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ABSTRACT

This report surveys various ways that physical flexibility (immediate and long term) may be incorporated into the design and construction of college buildings. Because flexibility should encompass every subsystem of construction within a building, this publication draws attention to the wide range of elements that must be considered within modular planning concepts, space conversion, services, and the industrialized total building concept. (Author)

Planning for Change

Colleges of Applied Arts and Technology

Prepared by
SCHOOL PLANNING AND BUILDING RESEARCH

March 1971

Architectural Services of the
School Business Administration Branch
Ontario Department of Education

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Contents

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Introduction

Flexibility allows for the freedom and capacity to bring educators, students and resources together in an appropriate space as determined by variations in class size, teaching materials and teaching techniques. Real flexibility is achieved when changes can be brought about immediately by altering not only a room but also one's relationship to it. By emphasizing the human flexibility of imagination and mobility, it may be more efficient to schedule classes in functionally inappropriate spaces. Such areas should not only have their own obvious functional characteristics, but also a certain ambiguity which encourages their use in unplanned ways. In reality, there are few circumstances that require a totally flexible physical environment. The economical importance of not over-specifying flexibility parameters must be stressed because these elements may cost several times as much as standard fixed elements. When physical changes occur they should be capable of being completed with minimal costs and maximum efficiency and without undue upset to the rest of the educational community.

This report surveys some of the various ways in which physical flexibility, both immediate and long term, may be incorporated into the design and construction of college buildings.

The primary concern in the creation of a physical environment for learning is its capability of being periodically updated and revised to meet changing educational demands.

Flexibility has been thought of in the past only in terms of movable walls. In reality, it encompasses every subsystem of construction within a building. The format of this publication is designed to draw attention to the wide range of elements which must be considered within the following framework:

- Modular Planning Concepts
- Space Conversion
- Services
- The Industrialized Total Building Concept

Modular Planning Concepts

Planned Growth

In the initial stages of campus planning, site, function, and movement systems determine the growth patterns.

Activity areas should be planned to permit expansion or modification without undue disturbance to the total building fabric and to the college schedule.

The educational development of the Colleges of Applied Arts and Technology requires a physical planning framework that allows each discipline grouping to expand without undue disruption in the rest of the college and without creating an undesirable separation of interrelated facilities. Moreover, the planning framework should incorporate the potential for random growth and change.

Structural Module (Planning Grid)

By considering the known and anticipated use of the various activity areas, together with the economical spacing of the principal structural elements, it is possible to determine an optimum dimension for repetitive structural bays on which to base the planning grid. Individual areas can then be designed within the guiding framework of the planning grid and with each function in mind. The structural grid provides an orderly basis for future expansion.

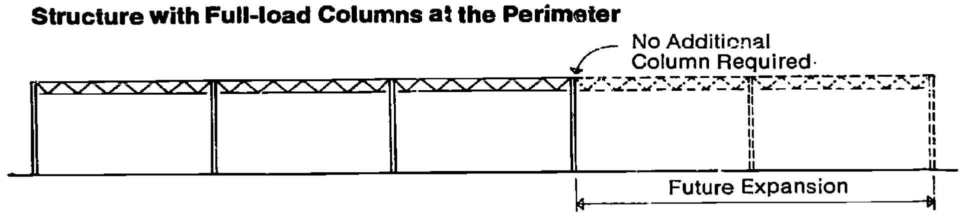
Frequently, the elements within the structural grid are standardized. Identical columns, beams and floor slabs can reduce future construction costs even if, initially, the perimeter elements are over-designed. For example, the external columns normally support only one-half the load carried by internal columns and therefore they do not need to be as strong as the internal columns. If, however, identical columns were to be used it would be possible to expand the structure without inserting additional columns or reinforcing the existing perimeter columns. If the building is designed with unique perimeter structural elements, a practical method of expansion should first be determined.

Vertical structural elements tend to restrict the possibilities for internal space manipulation. Therefore, the larger the structural bay size, the greater the planning flexibility. Unfortunately, with our present building technology, large spans are expensive. A balance must be arrived at between economy and flexibility.

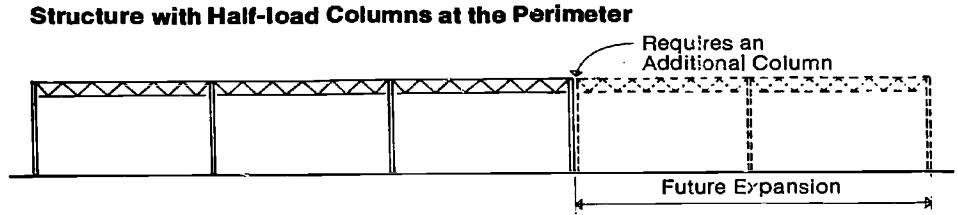
Vertical expansion is extremely difficult if the foundations and structural elements have not been designed to accommodate additional storeys. This method of expansion can cause a great deal of disturbance and may be inconvenient for the inhabitants of adjacent spaces.

Stairwells, ducts, mechanical and electrical service runs all need to have been originally designed to allow for the additional floors. Unless the site area is severely restricted, the costs involved in constructing vertical additions may rule out this direction for growth.

Structure with Full-load Columns at the Perimeter

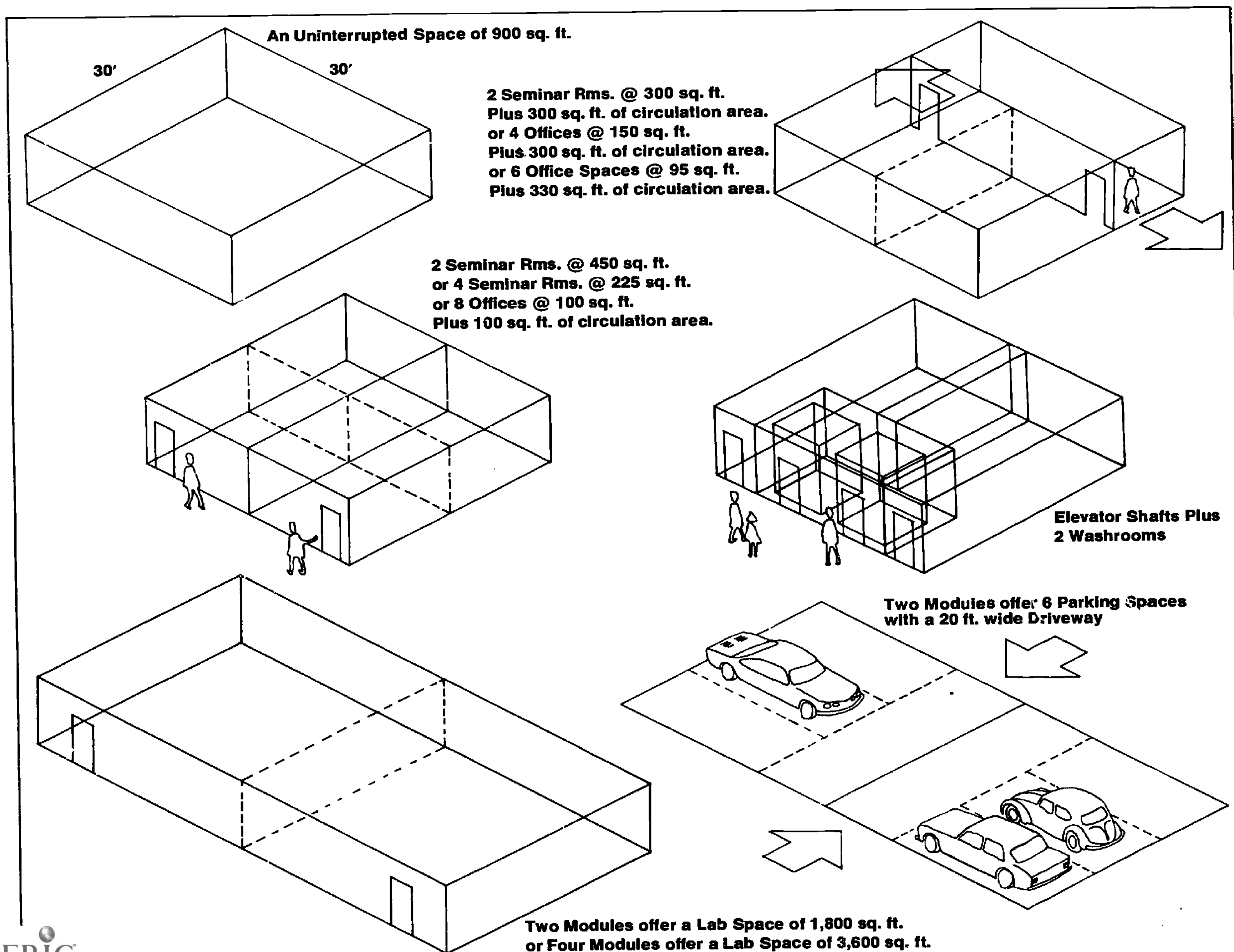


Structure with Half-load Columns at the Perimeter



Several Colleges of Applied Arts and Technology have adopted a matrix of 30 ft. for space planning. In general, this provides an economical structural frame and is well suited for sub-division into typical collegiate spaces. (The matrix for any particular campus development should be arrived at by evaluating all the factors peculiar to the unique case rather than adopting a matrix on an *a priori* basis.)

By applying the structural module to an entire structure, it is possible to see how it simplifies construction.



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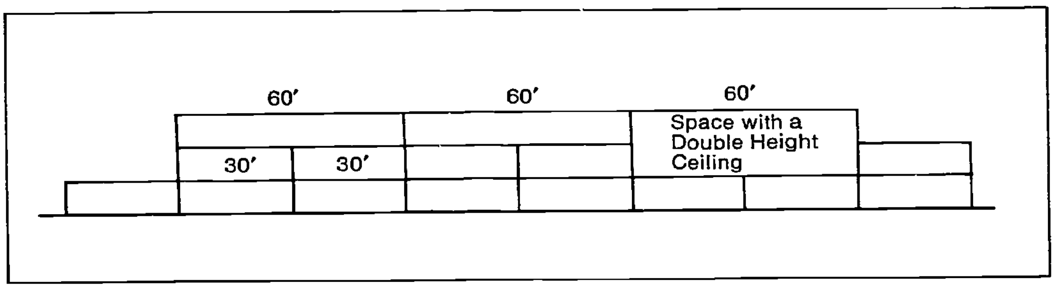
In some cases, it is possible to double the structural grid on the top floor because the roof loading will be significantly less than the floor loading. Thus if the 30′ x 30′ module is used, it may be possible to provide 60′ x 60′ spaces free from structural obstructions. Also, it may be possible to extend the space through two storeys to allow for special areas that require high ceilings, such as TV-studios or shop type classrooms.



Building Module (Subsystem Grid)

The structural module is used by the architect to provide the basis for the overall design in terms of large area planning, but as the design for the building progresses, more detailed aspects must be rigorously examined, such as lighting, ceiling and partitioning subsystems, which require a finer modular subdivision. (In reality the design of a building is rarely a clear-cut linear process and the considerations between the total system and the subsystems are jointly evaluated.)

This finer module is usually referred to as the "building module" (M). It may vary in size from several inches to a number of feet depending upon the characteristics of the design problem and the theoretical approach of the architect.

The module should be small enough that it does not result in spaces that are grossly overdesigned though maintaining the integrity of the module. On the other hand, if the module is too small it ceases to be of value as a design tool. At present a 5′ x 5′ building module is frequently used in Canada. Thus a typical 750 sq. ft. classroom 25′ x 30′ can be interpreted as 5M x 6M. If larger scale design considerations indicate that it would be advantageous to increase the dimensions of the room to 5M x 7M, the area would increase by 125 sq. ft. or 16.7% of the total area of the basic classroom. Such an increase in area in a few specific rooms in a total complex would be economically tolerable. The actual area increase is small enough so that there would be little waste space within the classroom and if it were necessary to decrease the dimensions by one module, the requirements of the area could be adapted to the available space.

The 5′ x 5′ module is favoured by a number of college planners because:

- It is large enough to fit basic space requirements thereby minimizing jointing conditions.
- It accepts the standard 4 ft. fluorescent luminaire with an adequate allowance for partition thickness and other obstructions in the ceiling plane surface. (Major manufacturers of lighting/ceiling systems stress that a significant economy can be realized by specifying 4 ft. fluorescent tubes rather than 3 ft. tubes.)
- The use of this module by the School Construction Systems Development project in Southern California and in the Florida School Building Program and the introduction of the School Educational Facilities (SEF) system in Ontario has influenced a number of building materials manufacturers to create products geared to the dimensional requirements of this planning module.
- It is used by a variety of structural, lighting/ceiling, partition, and vertical skin product and component manufacturers.
- It is commonly used in commercial buildings. The components and products produced for commercial buildings may also be economically applied to college buildings.
- It can be subdivided into a 20 in. sub-grid which has been suggested as a suitable grid in the design of residential high-rise buildings. Materials and subsystems developed for the much larger residential market can frequently be used for college buildings.
- It can be subdivided into 30 in. increments which is a common door and window unit dimension.

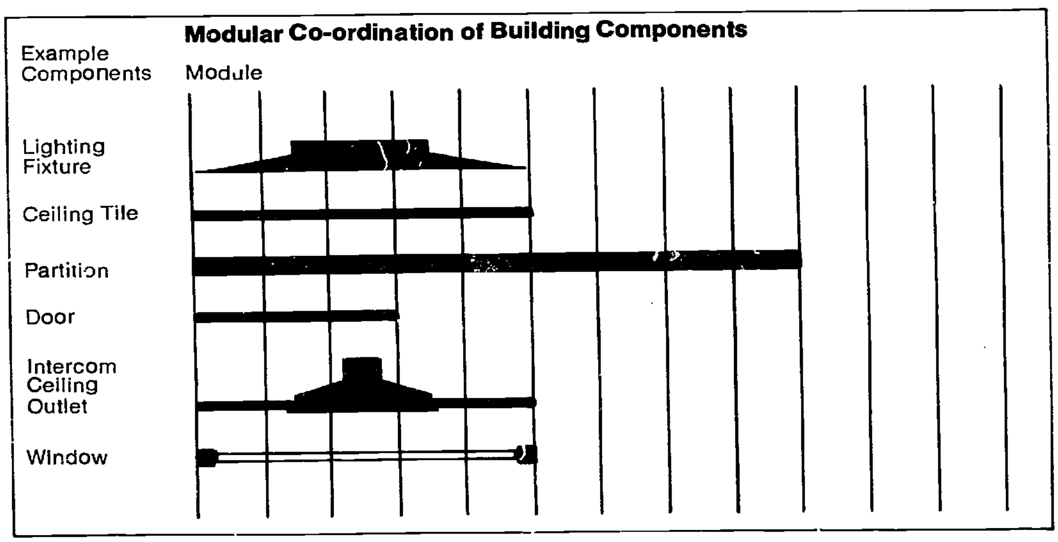
Interface Compatibility

Interface compatibility refers to the capacity of items, components or systems of different manufacturing origins to be joined together. To facilitate flexibility, it is important that the interfaces are designed for a semi-permanent state. Thus the devices that hold the building components together must be capable of being easily dismantled. Components are joined together in a number of different ways ranging from gravity, to ordinary bolts, to highly complex patented systems. Joints involving acoustical separation or fire stops must be airtight.

Modular Co-ordination

Modular co-ordination is the term given to a procedure for simplifying the assembly of building components dimensionally and are multiples of M. The conformity with modular dimension facilitates the interchangeability of subsystems of different manufacturing origins.

Modular co-ordination also infers fine tolerance when fitting components into their required spaces.



Space Conversion

Interior Partitions & Functional Requirements

Specific requirements for space division and acoustic control differ greatly from activity to activity within any college building, yet, due to the changes that take place in campus functions, it is frequently necessary to alter the shape of a room. Acoustic control plays a vital role both in necessitating physical divisions of activities from one another and in determining the appropriate type of dividing system.

Different functions require different sets of performance criteria for the partitioning. In order to determine the appropriate type of partition, the necessary physical characteristics should be evaluated together with the required degree of permanence.

Degree of Permanence
Permanence can be evaluated on a scale of five:

1 Temporary partitions are any walls that can be removed, replaced, or relocated without affecting the structure of the building. They may be internal or external. A partition in this report is understood to be a temporary partition.

2 Removable walls are partitions that are destroyed totally or in part when removed and consequently cannot be relocated without the addition of new material.

3 Demountable walls are partitions that can be erected, dismantled, and relocated without significant loss of material. Some fixing materials eg., tape, wire and screws, may not be re-usable.

The demounting process should be non-progressive, ie., it should be possible to remove a panel at any point without it being necessary to start dismantling from one end of the partitioning run. It should be possible to substitute electrical or mechanical components or alternative surface panels in one room without affecting the adjacent room.

4 Operable walls are partitions that can be moved on wheels at will or in a specified pattern. If a track system is used, it is usually demountable.

Demountable and operable walls should not be used for areas where:

- relocation is not expected, such as stairwells, etc.;
- they are subject to excessive moisture, such as washrooms and shower rooms;
- heavy equipment is expected to be supported from walls;
- high fire-ratings are required.

5 Fixed walls are walls that are structural and demand a surface that can accommodate high impact loads, potential surface damage, or heavy applied loads.

The initial choice of permanence depends on how often the wall will be moved. There are six basic conversions over time.

1 Real Time conversion is the ability to alter the size of a room between classes when the teaching method is changed.

2 Anticipated conversion is the daily rearrangement of a room due to scheduling.

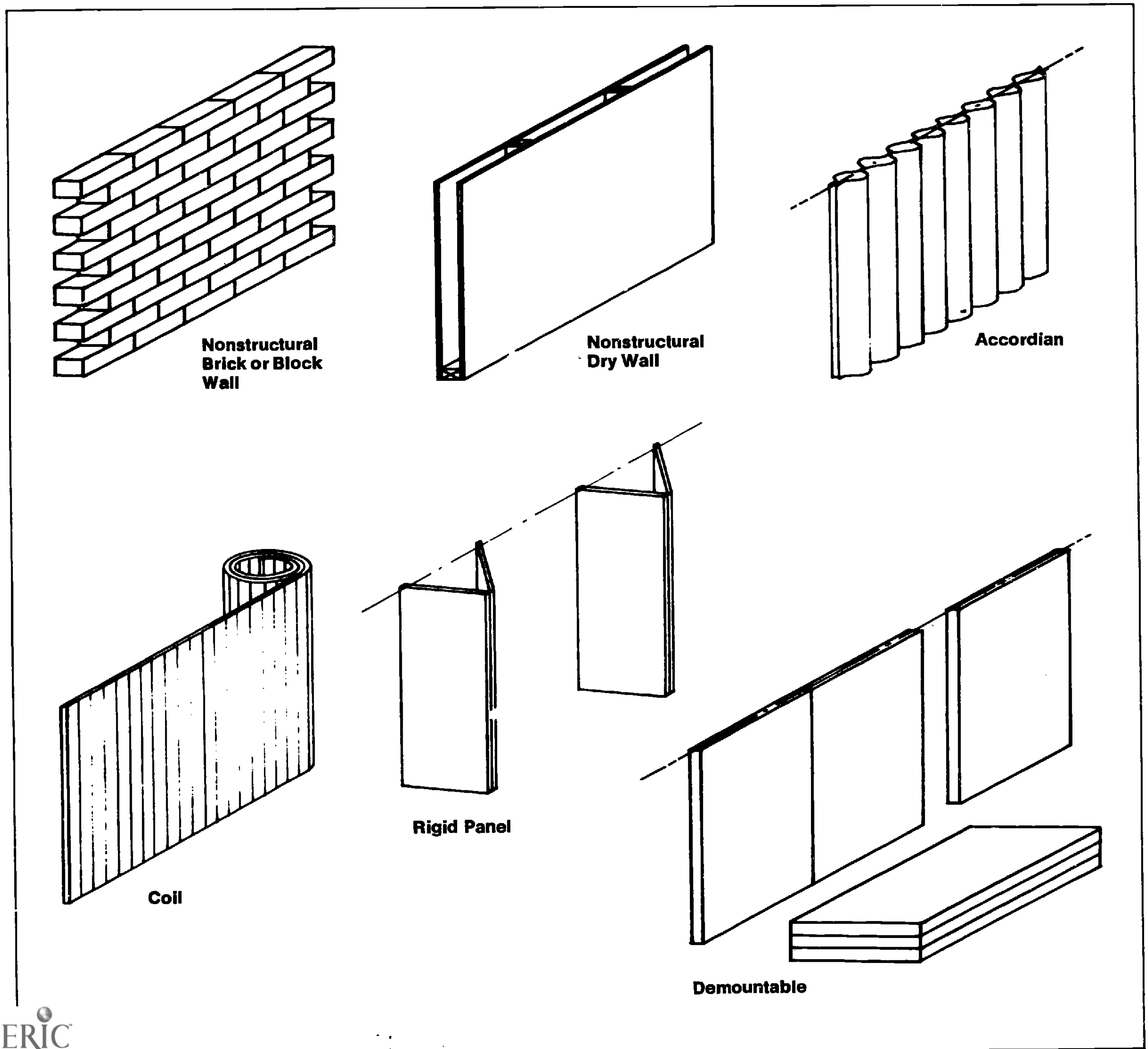
3 Semi-permanent conversion allows for term changes in curriculum.

4 Permanent conversion allows for the placing of fixed walls in functionally invariable space.

5 Experimental conversion satisfies the need of a multi-purpose space of maximum flexibility.

6 Building Expansion requirements must also be taken into account so that there will be a minimum of demolition or removal of existing walls, and little interruption of college activities.

When it is known that partitions will rarely be moved, the choice between demountable and removable partitions should be made on the basis of comparative cost over a number of relocations. Movement of partitions on less than a yearly basis can often be avoided by the provision of a variety of spaces.


Nonstructural Brick or Block Wall
Nonstructural Dry Wall
Accordian
Coil
Rigid Panel
Demountable

Physical Characteristics

The physical characteristic of any partitioning system will vary according to the required performance criteria.

Flexibility

Modular co-ordination can be obtained by relating the partitioning dimensions to the structural grid and the building module, and will result in a significant saving of on-site fitting. Thin partitioning conserves usable floor area, but a thickness great enough to accommodate service requirements must be adopted. (Plumbing in demountable partitions should be avoided.)

Acoustics

Effective sound control is the paramount physical characteristic to be considered when selecting the partitioning system.

Sound control is relative to the type of occupancy at any given time. Subconsciously, a person continuously scans the auditory environment. Some sounds are selected for their meaning, such as conversation or music. Other sounds, such as corridor noise or mass conversation, are deliberately rejected. But a person only rejects a noise when he is able to identify it and therefore recognizes that it is a sound he does not want to hear. The most annoying range of sounds are the intermediate sounds which may have meaning but, because they can only be partially heard, one must strain to identify. This type of auditory distraction is annoying to both students and teachers in the classroom setting.

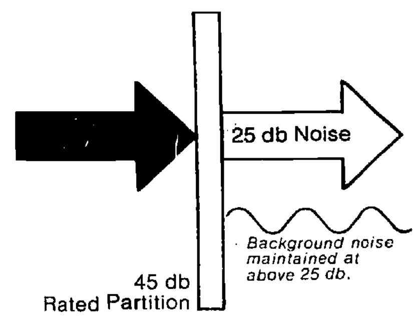
There are three factors that can be altered to affect the acoustic environment of a room:

1 The sound level of adjacent spaces.

2 The quality of sound insulation in the room.

3 The degree of background noise (white noise) within the room.

The white noise concept is based on the principle that background noise kept at a continuous level will be rejected. Therefore, if all superfluous sounds are maintained below the white noise level, effective integrated sound barriers are set up. This is the most economical way of drowning out unwanted sounds and creating the illusion of quiet. White noise is usually introduced through the air conditioning system.

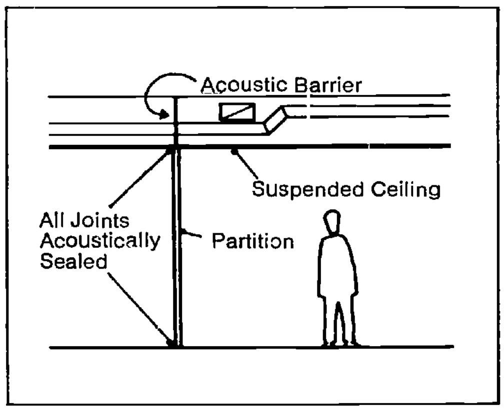


The 70 db noise is reduced below the background level in the room and will remain unnoticed in that room as long as the background noise level is above 25 db.

Installed barriers often fall short of their designed rating because they are improperly installed. Failure to eliminate sound leaks seriously affects the performance of an acoustical barrier; a hole one inch square, in a one hundred-square-foot wall will allow the passage of as much sound as is transmitted through the entire hundred-square-foot wall. Common plumbing fixtures, airducts, suspended ceiling, hollow floors, and back-to-back electrical outlets are the most frequent sources of sound leaks. Without baffles and proper caulking, a number of acoustical walls may as well not exist.

The following points should be remembered when designing for acoustical problems:

- Baffles should be placed above ceilings and below hollow floors.
- Non-critical spaces should be located on the noisy side of the structure, eg., stairwells, corridors, kitchens, washrooms, elevators, etc.
- Back-to-back electrical outlets should not be used.
- Fixed windows, which yield a better acoustical barrier than opening ones, should be used if external noises are a problem.
- Doors should be recessed off corridors to avoid sound travel in halls.
- Mechanical fixtures should be muffled or baffled.
- Noisy spaces should be located over noisy spaces.
- All partitions and mullions should be sealed.
- In order to give an even sound distribution and minimize the disturbance in other areas, a number of low-volume speakers rather than two loud speakers should be installed in lecture halls designed for audio-visual equipment.



Recommended transmission loss for different types of partitions

Acoustics design should provide for good hearing conditions and eliminate unwanted noise; and, since the level of acceptable sound varies with each function, it is advisable that the noise level of each function be checked before specifying the partitions. An overall cost saving may be realized by eliminating the over-design of acoustic requirements in non-critical areas.

When the requirements dictate the selection of high transmission-loss partitions, care must be taken to ensure that all other components, such as suspended ceilings and doors, are of equivalent or similar acoustical integrity otherwise the expensive partitioning will be valueless.

Typical applications	**Desirable hearing conditions**	**Partition requires a Sound Transmission Loss (S.T.L.) of:**	
		Background 25 db	**Background 35 db**
Privacy not required, partitions used only as space dividers.	Normal speech can be understood quite easily and distinctly through the wall.	35 or less	30 or less
Suitable for dividing non-critical areas. Provides fair degree of freedom from distraction.	Loud speech can be understood fairly well. Normal speech can be heard but not easily understood.	35 to 40	30 to 35
Provides good degree of freedom from distraction.	Loud speech can be heard, but not easily intelligible. Normal speech can be heard only faintly, if at all.	40 to 45	35 to 40
Provides a confidential degree of speech privacy.	Loud speech can be faintly heard but not understood, normal speech is inaudible.	45 to 50	40 to 45
Suitable for dividing private offices from noisy areas containing typewriters, computers, etc.	Very loud sounds, such as loud singing, brass musical instruments, or a radio at full volume can be heard only faintly or not at all.	50 or more	45 or more

Loudness

Loudness or sound intensity level is measured in terms of decibels (db). A decibel is a logarithmic unit of measure of sound pressure. The decibel scale extends from 0 db (threshold of audibility) to over 120 db (threshold of pain). The simplest way to identify sound pressure levels, or loudness in decibels, is to compare them with common easily recognized sounds which are present in everyday living. A sound level meter would indicate sound pressure levels approximately in the numerical range indicated in the chart.

	db	
	120	threshold of pain
Deafening	110	thunder, artillery nearby riveter elevated train boiler factory
	100	
Very loud	90	loud street noise noisy factory truck unmuffled police whistle
	80	
Loud	70	noisy office average street noise average radio average factory
	60	
Moderate	50	noisy home average office conversation quiet radio
	40	
Faint	30	quiet home or private office average auditorium quiet conversation
	20	
Very faint	10	rustle of leaves whisper sound-proof room
	0	threshold of audibility

Relative Interior Partition Attributes

Partition Types	Movability	Erection Time*	Demounting Time*	Salvageability	Maintenance
Demountable, steel faced, factory painted finish. Insulation. 3″ thick.	Demountable. Low irritant value for area occupants. Minimal disruption of area function.	45 min.	15 min.	95%	Scrubable. Paint cycle: 15 yr.
Demountable, vinyl covered gypsum board, self-finish. Insulation. 3″ thick.	Demountable. Low irritant value for area occupants. Minimal disruption of area function.	45 min.	15 min.	90%: snap-on fastenings 80%: screwed fastenings	Washable. Replace damaged board. No painting.
Concrete block, painted. 8″ thick.	Removable. Extremely high irritant value for area occupants. Interruption of area function.	4 hr.	3 hr.	15%: standard methods 25%: extreme care taken in removal. Increase in removal time.	Scrubable. Paint cycle: 4 yr.
Structural clay tile, self-finish. 8″ thick.	Removable. Extremely high irritant value for area occupants. Interruption of area function.	4 hr.	3 hr.	15%: standard methods 25%: extreme care taken in removal. Increase in removal time.	Scrubable. No painting.
Gypsum board on metal stud, taped and painted. Insulation. 3″ to 4″ thick.	Removable. Moderate to high irritant value for area occupants. Moderate disruption of area function.	4 hr.	2 hr.	20%: joint location unknown 40%: joint location known	Washable. Replace damaged board. Paint cycle: 4 yr.
Folding rigid panel. Vinyl faced. 3″ thick.	Demountable. Low irritant value. Minimal disruption of area function. Slides on a track.	Few minutes	Few minutes	95%	Washable. Replace damaged board. No painting.
Accordian, vinyl. Hand crank or electrically operated.	Slides on a track. Demountable. Low irritant value. Minimal disruption of area function. May easily form a curved wall.	Few minutes	Few minutes	95%: with extreme care taken in removal	Washable. No painting.
Coil. Hand crank or electrically operated.	Slides on a track. Removable. May easily form a curved wall.	Few minutes	Few minutes	95%: with extreme care taken in removal	Washable. No painting.

Additional attributes to be evaluated

- security partition
- [illegible]ht in relation to dead load [illegible]ments of structure
- need to accommodate mechanical & electrical service runs (in both horizontal and vertical planes)
- weight for handling if relocatable
- compatibility of different partitioning systems used in a single campus

Weight	Available Fire Ratings	Sound Transmission Loss	Services	Chalkboards & Tackboards	Windows & Doors
10 lb./sq. ft.	1 hour	42 db.	Integrated, accessible without damage to partition. Standard repetitive locations.	Integral with partition face (ie. chalk or magnetic tack panel replaces standard panel).	Location restricted by & integral with partition support. Supplied & installed by partition manufacturer.
6.5 lb./sq. ft.	Class "A" non-combustible	38 db.	Integrated, accessible without damage to partition. Standard repetitive locations.	Attached to partition. Patching required if relocated.	Location restricted by & integral with partition support. Supplied & installed by partition manufacturer.
50 lb./sq. ft.	1 to 4 hours	48 db.	Non-integrated. Cutting required for access. Location to suit.	Attached to partition. Patching required if relocated.	Location not restricted. Non-integrated. Supplied & installed by others.
50 lb./sq. ft.	1 to 4 hours	48 db.	Non-integrated. Cutting required for access. Location to suit.	Attached to partition. Patching required if relocated.	Location not restricted. Non-integrated. Supplied & installed by others.
6 lb./sq. ft.	Class "A" non-combustible or 1 hour, depending on gypsum used.	41 db.	Non-integrated. Cutting required for access. Standard repetitive locations.	Attached to partition. Patching required if relocated. or Attached to integral hanger locations.	Location restricted by stud spacing. Non-integrated. Supplied & installed by others.
7 lb./sq. ft.	1 hour	43 db.	Non-integrated.	Integrated with partition face.	Location not restricted. Fully integrated with partition system.
5 lb./sq. ft.	Non-combustible	35 db. 45 db. for double partition	Non-integrated.	Must be suspended in front of partition.	Partition opens at one end.
7.5 lb./sq. ft.	Non-combustible	30 db. 37 db. for double partition	Non-integrated.	May be attached to partition.	Partition opens at one end, or loose vinyl door may be added.

- availability of replacement parts for patented panel systems.
- ...ital cost & maintenance cost

- life expectancy of total panel and/or components that make up the panel system
- storage space when not in use

*Based on 4 men working on a 13 lineal ft. partition, 9 ft. high.

Exterior Walls

The configuration and characteristics of the exterior cladding have a very significant effect on the cost of the total building.

The selection of the exterior wall type should be carefully considered with respect to future requirements for expansion. In terms of physical flexibility external wall types can be divided into three catagories:

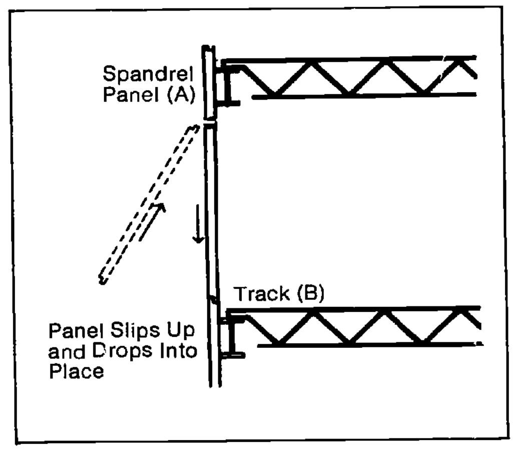
- Structural
- Removable
- Demountable

Structural (or load-bearing) walls, if used, should be carefully located so that they will not interfere with expansion or remodelling. If the locations of future apertures are known, they can be designed into the initial construction and filled-in as knock-out panels until required.

Removable walls are normally used when expansion is foreseen. These differ from demountable walls in that the material is not re-used, eg., knock-out brick panel in a concrete frame structure.

Demountable walls may be used when the expansion plans are definite, and it is known that the cladding used in the original situation is suitable for the later phase of development.

A spandrel panel (A) and a track (B) are fastened to the structural system. The demountable wall units are then rapidly slipped into place.



Relative Exterior Wall Attributes

Wall Type	Demountable (metal faced sandwich) Panels (non-structural).	Demountable (precast concrete) Panels (structural or non-structural).	Removable Block (8 in.).
Movability	May slide in track and/or lift out and interchange.	Clip angles may be used in the initial positioning to provide for movement at a later date.	Removable
Erection Time *Based on four men working on a 30 lineal ft. wall, 10 ft. high*	Fastest possible erection time if integrated properly with the structural system.	Depending on connections and the degree of fitting, a 30 foot wall may be enclosed within 3 to 4 hrs.	12 hours.
Demounting Time *Based on four men working on a 30 lineal ft. wall, 10 ft. high*	Windows, doors and opaque panels can be totally interchanged on a 30 foot wall in less than 3 hrs.	Depending on panel sizes and the number of connections, removal may take several hours for a 30 foot wall.	9 hours.
Salvageability	100%	95% (loss of connections).	15% (standard methods). 25% extreme care taken with increase in time.
Maintenance	Self washing (or paintable every 3 yrs.).	Due to a variety of finishes and surfaces, maintenance varies from self washing to scrubbing and painting require-ments.	Scrubable. Paint cycle is 4 yrs.
Weight	8 lbs./sq. ft.	85 lbs./sq. ft.	50 lbs./sq. ft.
Services	Non-integrated.	Not recommended as it may foul up the interface.	Non-integrated. Cutting required with location to suit.
Windows and Doors	Totally integrated (modular part of the system).	Moulded into panels as required (never cut in).	Non-integrated. Location not restricted. Supplied and installed separately.
Notes	Designed to be readily interchanged to meet internal space requirements.	Not designed for rapid interchange or removal but accommodates for such flexibility in the design of the connections.	This process takes the longest amount of erection time.

Furniture and Casework

Built-in and Standard Furniture
Furnishings limit the functional capabilities of a space more severely than the geometry of the room. Because furniture and fittings are usually functionally specific the need for flexibility should be carefully evaluated before selection decisions are made.

Built-in furniture generally limits the use of the space to that of its designed function and therefore should be provided only in long-life space. Because of the rapid changes in the colleges and in education in general, it is advisable that even such relatively permanent built-in furniture as lab benches be acquired in modular unit lengths and installed with demountable fittings.

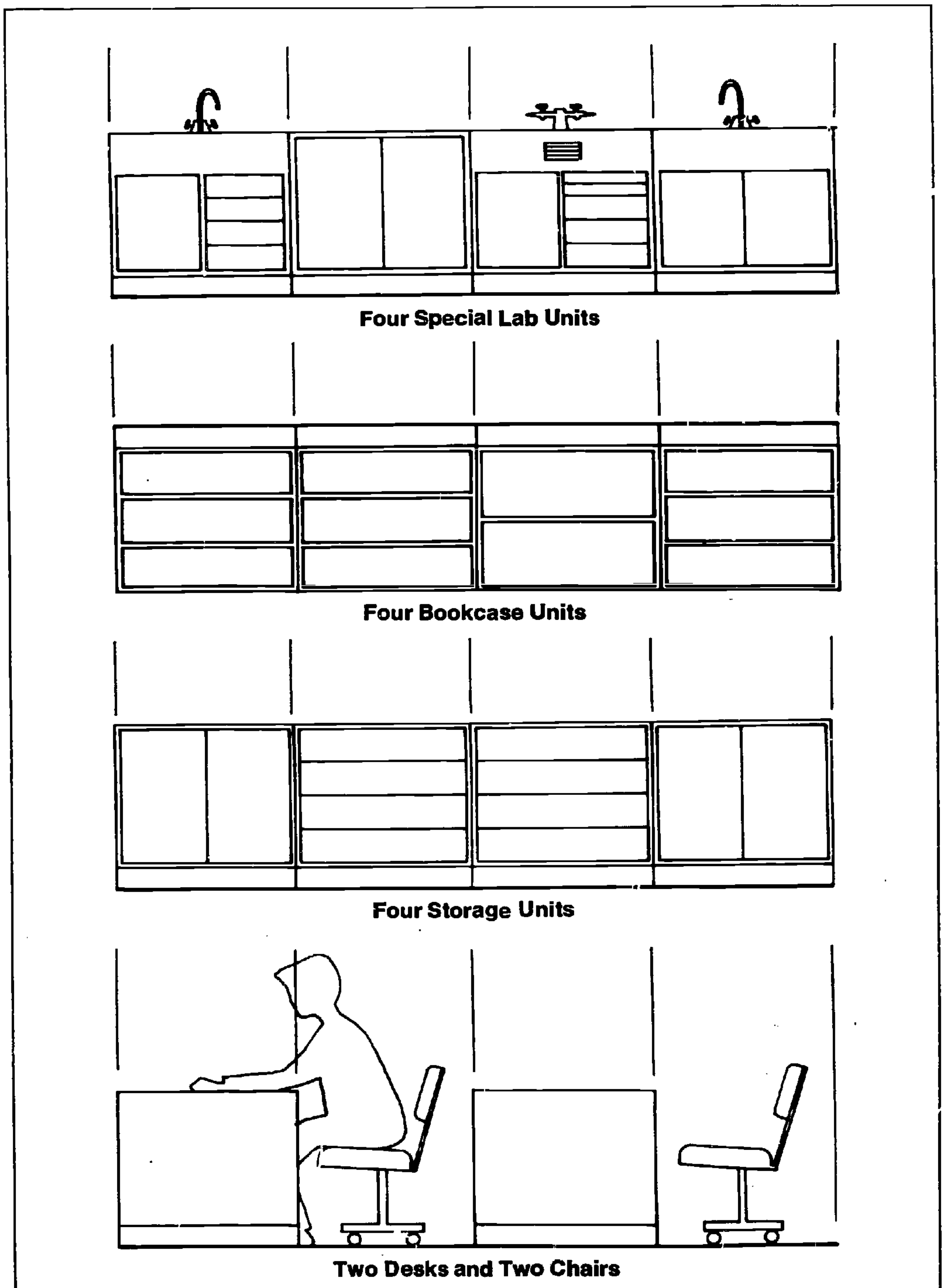
Standard classroom furniture has not been designed or selected to be interchangeable with other furnishings. Standard furnishings may not limit flexibility when only small units such as a chair are considered, but when large pieces (desks, storage units, etc.) are involved, non-modular pieces can be a problem.

Modular Furniture
The design of modular furniture and its use in an ordinary classroom is of doubtful value since there is seldom more than a writing surface and chair for each student station, and these are already interchangeable with themselves. The place where modular furniture is required is in laboratories and similar spaces requiring multi-storage and multi-activity flexibility.

For example, four storage units can be readily replaced by two desks and two chairs, four bookcase units, or four special lab units.

Rearrangement of Furniture
The simplest, quickest, and most economical way of achieving flexibility in classroom spaces is to move the furniture about to suit the teaching methods and media requirements of a specific course and teacher. Such rearrangement may be done on a timetable basis by the custodial staff or to meet spontaneous situations by the students and teachers.

Modular casework will greatly facilitate this [illegible] of quick alterations to space.



Four Special Lab Units

Four Bookcase Units

Four Storage Units

Two Desks and Two Chairs

There is a wide range of college space types that are suited to a single function. Even so, it is possible to incorporate some forms of flexibility into them.

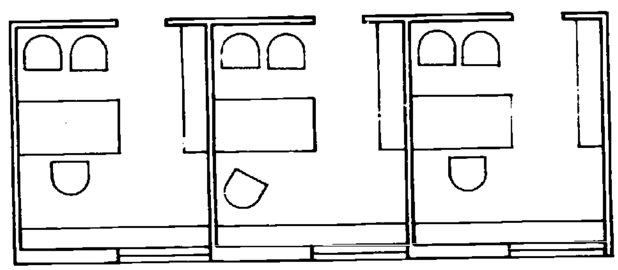
- office space
- technology areas
- grouping spaces
- storage space
- unscheduled space

Office Areas

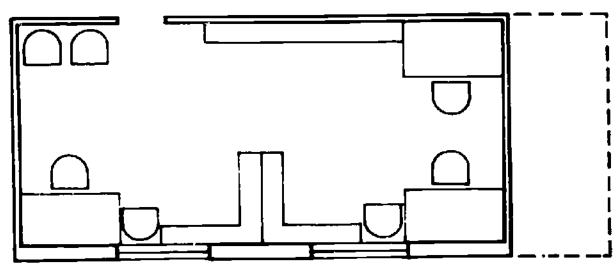
A significant percentage of college space is devoted to faculty offices. Ways need to to be found to maximize the utilization of faculty office areas and still provide the visual and acoustical privacy requirements that give rise to the request for a private office.

Economy necessitates that if private faculty offices are provided they be extremely small. As a result, they are claustrophobic and extremely inflexible and therefore under-utilized. They are used only as a "mailbox" and personal storage space. The illustration shows a three-man office that is about 20% smaller than the three individual office areas yet provides an office space which could be used for small staff meetings, tutorials, or work space for non-standard tasks.

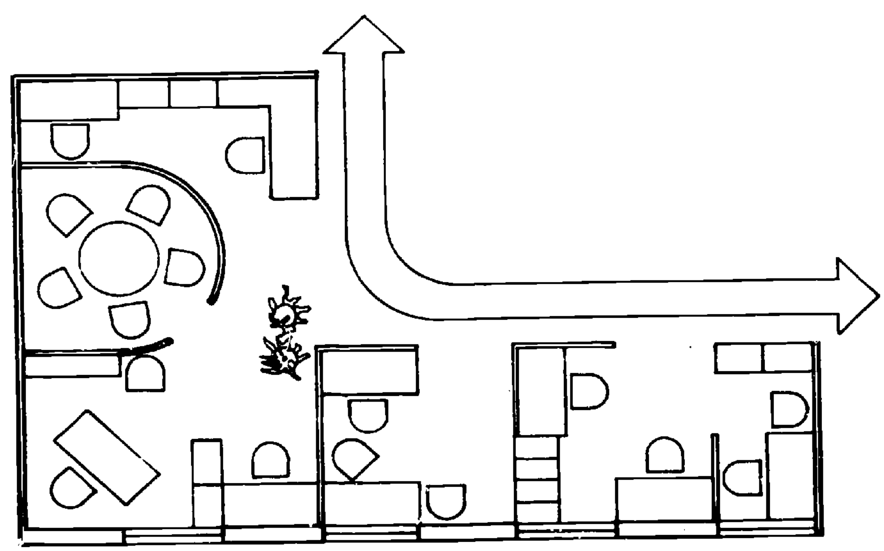
An "office space" can be considered as an area within a large "open" office. The space may be defined by filing cabinets, storage units, planters and landscape dividing screens. Sheridan College has combined open planning with multifloor levels to provide an effective, spacious, but highly efficient office space. Irritating noise sources must be isolated in an open plan office and sound absorption surfaces (carpets, curtains, padded dividers, etc.) maximized. The arrangement of furniture, plants and movable partitions, together with the use of colours, can create a more stimulating and intimate working atmosphere than the normal "boxed-in" offices.



Standard Offices



Open Office



A Large Open Office

Expected Renovation

Possible Advantages of Open Office Planning

Space allocation can be made quickly and economically.

Communication within departments is stimulated.

Work stations can be arranged according to work flow.

Groups can work more easily as teams.

More people can be accommodated in a smaller area and not feel cramped.

A sense of community is developed.

Possible Disadvantages

Friction or alienation may develop unless personnel have some say in the arrangement.

Personnel could be sensitive to noise disruptions.

Some people who wish to participate may force their presence on others.

Note: Large open offices should be supplemented by one or two small offices for private interviews or work requiring a high degree of concentration.

Technology Areas

Equipment installations and mechanical servicing reduce the possibilities of flexibility in technology areas. Those activities requiring special air handling arrangements can be considered to be fixed activities.

The visual arts labs, (a lightly serviced activity) at Sheridan College's Oakville Campus have been handled as large open areas, containing approximately 10 classes. Three small seminar spaces are provided adjacent to the lab for formalized instruction and discussions. These spaces are not scheduled but are used as areas for students who require more structured handling. Above the lab area there are a series of mezzanines which serve as faculty offices, special project areas and storage space. All services are suspended in a grid above the students' work stations.

Grouping Spaces

The arrangement of activity areas has a significant influence on the potential for flexibility. Clean and quiet labs, such as drafting and electronics, may be placed together to provide interuse of the drafting tables and class area. Similarly, heavily serviced shops may be clustered together for shared lecture areas and some specialized equipment installations. The repetitive formalized teaching areas do not need to be provided in lab and shop areas if classroom space is conveniently available. Separate classroom space should increase the college's utilization ratio because it is possible to obtain a far higher utilization of general academic space than it is in specialized shops or laboratories.

Storage Space

Storage space is usually the first area to be sacrificed in the name of economy. But flexible space requires storage for interchangeable items.

Unscheduled Space

There is a definite need in most colleges for unscheduled non-specific space capable of handling unpredicted timetable overlaps and spontaneous teaching events. Large divisible instructional space, preferably two storeys high, is capable of being used for events, such as theatre productions, convocations, dances and exhibitions. Although limited to use in good weather, open courts on roof tops as well as large balconies provide lecture and seminar space if appropriately surfaced. Interior open courts can be used for plays, fashion shows, cafés, art exhibits, and similar informal gatherings. Smaller spaces can be used for handling special or overlapping schedules. With an arrangement of seats and five-foot partitions, the space may be developed into an intimate discussion or seminar room. Seneca College has such an area that works well. The use of illumination levels to control the auditory environment is interesting. When several groups are using the seminar room simultaneously the lights are dimmed and the participants tend to whisper and there is seldom a disturbance between groups. Simple carpeted areas, which allow students to recline on the floor, have proved to be satisfactory when note taking is not necessary.

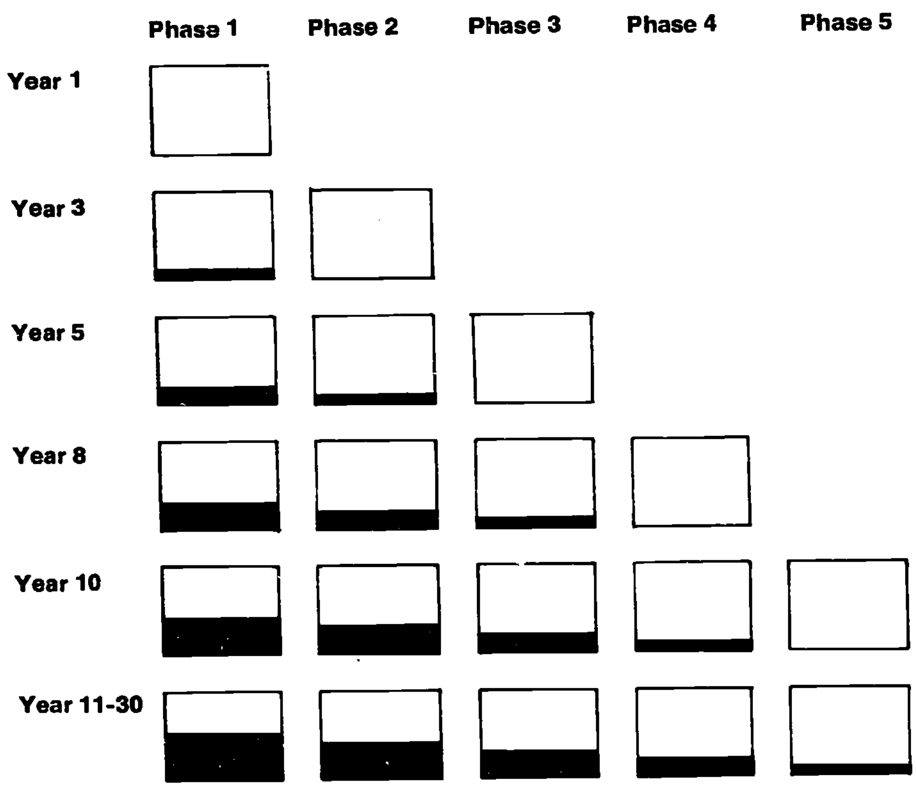
Degree of Flexibility

The degree of flexibility built into a college building will have a definite effect on the operating costs involved in updating the structure to meet newer educational program demands.

The uncertainty of future educational programs is a major factor in designing new buildings. A building scheduled for a specific use in the near future can be more efficiently and economically planned than one designed for varying uses in the distant future. Flexibility must be paid for, both in terms of capital expenditure and in loss of functional appropriateness for the original use. A balance must be struck between cost of renovation and the price of flexibility. When planning a building in a phased construction program the anticipated renovation work due to the introduction of a new phase of building should be evaluated. It may well be that the need for expenditure on flexible construction features can be significantly decreased during the construction program.

Physical flexibility includes the altering of space which, in turn, causes variations in egress and fire rating demands. These changes may create major safety problems.

It is important that *all* renovation plans be submitted to the Ontario Fire Marshal's office for approval. Failure to comply with the fire regulations can be a costly mistake. Overspecifying fire regulations as well as underspecifying them can also be a wasted expense.



New construction □

Renovation ■

There is a probable percentage of renovation over the life expectancy of a building. As each new phase is constructed, some of the facilities in the previous phases may be relocated to allow the remaining facilities to expand. Later phases of construction frequently are designed for functional specific activities which are subject to less change. To equalize the flexible elements in every phase of construction would be impractical because the need for flexibility tends to decrease as the physical plant expands.

Cyclical Building Renewal
Dimensionally co-ordinated subsystems should simplify cyclical building renewal, ie., renewal of building on a continuing basis. A college must phase its expenditures in relation to changing financial circumstances. It should be possible to assign budgeted amounts to each subsystem in accordance with its life span. Accepting the concept of cyclical renewal, phasing for buildings, and their subsystems, in the future components may be developed having a specific life span and may be marketed under a series of lease-rent arrangements. It is conceivable that a manufacturer might sell the service of a subsystem in addition to or rather than the manufactured component. SEF has discussed this methodology of approach to solve problems involved in updating building components.

An added attraction of such a system would be that the responsibility for maintenance and repairs would rest with the owner.

Services

Atmosphere
Each activity has a set of environmental criteria which must be met in order to assure the appropriate operating conditions for equipment, such as musical instruments and electronic equipment and for storing materials such as chemicals and biological and zoological specimens.

Redistribution of space and activities within the college will require adjustments to air conditioning systems.

Heating
The system must be able to accommodate varying heat losses such as radiation, conduction, infiltration, ventilation, and pressurization.

Cooling
The system should allow for varying heat gains such as conduction, solar heat (very important), and sensible and latent heat gains from occupants, equipment, and materials.

Air Distribution
Flexible air conduits should allow for alteration of the air handling system due to a partition move. The number of outlets will depend on the probable number of space subdivisions.

Within a single campus there may be three separate systems for handling exhaust air.

- Standard room exhaust
- Toxic fume exhaust
- Corrosive fume exhaust

Humidity
In order to maintain comfort, humidity must vary with temperature changes. Also, humidity control is an important factor in some types of equipment and systems maintenance.

Filtering
Air filters should be easily accessible for changing and/or cleaning, and should be of a size that is readily replaceable.

Acoustic Control
Devices such as diffusers and return grills should be placed in duct layouts to reduce room-to-room sound transfer. (See Section on Acoustics)

Controls
Individual controls will increase the cost of the mechanical installation, but will decrease the number of user complaints.

The controls should be capable of meeting rearrangements, additions or deductions with minimum disruption to finished surfaces and equipment.

Prime equipment and trunk services need to be easily accessible for adjustment and alterations.

In general, the simpler the mechanical installation the greater the ease of adaptation, although not necessarily the cheaper.

- Repeating Situations — Identical units, terminals, and controls permit readily interchangeable patterns of space by minimizing fitting time and enabling continuous reuse of elements.
- Logical Numbering Systems — The numbering of units and controls based on the building grid will give instant recognition of elements by tradesmen involved in renovating the services to meet varying space requirements. This should speed alterations and reduce costs.
- Standard Selections — In choosing components to meet the environmental criteria, standard items should be utilized to facilitate replacement and interchangeability and simplify renovations unless a custom selection is justified.

Mechanical Plant
The mechanical plant is the primary control centre for the delivery of the environmental requirements to an area where they are refined by local controls. The aim is to get a service from a source to a terminal point in the least transfer distance, thus reducing both capital and operating costs.

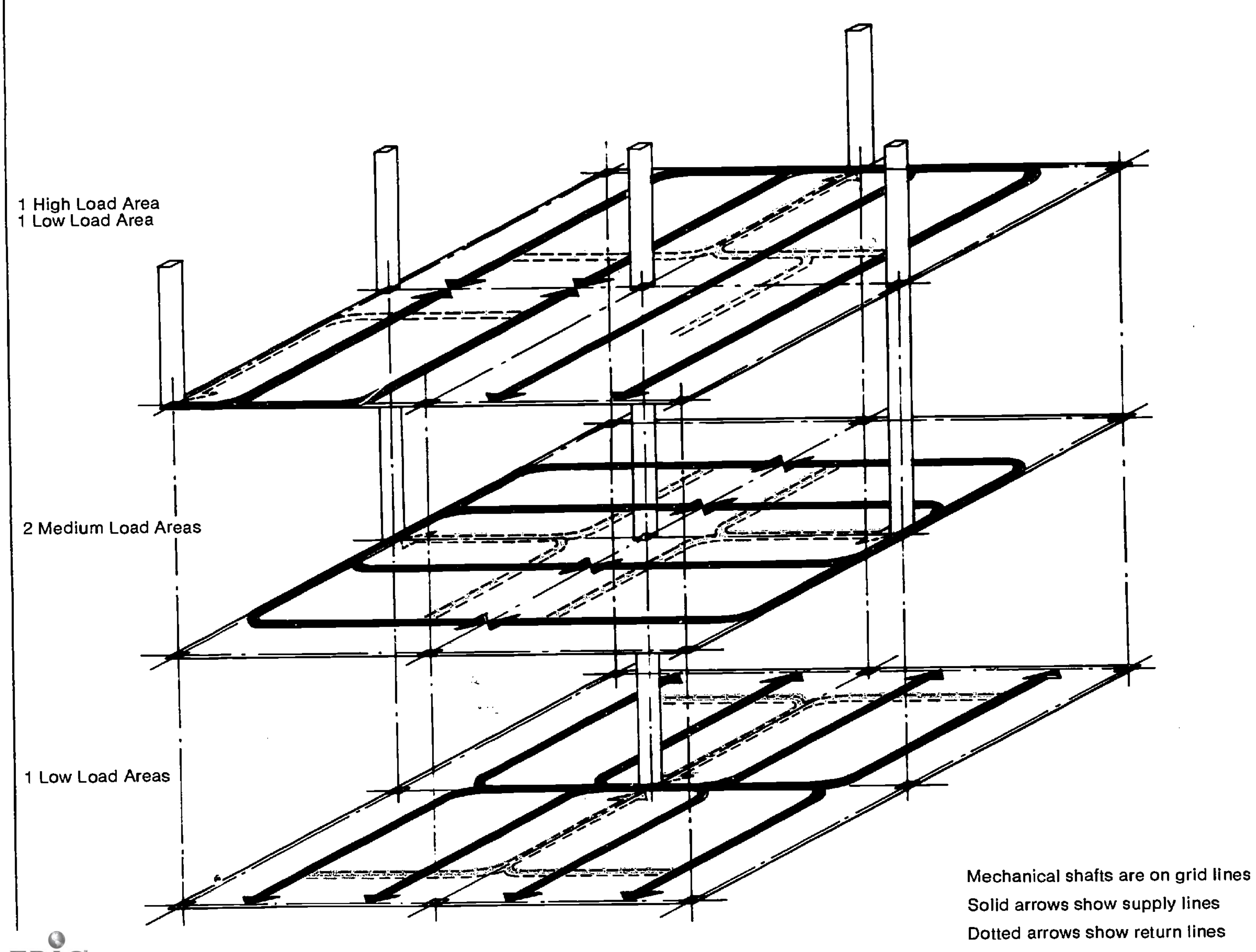
There are basically four choices.

- One large plant
- Smaller plants every two or three phases
- One plant per phase
- Modular package units

Each of these choices has advantages and disadvantages and each college should make a cost-benefit analysis before making this decision. The type of mechanical plant and ductwork system should be conceived in the early stages of design as the choice may place various physical and economical constraints on the building form.

Greater flexibility can be achieved if provision to receive mechanical and electrical service shafts are provided on a grid. In medium load areas, one shaft may be equipped with sufficient ducts to handle the present demands. If a higher load is required in the future, other ducts can be introduced into the nearest unused shaft or, if the load is reduced, the ductwork may be removed and utilized elsewhere.

Isometric Drawing Showing Ducts on Grid Lines and Methods of Distribution



Lighting/Ceiling

The variable intensities and types of lighting required by student tasks and teaching media must be readily accommodated within the lighting system.

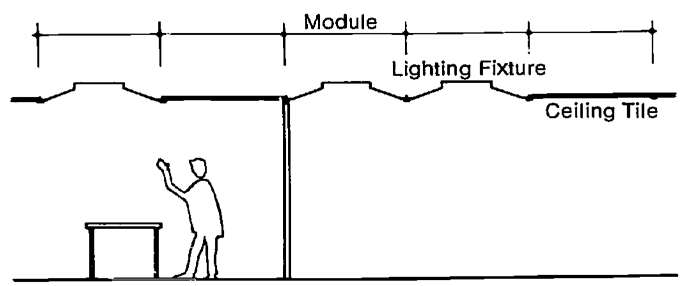
Because natural lighting is unreliable and variable, the lighting level for each task must rely on artificial systems. If the components are suspended in a modular frame (preferably the building module), each unit will be interchangeable with other lighting components as well as with ceiling tiles.

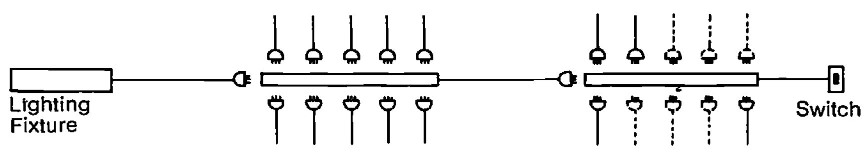
When altering either the lighting/ceiling or partitioning system, make certain that the systems can be rearranged in a combination compatible with necessary resolution of illumination, acoustic, and safety problems.

Plug-in System

If a room size is changed, the electrical controls must be adapted to meet the new room requirements, eg., more or less luminairs. One solution is the SEF system using flexible plug-in cords. In some respects it is less expensive than standard permanent wiring systems because of saving in the cost of junction boxes and skilled labour.

Interchangeable Ceiling Components





Provision of Services
There are three primary areas of concern in the design of an electrical system that will meet the expanding requirements of educational technology.

1 Receptacles should be identically installed in a slightly larger space than needed to provide for future requirements. Flexible electrical strips with snap-on receptacles simplify requirements for multiple outlets in labs.

If receptacles are located three feet above the floor, casework, etc. can be installed along the perimeter of the room without necessitating the relocation of the receptacles.

2 Wiring a modular raceway system facilitates the branching of new services to the existing services. Flexible cord may be used to connect movable components to the main wiring channel. It is most important to have an easily accessible system to facilitate additions and alterations.

3 Special Wiring:

The fire alarm system may allow for both electrical and manual alarms.

The telephone system may allow for simultaneous conversations.

The intercom system may be multi-channel in order to accommodate fire alarm warnings, radio, microphone, TV, and signalling functions.

Control Centres
There are several ways that the controls for service wiring may be installed in a room and still permit the relocation of partitions.

The control centres may include such items as a clock, light switches, special electrical/electronic switches, a thermostat, a fire alarm and/or an intercom device.

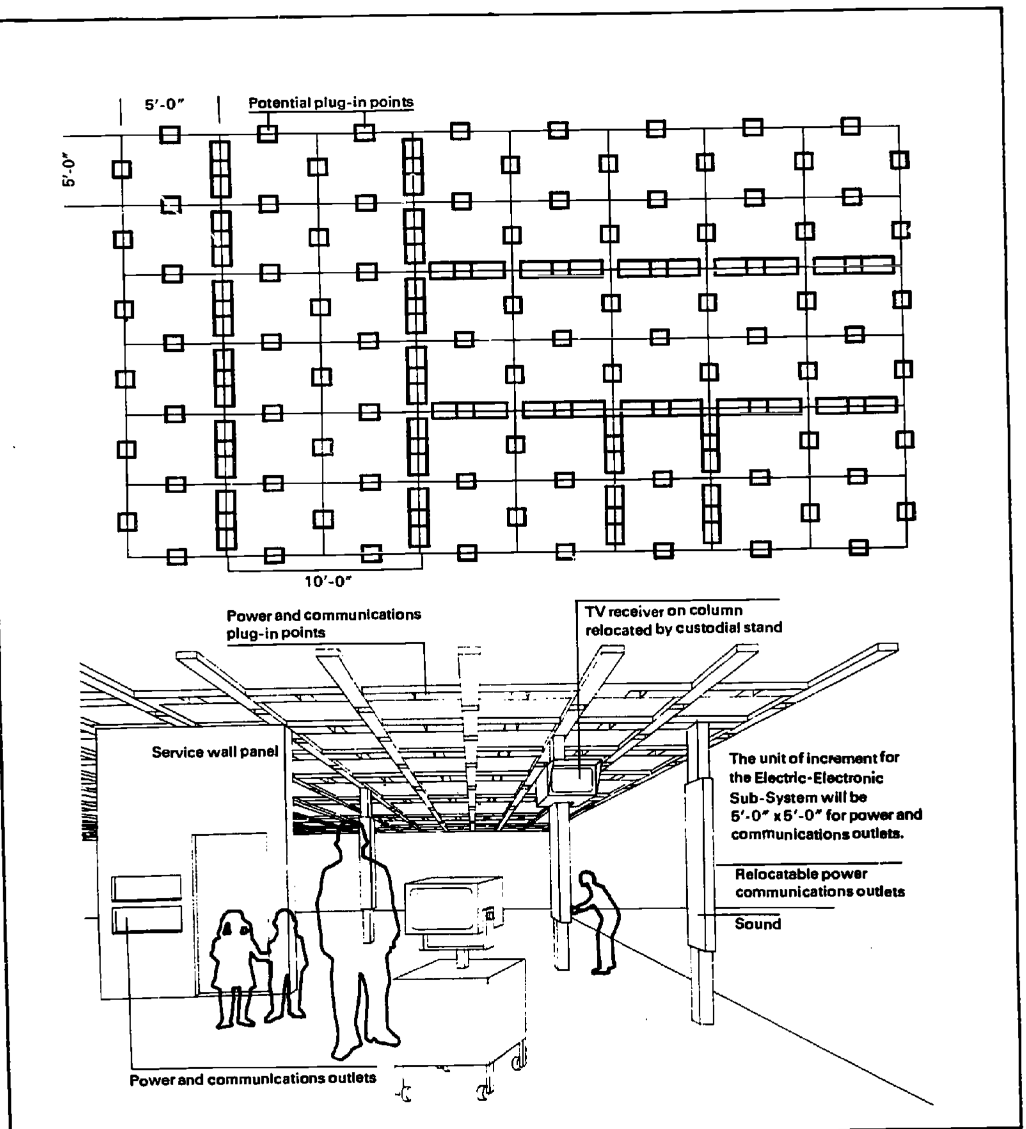
Clip On
The control panel may clip on to the vertical metal support of a demountable wall or may be similarly supported on various other walls by the addition of attachments to the surface.

Special Partition
Assume a building module is 5 ft. and a standard door size is 3 ft. Thus, within that 2 ft. difference, a special control partition will be used. Controls are usually placed by t[illegible]nce/exit for convenience.

At Lambton College a special control panel is located next to the door from the corridor. The door unit together with the control panel is equal in dimension to the standard partition width.

Plug-in
The plug-in method is used by the SEF school construction system. All the electric/electronic services are concentrated in the ceiling to reduce the need for cutting holes through floors and floor finishes. The module for power and communications is a 5 ft. by 5ft. grid as are the other SEF subsystems. Although a subsystem must be capable of this modularity, only outlets that are actually required are installed.

The use of modular components facilitates the interchangeability of components in the control centre.



Plumbing

Pipes must be solidly assembled to withstand pressure. Hence plumbing is probably the most inflexible component in a building.

Installation should be carefully located so that relocation is not necessary and does not interfere with other patterns for expansion and/or adaptations. All plumbing elements should be readily accessible for adjustment, maintenance and renewal.

Laboratory Services

Water, gas and electrical services are found in most college laboratories and shops. Since the probability of reallocation of these spaces in early phases of the campus is quite high, it is advisable that these services be placed along the more permanent walls so that dismantling of partitions has little effect on the services system.

When only a few electrical receptacles were required in a room, placing them on the exterior wall and using long extension cords (taped and aligned so not to pose a hazard) proved more convenient and less expensive than locating them on temporary walls.

Water, gas, and electricity can be brought into a laboratory space by three means; the floors, the walls, and/or the ceilings. Each has advantages and disadvantages.

Advantages

Floors
Allows for variations of furniture in centre and along walls of a room.

Walls
Allows for variations in equipment along walls.

Ceilings
Allows most flexible furniture arrangements.

Disadvantages

Floors

Impedes cleaning.

Walls
Cannot service interior of room without continuous counter from wall.

Ceilings
Services must be hung. May obstruct visual communication.

Service Distribution Systems

Depending upon a building's flexibility requirements, it will use one of two types of service distribution systems:

- Fixed distribution — built-in for specific function.
- Branch distribution — flexible to limits of design of service runways.

Fixed Distribution
This system is usually built into relatively permanent ceilings, floors, and walls to satisfy the requirements of specific functions. It is very inflexible, in that additions or renovations to the system involve the costly loss of materials.

Branch Distribution
Services may be channeled along fixed branches from main arteries. This system is well suited for modular or lab space with high service requirements. Local distribution is brought into a space by flexible conduits.

The Industrialized Total Building Concept

The industrialized total building concept maximizes the construction labour done in factory conditions, thereby reducing on-site labour. The components within any single building system are designed and manufactured to be assembled with little adjustment or waste. To satisfy the required compatibility of each product, it is necessary that they be dimensionally co-ordinated. A number of parts are capable of being installed interchangeably in the space required by another with little or no fitting. The structural components establish the overall dimensional framework for a building without which standardization of other major components would not be possible. Many building systems involve industrialized manufacture of structural components only, leaving the remainder of the building to be constructed from generally available products assembled in the traditional manner. There are four types of structural building systems: frame, panel, box and component. System building is generally defined into two broad classifications:

The "open building system" is one that allows the widest possible range of subsystem components manufactured by others to be physically integrated and dimensionally co-ordinated with each of the related series of parts of the basic structural system.

The "closed building system" is one where the manufacturer sells an entire or nearly complete building package which is not capable of accepting another manufacturer's subsystems. A mobile home is the most extreme example of this type.

Non-system refers to that portion of the work that is completed on site using traditional materials and labour practices.

SEF and California schools building systems co-ordinate a number of modular integrated components which comprise up to 80% of the total building. Both systems deal only with low rise buildings. They offer flexibility of interior rearrangements, mechanical and electrical equipment, and provision for expansion.

A number of features are common to all the major North American educational building systems:

- All are modular.
- Various structural requirements are accommodated by varying column sizes and structural grids.
- Structural grids vary in length and shape up to a maximum span of about 65 ft.
- The structural system usually allows for systematic "open distribution" of services.
- Stairwells and mechanical cores are positioned in permanent locations and act as wind bracing.
- The air handling systems are usually located on the roofs of buildings.
- The ceiling/lighting/air handling/electronics/partitioning systems are all integrated and demountable.
- The partitioning system is usually gypsum board.

Advantages

It reduces cutting and fitting on site.

The building is closed in more quickly therefore weather conditions are less of a concern.

Because site activity is more assembly than construction, the construction work is frequently of a higher quality.

It allows some work to be completed coincidental which, under conventional construction, would have to be in sequence, reducing the total construction time.

Disadvantages

It will be more costly unless a larger complex or several smaller structures are built with the same system. (The original moulds and forms may be costly.)

It will require unified building codes and fire safety standards to be efficient.

The design and construction possibilities are restricted.

Competitive tendering may not be possible.

A Summary of Building Systems

Frame Type	Component Type	Panel and Slab Type	Box Type
Non-committed interior wall system.	Functionally specific space layout may be structural or non-structural.	Committed space layout although some size variations may occur in the same building block.	Committed space layouts.
Utilizes columns, beams, non-structural wall panels and, usually, poured concrete floor slabs.	Utilizes all types of functional components including manufactured stair, wall, ceiling and casework systems.	Utilizes manufactured structural floor slabs and wall panel.	Utilizes structural, manufactured three dimensional modules which may have finished interiors prior to erection.
Relatively simple physical coordination.	Many components are interrelated, thus the physical coordination is critical.	Simple physical coordination.	Extremely critical tolerances, rapid yet complicated physical coordination.
Plan and layout have maximum flexibility.	Plan and layout *may* have maximum flexibility.	Plan and layout must be linear.	Plan and layout must be linear.
Least expensive system.	Very expensive if components *are not* standardized.	Competitive system.	Very costly system.
Average erection time.	May be slightly faster erection time.	Fast erection time (20-40% saving).	Fastest erection time for multi-storey building (30-60% saving).

Conclusion

College buildings must accommodate a wide range of user demands having diverse architectural requirements. Changing educational demands require a building fabric that can be efficiently altered and expanded. However, there is no single architectural solution which will satisfy all college requirements.

The basic approach to the planning of the college has two fundamentals bearing on the future flexibility of the space. The initial planning decisions delimit the possibilities of internal and external changes. Some planning choices have inherent disadvantages, for example, modular planning requires an almost dictatorial adherence to the dimensions of the module, which limits the range of suitable building materials and techniques. This must be weighed against the advantages of simple and efficient internal alterations.

Building materials, mechanical and electrical systems, furniture and equipment also have a basic effect on the flexibility of the space. The first costs of flexible components may be greater than the non-interchangeable alternatives. Often a compromise must be struck between the present budget and estimated future costs of remodelling. In order to evaluate the conflicting parameters the priorities must be clearly understood.

The importance of human adaptability must not be overlooked in evaluating the requirements for functionally specific areas. Decisions must be made concerning the acceptable degree of human adaptation to a functionally inappropriate space which could be tolerated without an attendant deterioration in the educational program. This must be weighed against other demands on the capital budget. The construction of a flexible system does not in itself generate flexible use. Both human flexibility and physical flexibility are vital to the working efficiency of a campus, neither should be evaluated in isolation.

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