrate partitions above the ceiling, demountable partitions are not economically practicable.

M.2.8 ACCESSIBILITY

M.2.8.1 In laboratory spaces the need for future adaptability takes precedence over the need to minimize initial construction cost. All parts of the service space should be accessible without entering the occupied space below; consequently, the ceiling must support the workmen above in the service space.

M.2.8.2 In offices and classrooms that do not require a high degree of adaptability, a conventional suspended ceiling with access from below can be used at lower cost.

M.2.8.3 The ABS system provides for both types of ceiling.

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To be designated at a later date

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M.4 GLOSSARY

ABS: Academic Building System.

ABS SUBSYSTEMS: a group of building subsystems appropriate for simultaneous development to improve the combined performance through controlled interaction.

ACCESS CEILING the ceiling providing vertical access from below to the ABS shallow service space.

ADAPTABLE ELEMENTS: those building elements responding to particular academic program requirements; considered as non-permanent items; each is individually movable or replaceable with minimum damage or dislocation of other items.

ADAPTABILITY: the capacity of a building to accommodate changing programs and activities during its lifetime.

ASF: assignable square feet; the square feet of area within a room designed and available for assignment to occupants for specific academic programs.

BUILDING SYSTEM: a coordinated set of building components, concepts and procedures which together comprise a building production method.

BUILDING SYSTEM INTEGRATION: the simultaneous development of a group of building components, traditionally treated independently, to improve their combined performance through controlled interaction.

CATWALK CEILING: the ceiling with a walking surface above, permitting horizontal access to all building services and utilities within the service zone, with the ABS deep service space.

COMPATIBILITY: the state of functional, economic and aesthetic coordination between two (or more) subsystems or components.

COMPONENT: a coordinated group of parts forming a portion of a building subsystem.

CONFIGURATION: the organization of structure, functional space, and circulation patterns of people and services in a building.

COST-BENEFIT ANALYSIS: the simultaneous comparison of alternatives in terms of performance and cost.

COUPLED SPACE MODULES: two single space modules horizontally combined within the same perimeter frame.

DEEP SERVICE SPACE: a mechanical service zone above the ceiling enabling construction, maintenance and service personnel to work on building services without disturbing building components.

DOWNGRADING: to change the use of a building from one requiring numerous services to one requiring fewer services.

ELECTRICAL DISTRIBUTION: power, lighting, communications and

FIRST COST: construction and the costs associated therewith.

FUNCTIONAL AREA: an occupied portion of a building with a particular, assigned use, such as offices, classrooms or laboratories.

HARDWARE: the physical components of a building.

HVAC: heating, ventilating and air conditioning.

INCOMPLETE SYSTEM: a building system whose hardware and software components do not encompass the full range of items included in the total building production method.

INTERFACE: a surface regarded as the common boundary of two bodies or spaces.

LIFE COST: total owning cost during life span of a building including construction, operation, maintenance and alteration costs.

MECHANICAL ROOM: that space housing all air handling equipment (except for exhaust fans), the electrical distribution equipment, transformers, main panels for each space module.

MODULE: an incremental dimensional discipline.

NON ABS SUBSYSTEM: building subsystems outside the scope of the ABS system definition.

NON SPECIFIC BUILDING: the building concept of providing generalized, indeterminate space permitting a range of choices for initial and future configurations.

OCCUPANCY: the use of a functional area.

OGSF: outside gross square feet; the sum of the occupied floor areas included within the outside faces of exterior walls for all stories or areas.

OPEN SYSTEM: a building system wherein the subsystems can be of more than one proprietary design and thus procurable from more than one source.

PERFORMANCE REQUIREMENTS: the performance characteristics that each component or subsystem must provide in order to meet project objectives.

PERMANENT ELEMENTS: those building elements less affected by specific academic program requirements, and expected to remain unaltered throughout the life of the building.

PLANNING CONCEPTS: the space module, service tower, partition module, and lighting-ceiling module used in making fundamental planning decisions.

RATIONALIZED TRADITIONAL SYSTEM: a building system that optimizes the use of conventional building products.

SERVICES: distribution of HVAC and utilities.

SERVICE TOWER: a building element outside the space module containing staircases, elevators, all utilities distribution risers, mechanical rooms, all vertical air ducts, and toilet facilities.

SHALLOW SERVICE SPACE: the zone of sufficient height above the access ceiling to accommodate required services distribution elements, with access from below for maintenance and service personnel.

SOFTWARE: the non-physical components of a system, e.g., a procedure or a concept; the "set of rules" for a building system.

SPACE MODULE: a one story block of building volume of varying width and length, and two alternative heights, mechanically and structurally independent, accommodates a reasonable grouping of associated academic space types, and is economically served by an independent air handling unit.

STRUCTURE SERVICES MODEL: the routing of the service subsystems of HVAC, utilities and electrical distribution in relation to the structure and lighting ceiling subsystems.

SYSTEMS ANALYSIS: the examination of the effects of interaction among the elements of a system and the total system.

SYSTEMS APPROACH: a strategy of problem definition and solution emphasizing the interactions among problem elements and between the immediate problem and its larger context; specifically avoids independent or ad hoc treatment of the various elements.

USER REQUIREMENTS: those requirements originating in the activities of various users that must be met by the programming, design, construction and operation of a building.

UTILITIES DISTRIBUTION: plumbing and electrical distribution.

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