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STRUCTURAL CONSIDERATIONS IN SCHOOL BUILDING ECONOMY. SCHOOL BUILDING ECONOMY SERIES, NUMBER 5.
CONNECTICUT STATE DEPT. OF EDUCATION, HARTFORD

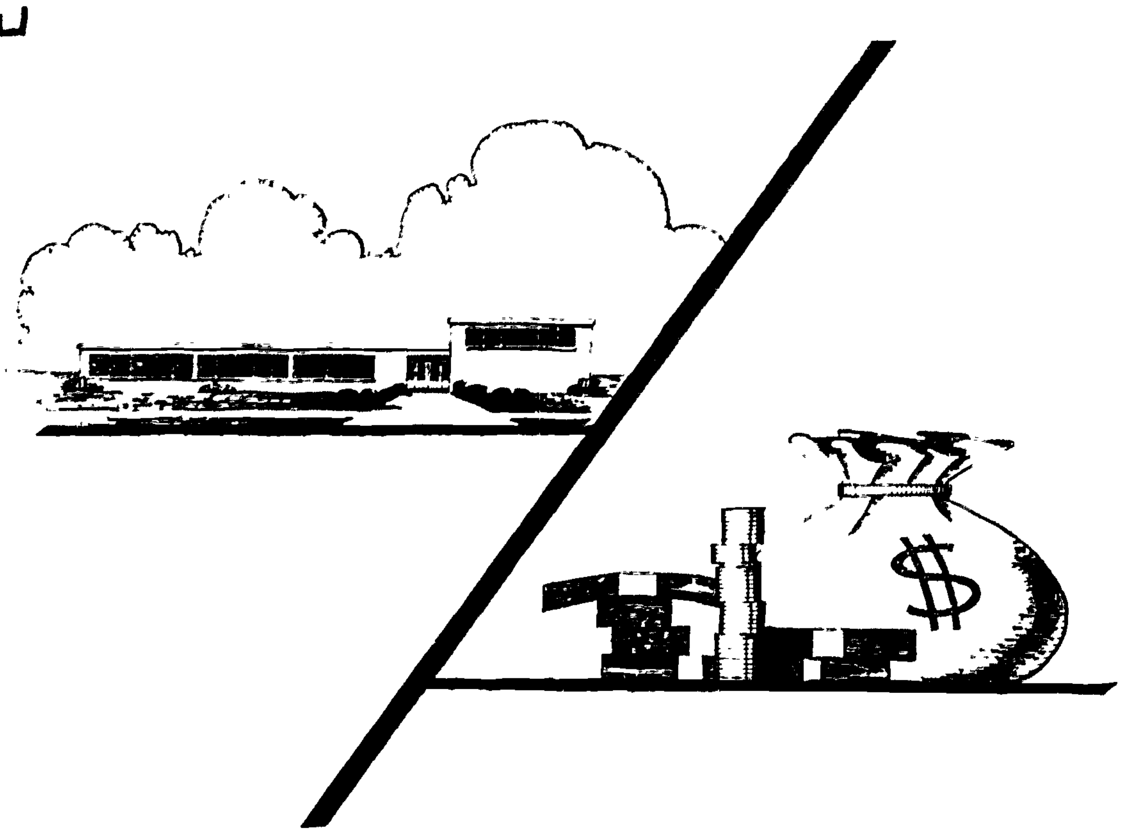
PUB DATE JUN 63

EDRS PRICE MF-$0.25 HC-$1.40 33P.

DESCRIPTORS- *ARCHITECTURAL ELEMENTS, *CONSTRUCTION COSTS, *CONSTRUCTION NEEDS, *SCHOOL CONSTRUCTION, *STRUCTURAL BUILDING SYSTEMS, BUILDING DESIGN, BUILDING EQUIPMENT, PREFABRICATION, SCHOOL ARCHITECTURE, SCHOOL BUILDINGS,

ALL SCHOOL BUILDINGS ARE BASICALLY SHELTER STRUCTURES. THEIR ELEMENTARY COMPONENTS ARE (1) STRUCTURAL MEMBERS, (2) WEATHER PROTECTION ELEMENTS, (3) MECHANICAL INSTALLATIONS, (4) FINISHING ELEMENTS, AND (5) BUILT-IN EQUIPMENT. THE CHOICE OF BUILDING SYSTEMS IS DEPENDENT ON (1) SUBSOIL CONDITIONS, (2) SITE CONTOURS, AND (3) CLIMATIC CONDITIONS. SEVERAL STRUCTURAL SYSTEMS ARE ANALYZED IN TERMS OF THESE CRITERIA. WEATHER PROTECTION ELEMENTS SUCH AS (1) ROOFING, (2) FLASHING, (3) SIDING, (4) WATERPROOFING, (5) INSULATION, (6) OVERHANGS AND SUNSHADES, (7) CIRCULATION CHARACTERISTICS, (8) AIR AND LIGHT PASSAGE, (9) ACOUSTICAL CORRECTION, AND (10) AESTHETIC IMPROVEMENT ARE DISCUSSED IN TERMS OF SCHOOL CONSTRUCTION. THE ASPECTS OF FIRE-RESISTIVITY MENTIONED ARE (1) SAFETY, (2) BUILDING RATING, AND (3) LOCAL ORDINANCES. MISCELLANEOUS ARCHITECTURAL CONSIDERATIONS ARE LISTED ALONG WITH RECOMMENDATIONS FOR THE ADOPTION OF A MODULAR SYSTEM OF DIMENSIONS. (MH)

STRUCTURAL CONSIDERATIONS IN SCHOOL BUILDING ECONOMY



THE SCHOOL BUILDING
ECONOMY SERIES 5

STATE DEPARTMENT OF EDUCATION
Hartford, Connecticut June, 1963

STRUCTURAL CONSIDERATIONS IN SCHOOL BUILDING ECONOMY

SCHOOL BUILDING ECONOMY SERIES — No. 5

State Department of Education

State Office Building, Hartford, Connecticut

June, 1963

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TABLE OF CONTENTS

INTRODUCTION

Under the system commonly used in Connecticut, a school building committee exists or is created to act for each municipality in the construction of new school facilities. This body, in turn, engages an architect to represent its interests and to carry out all the complex details of the planning process and negotiations with the builders.

In the course of the planning process and the construction period many matters involving structural materials and methods must be discussed by the building committee and sound decision reached.

It is quite usual that some or all members of the building committee have little familiarity with the materials and methods about which they must make these decisions. The usual result is a cumulative delay in progress during a critical period and serious errors are possible through misunderstandings.

Therefore it is the purpose of this booklet, fifth of the SCHOOL ECONOMY SERIES, to provide a brief review of some of the basic aspects of structure for the lay members of school building committees. It is neither expected nor intended that perusal will make the reader an expert in structural matters; rather, it is our belief that this additional glimpse into the structure of buildings will substantially assist building committees toward saving valuable time and in more effectively guiding their architects toward attaining the maximum value in new Connecticut school buildings.

Richard L. Howland, Architect
School Construction Economy Service

CHAPTER I

SCHOOL BUILDINGS — WHAT ARE THEY?

An umbrella is one kind of "shelter structure." It has been designed with specific qualities and purposes in mind. Closed, it is light and compact for portability; when opened, it affords a degree of shelter from rain, snow, or bright sunshine.

Fundamentally, all buildings are shelter structures. They are designed to provide varying degrees of protection from an unsympathetic environment for a vast number of human activities.

A school building is a shelter structure so designed and built as to provide as ideal an environment as practical for a large number of activities which together make up the educational program of the school.

The basic parts or components of a school building fall into five natural classifications:

Structural Members	— The foundations and those parts which support the enclosure of space; the "bones" of the building. These "bones" may take the form of an interior skeleton, an exterior shell, or a combination of both.
Weather Protection	— Those components which keep out rain, snow, wind, dust, and inhibit transfer of heat energy.
Mechanical Installations	— Equipment and machinery for heating, cooling, lighting the enclosed spaces, for communications, and for supplying fluids, gases, and solids to various interior points and removing waste.
Finishing	— Covering materials such as floor tile, wall coverings, ceilings, paneling, paint, decorations and the like.
Built-in Equipment	— Items of many sorts and for various purposes, such as folding partitions, lockers, kitchen equipment, wardrobes, basketball backstops, stage equipment, venetian blinds and so forth.

The selection of any system or component must include careful consideration of all the others in the total assembly so as to assure their mutual compatibility. Each item must fulfill its purpose without interfering with the function of any other part. The possible number of combinations of materials is almost literally infinite and making the best possible selections is a matter requiring a high order of professional skill and experience on the part of the architect.

In school buildings, the "shell" of the building — that is, the structural elements and weather protection components that they support — usually represent over forty percent of the total building investment, exclusive of site work and outside utilities. It is this "shell" that is to receive our attention in this booklet.

CHAPTER II
LOCAL CONSTRUCTION PROBLEMS

Before discussing methods and materials, it should be pointed out that local conditions commonly affect the choices to be made to a considerable extent. Special thought should be given to:

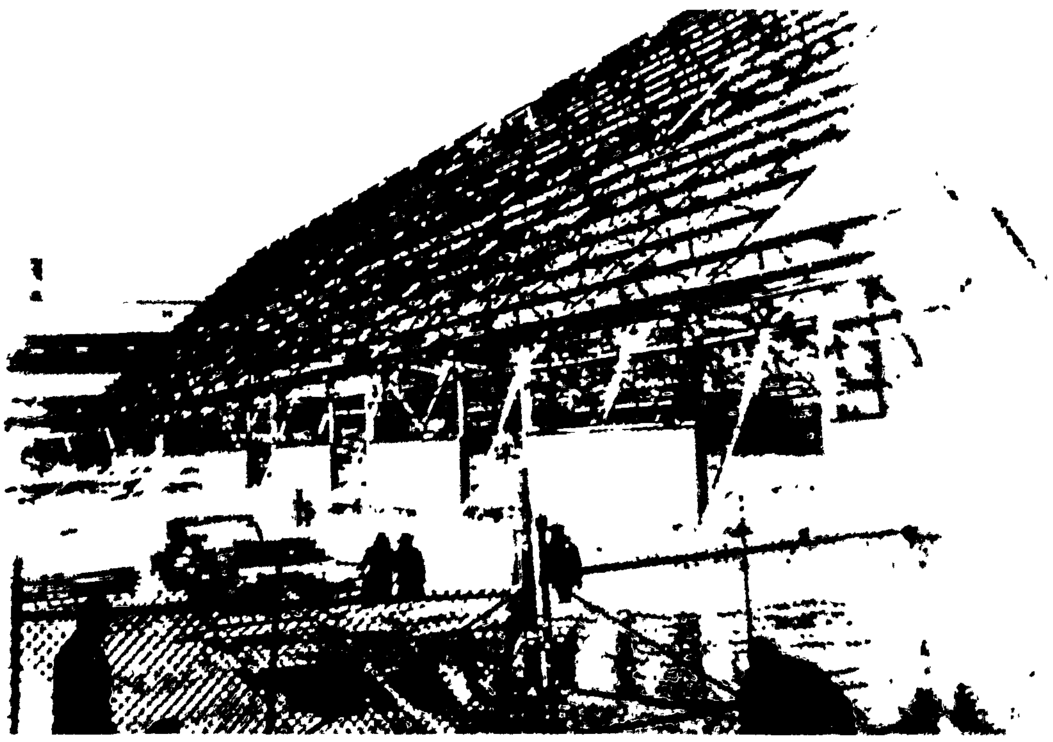
Adverse Subsoil Conditions such as rock, poor bearing soils, high water levels or soils impervious to water will usually cause difficulties and increased costs. Rock excavation requires extraordinary methods and is relatively expensive. Poor bearing soils may require piling or other expensive means of providing an acceptable foundation and should be avoided wherever possible for schools. High water levels will require expensive measures for waterproofing any basement areas, cause extra dewatering costs during construction and may make sewage disposal systems either unduly expensive or entirely impractical. Soils impervious to water lead sometimes to surface drainage problems, erosion, and will make sewage disposal either difficult or impossible.

Obviously, a site should not be seriously considered for a school building unless these matters have been investigated, and no building should be designed before its proposed location has been subjected to a thorough subsurface inspection by borings or other means acceptable to those responsible for design success. In this connection, a review of ECONOMY BULLETIN No. 3, "School Sites — Selection and Acquisition" is recommended.

Difficult Site Contours may cause substantial extra expense. However, the complications of site contours are not readily comprehended by most laymen and their evaluation is best left to the architect and to the land-planner, if one is involved. Frequently an imaginative designer can find ways of utilizing what is seemingly a difficult site with results more satisfying than those achieved on a monotonously flat site. Whenever possible, an architect should be consulted on site selection, and preferably the architect who will ultimately design the school to be built there.

1.

Winter Weather with its cold winds, freezing temperatures and snow brings difficulties. Foundations cannot be placed on frozen soil, nor can frozen soil be easily moved by ordinary means. Concrete ingredients must be heated and poured concrete must be kept from freezing until fully set. Artificial heat and weather protection must be provided for masonry work, and workmen cannot perform efficiently in outdoor winter conditions. All along the line, until the building is enclosed and its heating system operative, special measures must be resorted to for winter construction, all of which increase the cost with no improvement whatever in the resulting building. The contractor, meanwhile, is subjected to strong temptations to "save" these extra costs, to the probable detriment of the finished product. Consequently, for economy's sake, projects should be so timed as to avoid winter construction whenever possible. Such practical timing, naturally, requires an earlier start to the planning period than municipal procrastination frequently permits.



2.

CHAPTER III

STRUCTURAL SYSTEMS AND COMPONENTS

Before structural systems and components are selected for a given building, the following matters must be given careful thought by the architect:

Site Contours may profoundly affect the form of a building and hence the type of structural system best adapted to it. Sometimes modifications to the shape of a site may permit structural methods which more than save the cost of the earth-moving involved. In addition, site contours particularly affect sewage disposal and storm drainage systems; modifications to contour may be less expensive than accommodating the system to existing shapes, and will often deserve serious consideration.

Design Assumptions as to loads which will be carried are basic to all structural designs. Care should be taken that these assumptions are entirely rational, within legal limits of such building codes as have jurisdiction. Overdesign through unrealistic assumed loadings and material strengths can lead to waste of significant proportions.

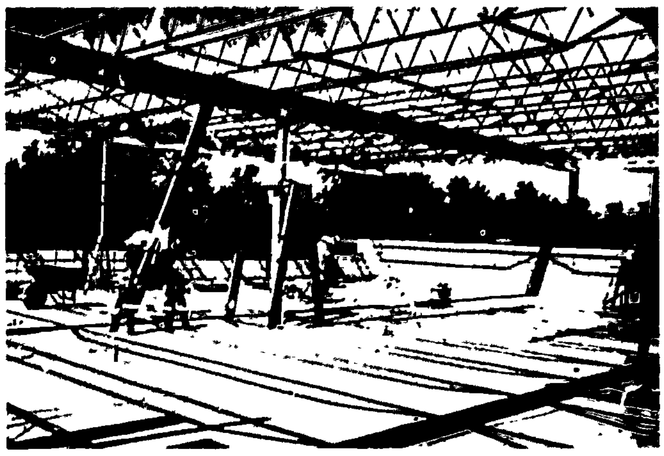
Structural systems, which include foundations, are many, with new schemes being developed almost constantly. However, most of them are based upon a few very fundamental ideas:

Masonry Walls or Piers have been used since before written history began and are still very actively in use. Openings are necessarily limited to size and location, but the "bearing wall" is frequently found in smaller contemporary one-story school buildings, usually somewhat in this fashion:

3.

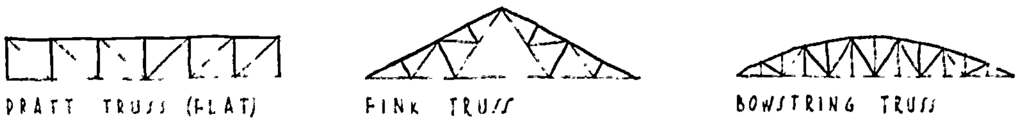
Post and Beam is the designation for the idea basic to the usual simple steel frame found frequently in school buildings, and the system permits great flexibility in the size and location of openings. Its source is earlier wood construction, though it may seem more complicated when developed in structural steel:

4.



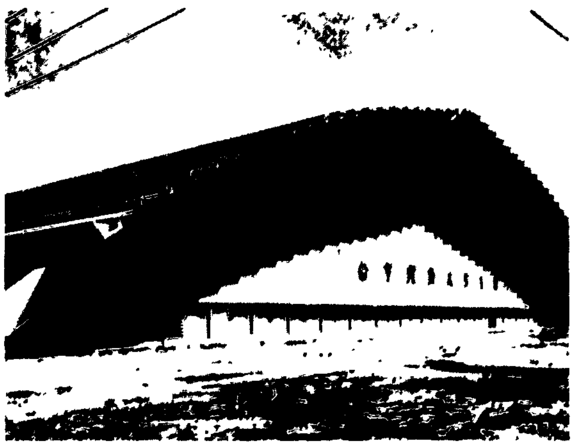
5.

The Truss, originally done with wood, has been executed effectively in steel for many years. Its purpose is to develop sufficient stiffness to span larger spaces with less material and weight than would be necessary with an ordinary beam. A few of the very many forms are:



6.

Arch, Vault and Dome were developed to a high degree by the Romans many years ago, but modern methods have resulted in much thinner structures of this type, spanning far greater distances than were previously possible, with resultant economy. The principles involved are frequently utilized in materials such as wood and steel, as well as in reinforced concrete and the original masonry materials. Following are examples of the forms involved:



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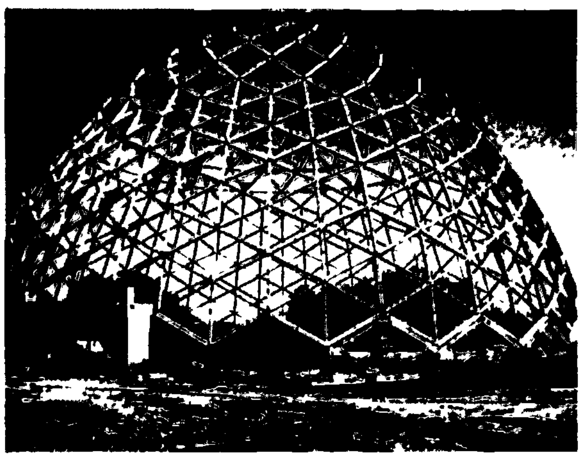
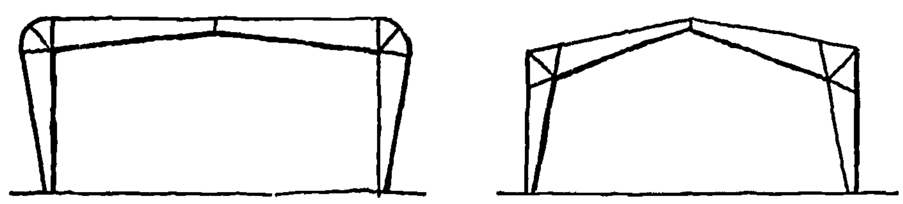


9.

Rigid Frames are relatively recent and executed in steel, laminated wood, or reinforced concrete in a variety of forms, including the following:

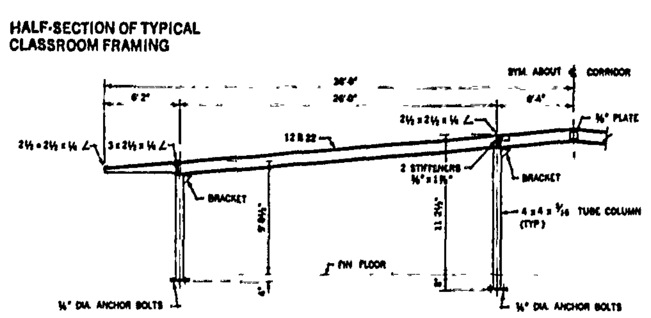


10.

11.

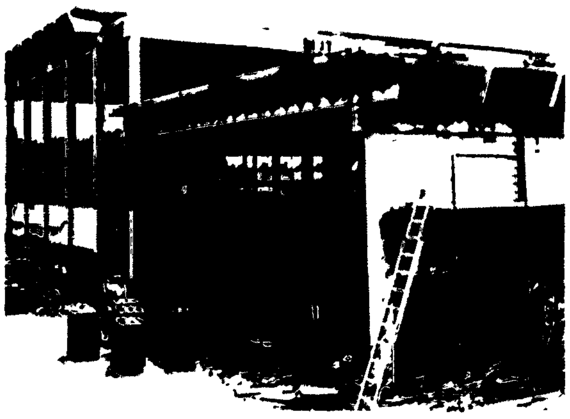
Thanks to rapidly advancing science, mathematics and construction technology, newer systems are increasingly used, including:

Cantilevered Framing, ordinarily done in steel, looks like "post and beam" construction, but newer design techniques, coupled with different connection locations and methods, permit significant economies in the quantity of material used, when its principles are applicable:



12.

P..ast and Prestressed Concrete members have been extensively utilized for school construction. Such members may be either factory-made or cast on the job, as conditions may require, and assembled in place at the site. Prestressing the steel in reinforced concrete members involves a "stretching" process which reduces bending of members, increases overall strength and permits substantial reductions in material requirements. Precasting of sections takes advantage of duplicating techniques to prod''ce structural members more economically than they can be cast in individual forms in the final locations. The "Lin-Tee" and the "Flexicore" slab are examples of factory-made prestressed reinforced concrete members:



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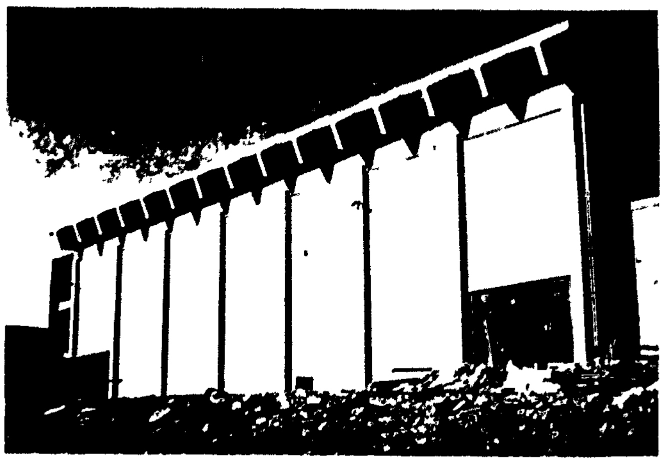

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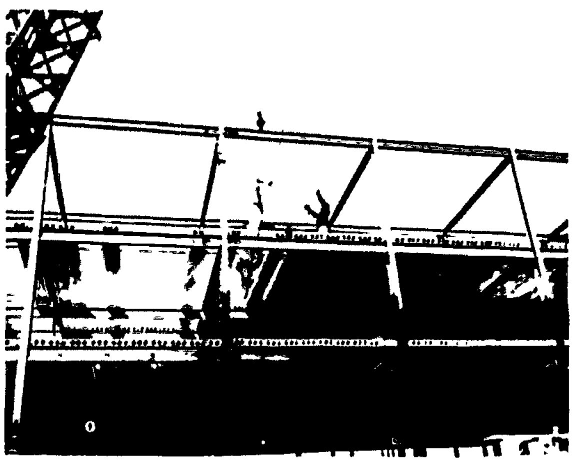
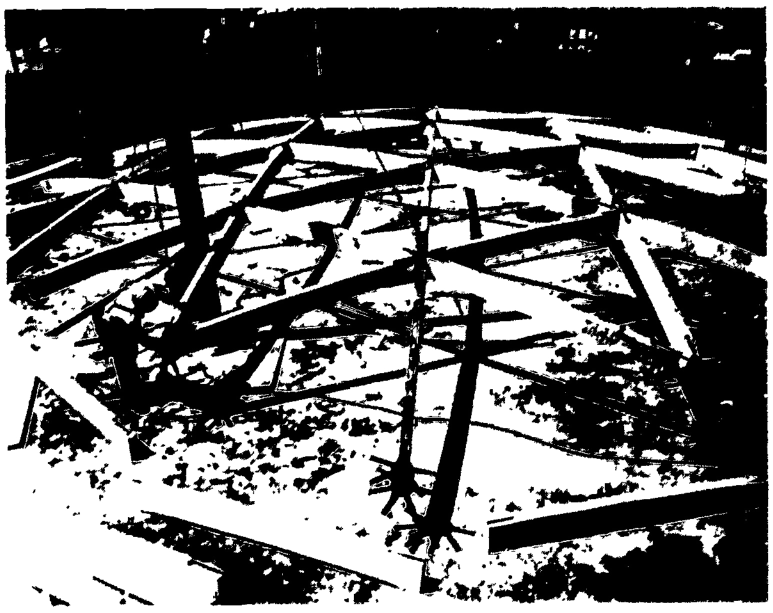


15.

The Geodesic Dome, invented and developed by R. Buckminster Fuller, is capable of a great range of spans with relatively little material, using small, easily transported interchangeable components, such as shown below. It has been used for athletic field houses and other large spaces in school plants, with resulting economy where it is adapted for use:



16.

Lift-Slab construction technique, invented and developed by Youtz and Slick, has its major use in multi-story buildings, though it has been used in one-story schools. Its economical use depends greatly on uniformity of support locations and other factors which must be considered in the basic design. The technique consists of casting flat slabs on the ground atop one another and then jacking them up the columns to their final locations, where they are welded into place.

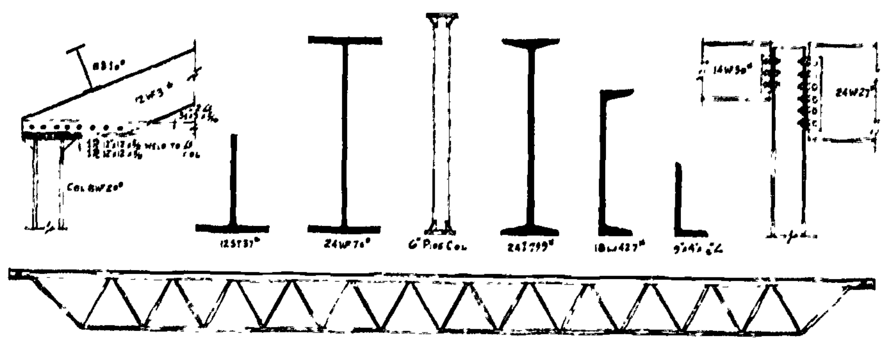
17.

Criteria for System Selection — The architect, together with the structural engineer, must select an economical system or combination in accordance with their experienced judgment of a great many factors, among which are usually included the following:

— Distances to be spanned; appropriate column-to-column dimensions
— Occupancies and resulting floor loadings
— Local climate; wind loads, snow loads, seismic and atmospheric conditions
— Local subsurface conditions
— Degree of fire-resistivity required for safety and overall economy
— Building type; number of stories, spread out or compact form
— Season of the year for construction period
— Local availability of necessary materials and installation skills
— Practicality of erection and placement techniques for specific methods
— Appearance, if structural system is not to be concealed
— Compatibility of systems with mechanical installations

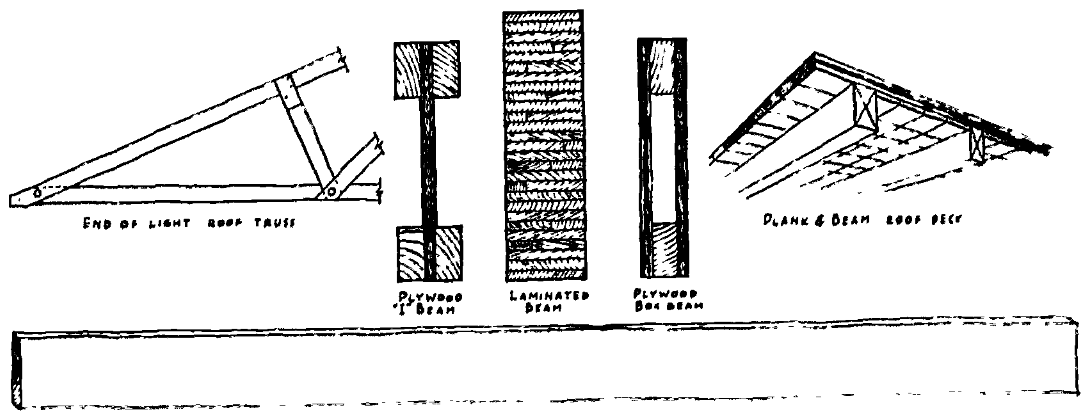
STRUCTURAL COMPONENTS are many, but the principal classes are these:

Structural Steel: Rolled, red-hot, from cast ingots of mild steel, sections can be cut, punched, drilled, assembled and erected with considerable precision. Members are joined by bolting, riveting or welding. It is non-combustible, but requires insulative protection to gain substantial fire-resistivity ratings.



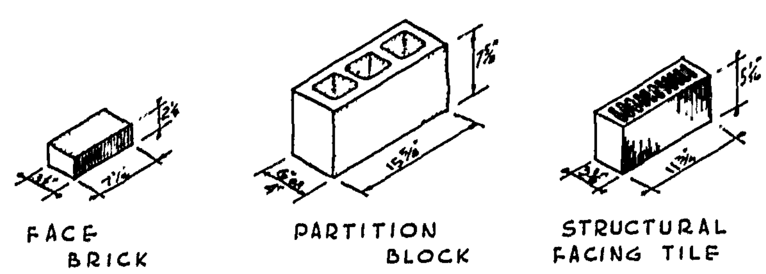
18.

Structural Wood: This versatile material is processed into many forms for a great many different uses. Its greatest virtuosity is developed through laminating and the unique structural uses are primarily made possible with plywood and heavier sections made up of glued-up laminations. Rendering these materials fire-resistive is possible, but generally too expensive to be competitive with other materials where higher ratings are required. Heavy timbers and glued-up sections, however, burn slowly and retain strength far longer in a fire than unprotected steel members.



19.

Laid-up Masonry: These are ancient materials, now made highly consistent as to quality by modern methods of production control. Installation is still a hand labor process, however, and the finished product is greatly dependent upon assembly skill and care. Practically all masonry products are inherently non-combustible and, as assembled, carry good fire-resistivity ratings.



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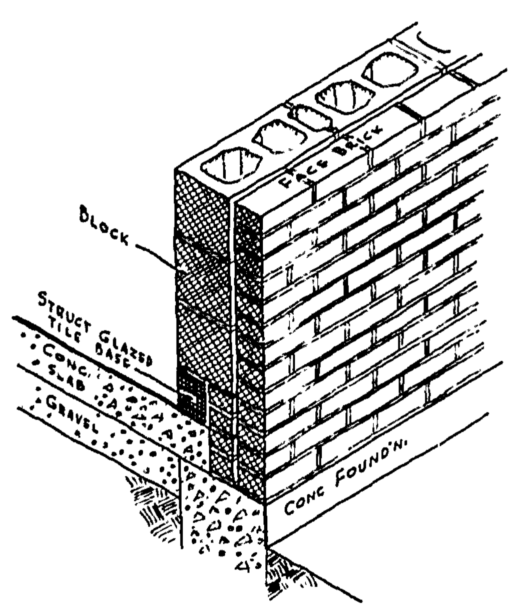


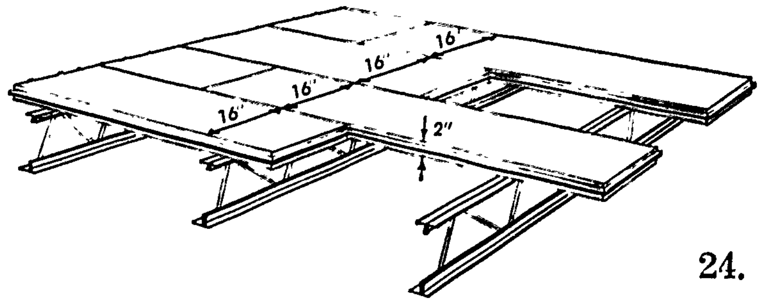
21.

Reinforced Concrete: This non-combustible material can be poured into practically any shape that can be formed, hence is one of our most flexible materials. Intricate forming and reinforcing, however, can make expenses rise rapidly. It is at its economical best in slabs on grade and foundations. Where higher fire-resistivity ratings are required, such as in multi-story structures, it is often the most economical. Winter temperatures increase job concreting costs substantially. Pre-cast members are increasingly used, and factory-made components are particularly advantageous for winter construction, where haulage distances are not too great.

22.

23.

Roof Decking: Many materials are now available either partially or wholly prefabricated and running the gamut from combustible wood to non-combustible light-weight concrete and metal-bound gypsum "planks." These are generally well adapted to cold weather construction, though some must be protected from wetting. A great variety of steel decking is available, including some with acoustical properties and those providing for mechanical installations. None of these are fire-resistive to any great extent without additional insulative protection. Poured-in-place materials include reinforced gypsum and portland cement concretes with various light-weight aggregates. Some of these are poured on acoustically absorbent, permanent form-boards. A number of decking systems are suitable for exposed installation, thus permitting the economical omission of a separate ceiling, at the penalty of finding other locations for piping and ductwork.



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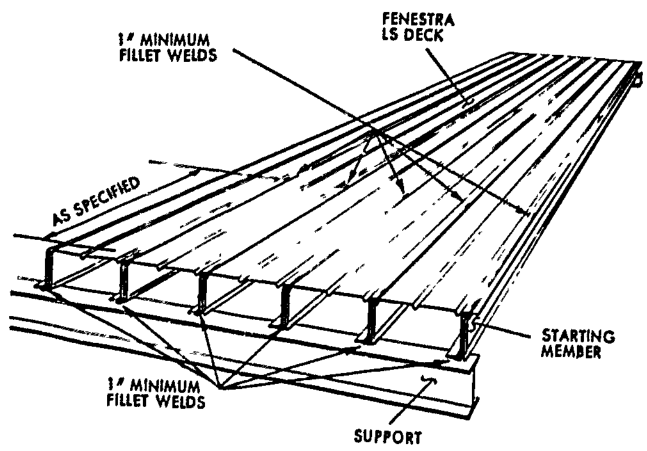

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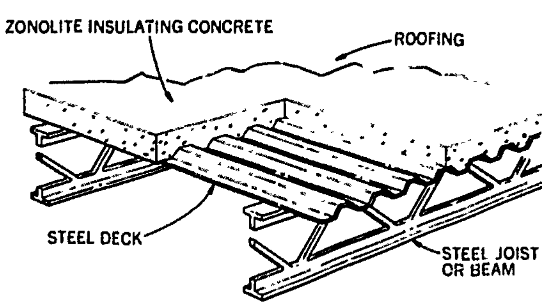


26.

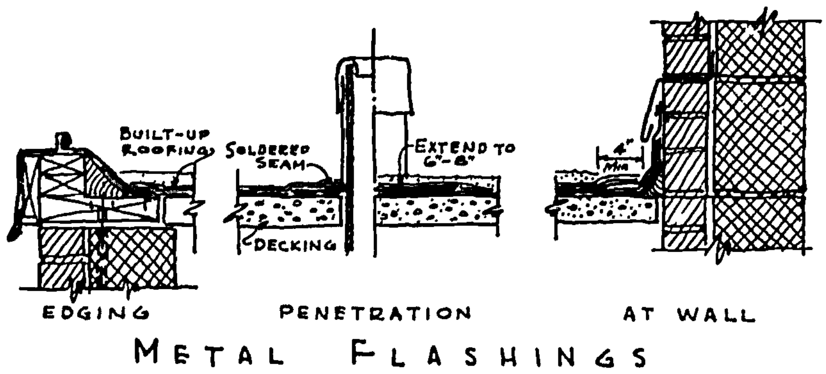
CHAPTER IV
WEATHER PROTECTION ELEMENTS

These include the items which give control of the effects of outdoor weather conditions, and involve the following:

Roofings — Except for shingle types, roofings consist of a membrane impervious to water, extending over the entire structure. Usual materials are multiple layers of felt, cemented together and to the decking with pitch or asphalt and covered with gravel or other wearing surface, also set in pitch or asphalt.

27.

Flashings — These are of metal or heavy felts and are used to join the roofing to other materials, such as edgings, walls, and openings through the membrane at various points.

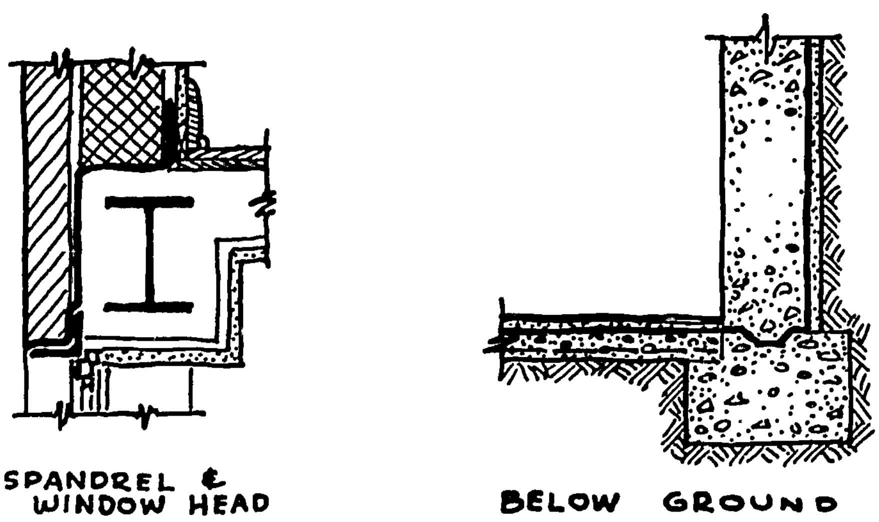


METAL FLASHINGS 28.

Sidings — Sidings are used for exterior vertical surfaces, and may or may not be load-bearing; usually the latter is the case. Their function is to keep cold air and water out of the building and the heat inside, while providing privacy and security.

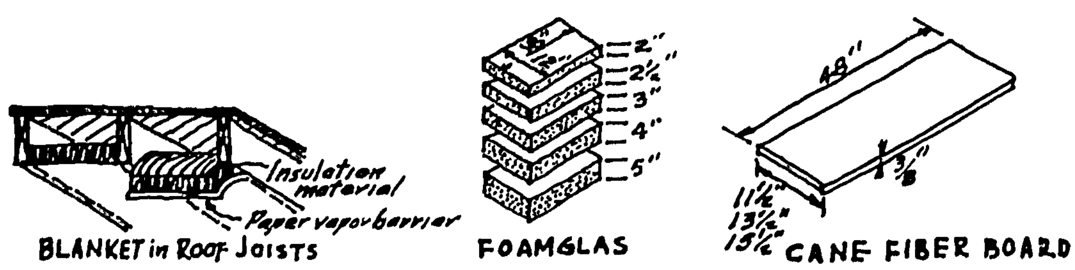
29.

Waterproofing — These are intended to prevent moisture penetration through walls, both below and above ground, and from beneath floors. Wall installations are usually discontinuous, somewhat in the manner of shingles, but below ground, where water pressure is likely, a continuous membrane is required.



30.

Thermal Insulations — These materials are intended to discourage the transfer of heat, either to conserve that inside a building, or to exclude outside high temperatures and solar radiation. Various materials are used, but all involve small entrapped air spaces to prevent heat transfer. Most types are prefabricated into slabs or panels, though some applications are sprayed on or poured into place. Many types of structural materials, including wood, are such as to have inherent insulative value as well as suitable strength.



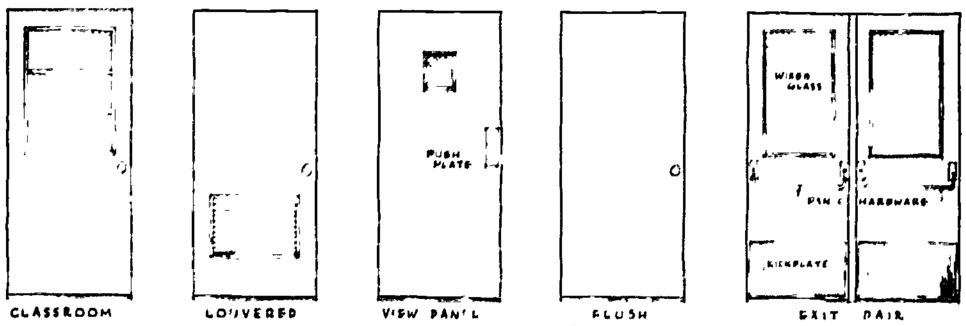
31.

Overhangs and Sunshades — These may be extensions of the roof itself, or be attached to the roof structure, though vertical screening is sometimes built up from a wall in the earth. Their purpose is to minimize heat input from solar radiation and to improve interior seeing conditions by means of reduction in high brightness contrasts.

32.

While keeping adverse climatic effects at bay and retaining desirable interior conditions, assemblies of these components provide for additional functions by the following means:

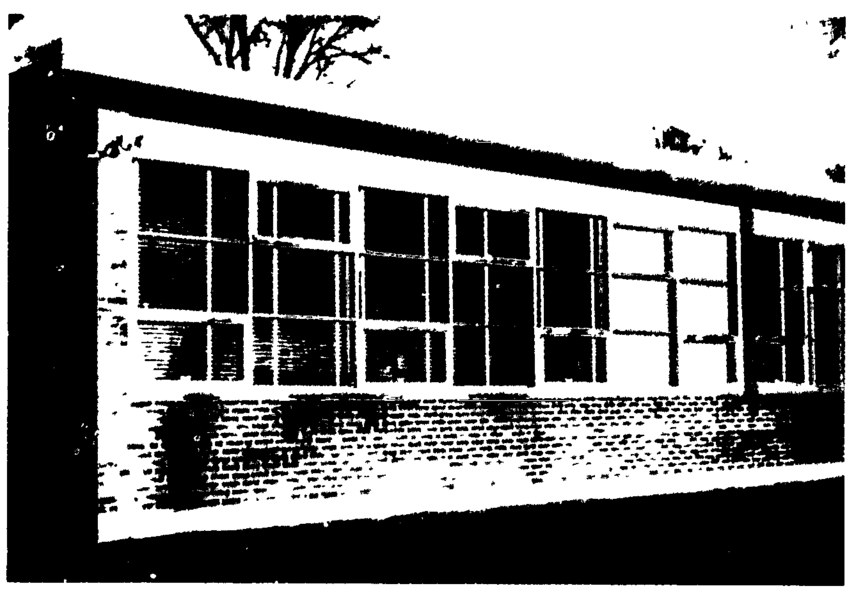
Passage of People and Goods — The people for whom the building is designed must have convenient and safe means of ingress and egress, mechanically dependable and reasonably secure from unauthorized entry. Doors of both metal and wood, together with their frames and hardware, perform these functions well. Examples in common use include the following:



TYPICAL SCHOOL DOORS – WOOD OR METAL

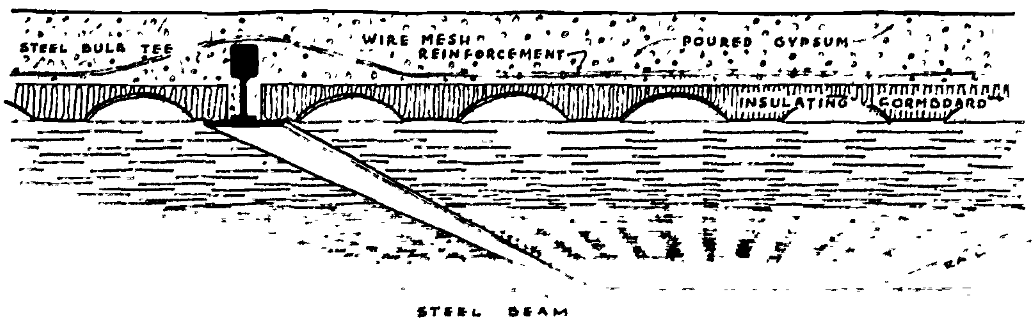
33.

Passage of Light and Air — Windows of metal, usually nonferrous, are increasingly used because of installation simplicity and freedom from future maintenance. Glass, ar ancient material, is periodically improved, so that a great variety is now available, including tinted, heat-absorbing, wired, many translucent patterns, and even impact-resistant plates. Thus varied requirements for light admission, seeing or not seeing, fire-resistivity and strength can be met. Most forms of windows can be equipped with a variety of opening types and locations for the admission of outdoor air. Where air only is to pass, louvers are ordinarily used.



34.

Acoustical Correction — Where acoustical absorption is desired, some structural materials, notably roof deckings, are able to perform this function quite well, in addition to being the finished ceiling.

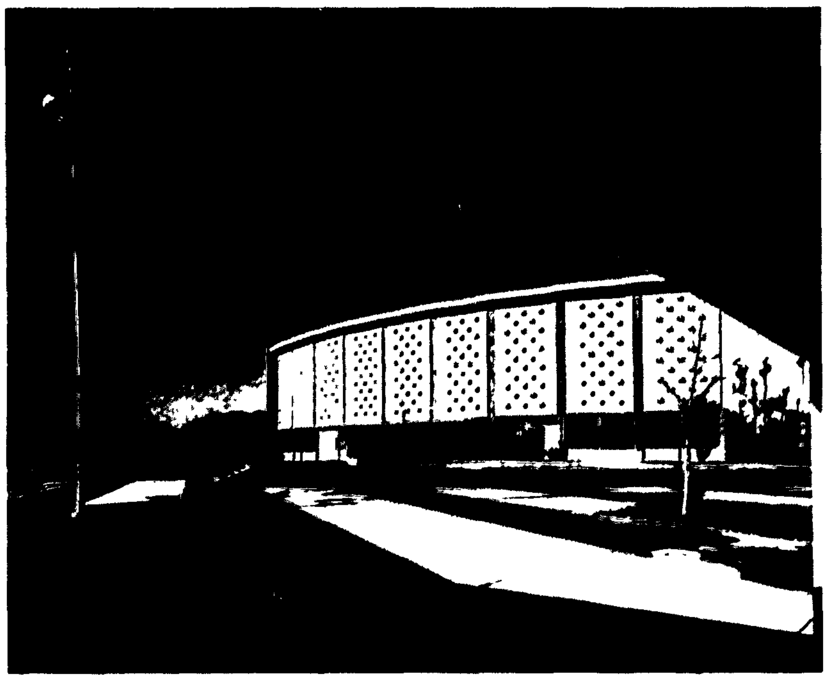


STRUCTURAL - INSULATING - ACOUSTICAL
EXPOSED ROOF DECK

35.

Aesthetic Improvement — A number of structural materials are either surface-treated or may be arranged in assembly to greatly enhance the texture and appearance of finished surfaces — even to the extent, on occasion, of including works of art. Many blocks, tiles, and bricks are available in surface textures and colors of great variety. Block and brick in particular lend themselves to artistic arrangement to add interest to otherwise dreary surfaces, at a very minor additional cost for labor.

36.



37.

DECISION MAKING: The range of materials and equipment available to the architect today is almost literally bewildering. (Sweet's Catalog of manufacturers' literature in this field is a set of large volumes extending over more than three feet of shelf space, for example.) New techniques are being developed constantly, yet evaluation is frequently difficult. Strikes and market conditions often adversely affect some materials or methods at particular times. Some materials are cheap initially and expensive to keep up as the years go by, and the converse is also true. All these factors and more must be considered and balanced against the requirements of the particular job at the particular time involved. Only scrupulous care and a high professional competence can provide the "right" combination of all the items that go into a modern school building and its grounds.

CHAPTER V
FIRE-RESISTIVITY IN SCHOOLS

School fire safety is intimately involved with the structural and weather-protective elements of the building. It is most important, however, to distinguish between two quite different but closely related aspects of the problem:

Human Safety is primarily concerned with the isolation and containment of hazardous conditions, the provision of early and adequate alarms, and rapid, safe means of egress to a place of refuge. Minimum requirements for human safety in schools are established by regulations of the State Fire Marshal and are published in the "State Fire Safety Code." A national standard, for optional local adoption is the "Building Exits Code," published by the National Fire Protection Association.

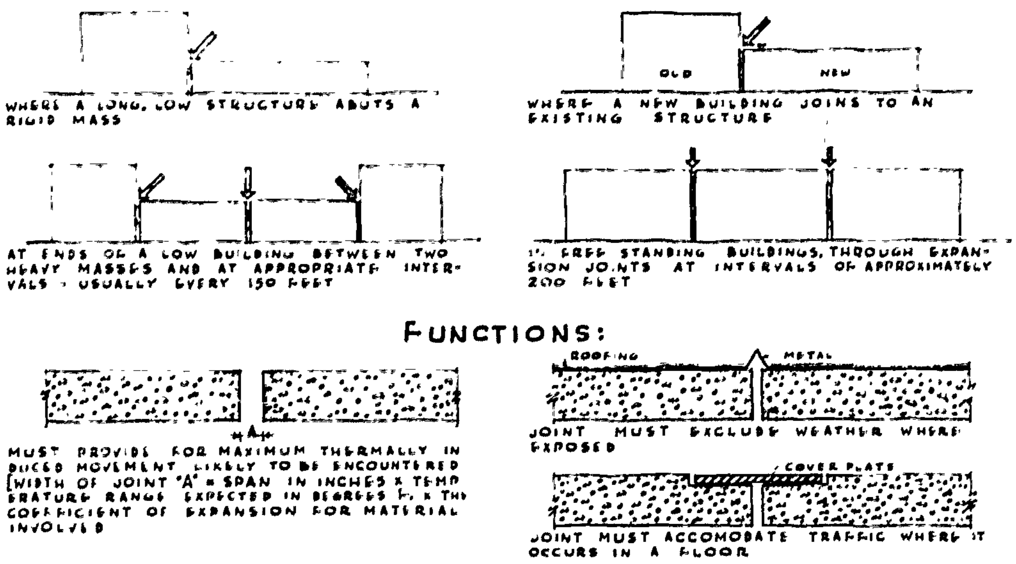
Property Safety directs attention more toward minimizing financial losses due to fire. This is accomplished by various means, including reduced combustibility or the protection of various materials, the subdivision of spaces by firewalls, plus alarms and automatic extinguishing systems. Recommendations in these matters are published by the National Fire Protection Association and the National Bureau of Fire Underwriters. Insurance rates vary in accordance with the degree to which these recommendations are carried out. "Base" rates may be radically adjusted by many related details; for this reason it is well to consult the nearest office of the New England Fire Insurance Rating Organization during the development of school building plans. Arrangements may well be made through the local agent who will handle the owner's account after completion; frequently advice given then will result in very substantial savings through lowered insurance premiums over the entire long life of the building.

Ratings: "Fireproof" is a term often loosely used. Buildings are properly classified as to "fire-resistivity," in terms of the time various portions, such as columns, floors, partitions, will withstand a standard, test fire condition. These ratings are based upon actual tests, and may be obtained from listings of the National Board of Fire Underwriters. Non-structural surfacing materials are rated to a "Flame-spread" scale, indicating the relative speed with which materials will assist a fire to "travel" within a building.

Local Codes or ordinances and the State Building Code are frequently adopted by municipalities and enforced everywhere within its boundaries. Consultation with the local Fire Marshal and Building Inspector is always a wise step to take during development of plans, so that costly changes may be avoided at later planning stages, during construction, or even after completion. Occasionally local ordinances may impose unrealistic restrictions or are subject to unusual interpretations which adversely affect costs as compared with general practice; all local building requirements should therefore be investigated with care in order to avoid costly non-compliances.

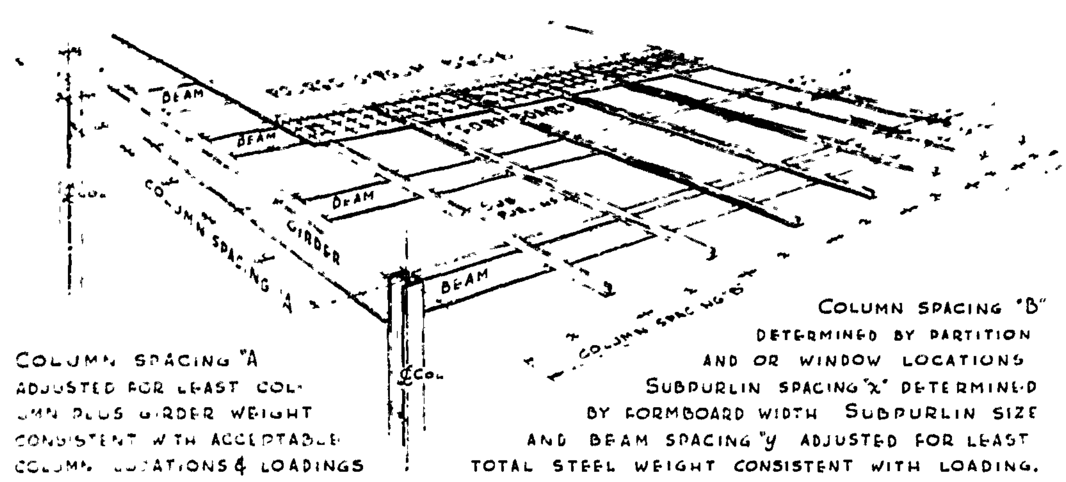
CHAPTER VI
MISCELLANEOUS CONSIDERATIONS

Expansion Joints will be needed in larger buildings to allow for movements due to temperature changes or the varying settlement rates of additions to buildings.



38.

Span-Load Ratios should be kept relatively low for economy's sake. For example, one does not locate a heavily loaded area such as a gymnasium directly over a large space having no intermediate supports. It should be noted also that most systems have optimum spans or bay spacings which prove most economical with a given load condition:

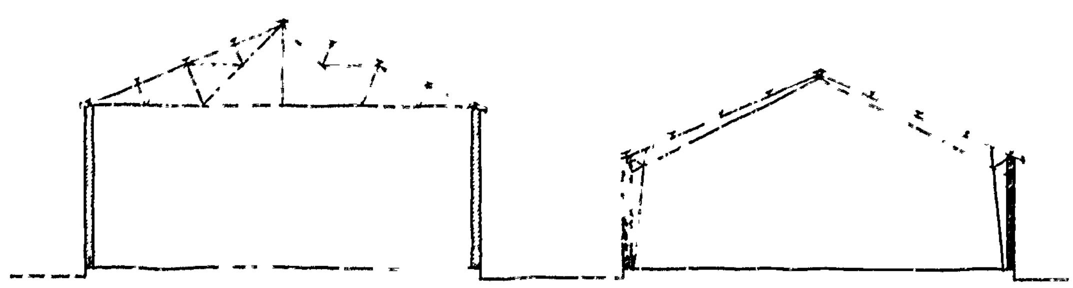


39.

The various spacings and sections must be studied and compared in order to choose combinations using the least structural steel or other material compatible with partition and window locations.

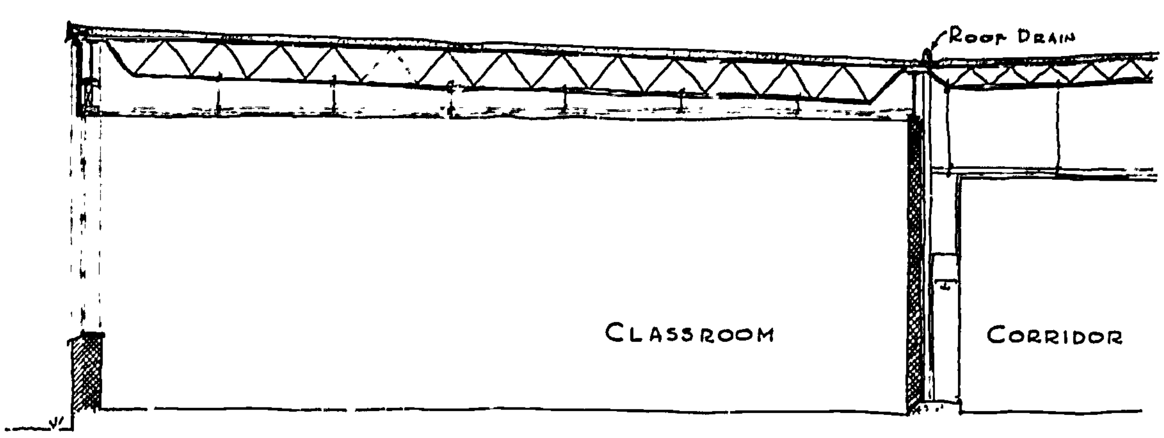
One-Story vs. Two-Story is a perennial subject for discussion. This question should be resolved in each individual case, on its own merits, and in the light of local conditions. Sometimes site conditions — too small or too steep, and so forth — will dictate more than one story. Some plants are so large that more than one story is justified to avoid long travel distances for occupants and far-flung utility lines. When the disadvantages of more than one story are carefully considered, it is seldom that a moderate school building of more than one story is justified. This subject is treated in more detail in ECONOMY BULLETIN No. 4, "Designing the School Plant for Economy."

Roof pitches will vary according to a number of circumstances. Steep pitches may be used to enclose trusses or minimize wall height with rigid frames spanning large distances:



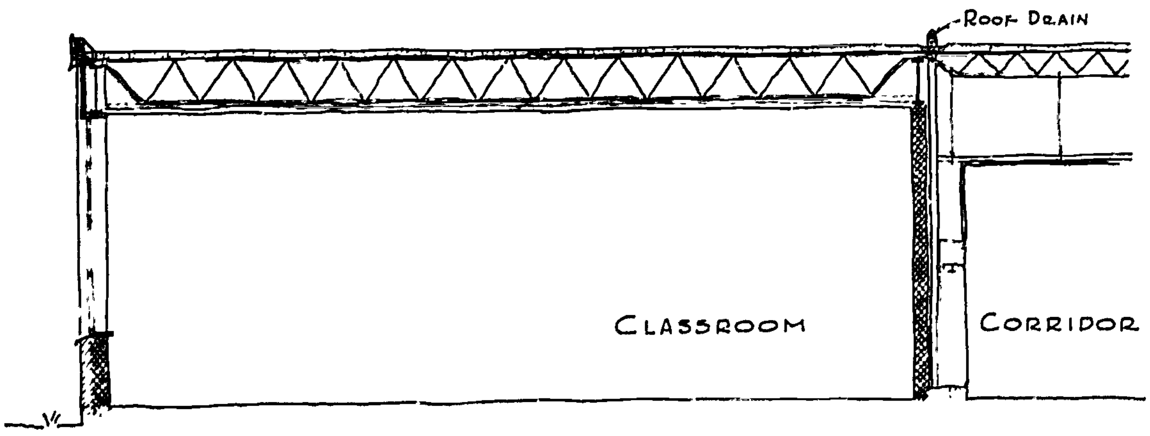
10.

Gentle slopes toward central points are frequently used on "flat" roofs to guide water to interior roof eaves connected to storm water drainage system:



11.

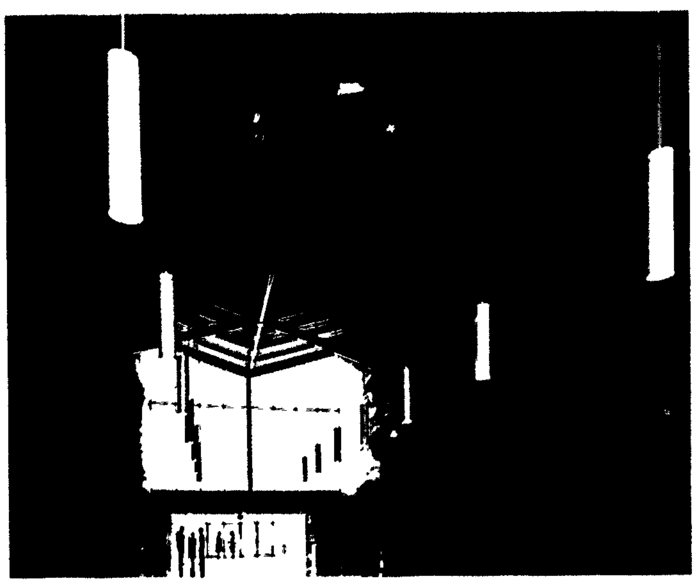
Occasionally, roof decks are made substantially flat so as to permit the economy of attaching the ceiling directly to the structural members above:



42.

In such a case, roof edging is usually built up higher to prevent runoff at the edges. Meanwhile, non-harmful "ponding" can be expected on the roof.

Exposed vs. Concealed Structure deserves consideration. Increasingly, structural members are being left exposed to become an interesting visual feature and at the same time use less materials. In such a case, however, workmanship and finish on such items must be superior to that used when structural members are later to be covered with other finishing materials:

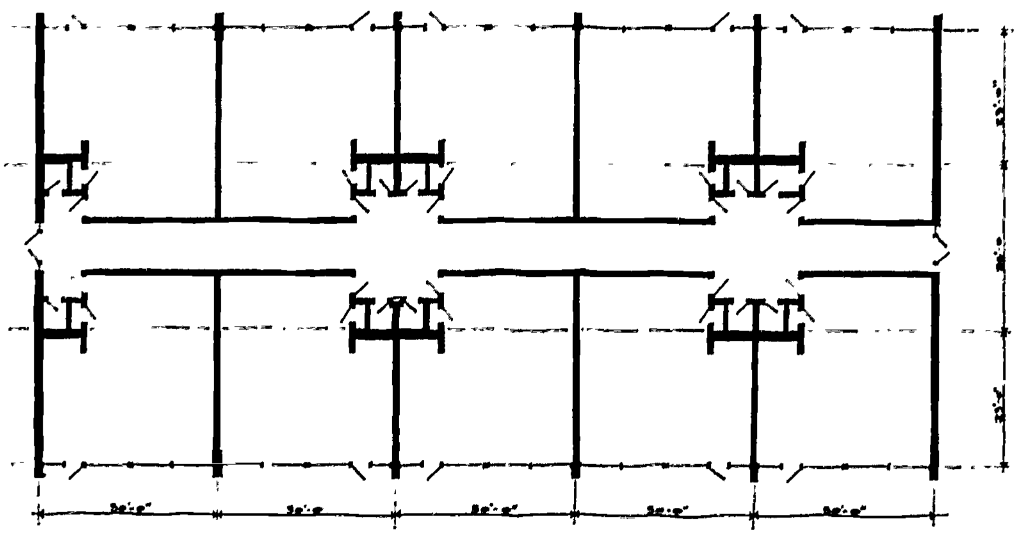


43.

New Materials and Techniques are generally viewed with suspicion by architects until they have been thoroughly proven by use in the field. A public building built for use over a great many years is hardly an appropriate place for experimentation with untried methods or materials. However, one should not discourage new combinations of proven materials or the use of systems of materials proven to be successful in similar uses in other types of buildings.

CHAPTER VII
MODULAR LAYOUT, DIMENSIONING AND MATERIALS

Often an area which is a sort of "greatest common divisor" of most of the rooms in a building, in combination with optimum spans or bay spacings, can result in a "planning module," in accordance with which the structure may be laid out:



44.

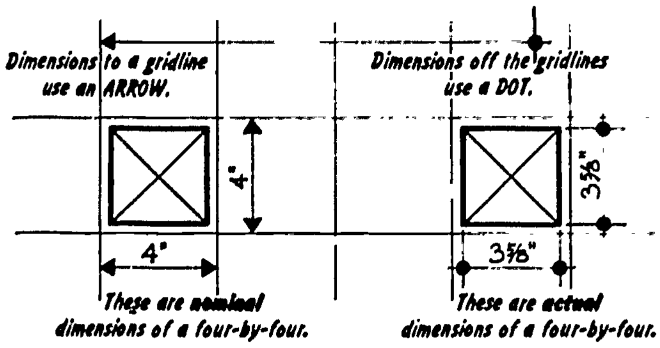
By this kind of layout, many "special" structural details can be avoided and the economies of duplication can be realized in many of the components involved, as well as aiding in simplifying field assembly of the parts.

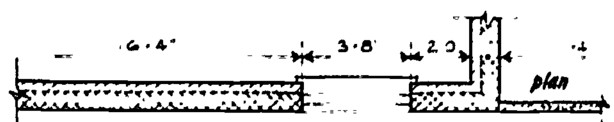
Modular Dimensioning involves marking off all distances to important reference lines on a layout in multiples of four inches. In this manner, all major locations are defined in simple terms devoid of fractions, which minimizes errors in computing and in field layout. It also paves the way for the use of "modular" materials, which are planned to fit into such four inch increments of size without trimming. Instructions to contractors often take this form on the working drawings:

NOTE—All drawings are dimensioned by Modular Measure

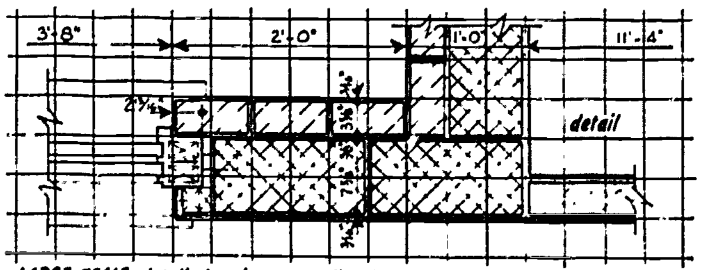
in conformance with the American Standard Basis for Coordination of Dimensions of Building Materials and Equipment (A62.1-1956).

This system of dimensioning is used for greater efficiency in construction: less cutting, fitting and waste of material, less chance for dimensional errors. The Modular Method uses a horizontal and vertical grid of reference lines. The gridlines are spaced 4 inches apart in length, width and height.





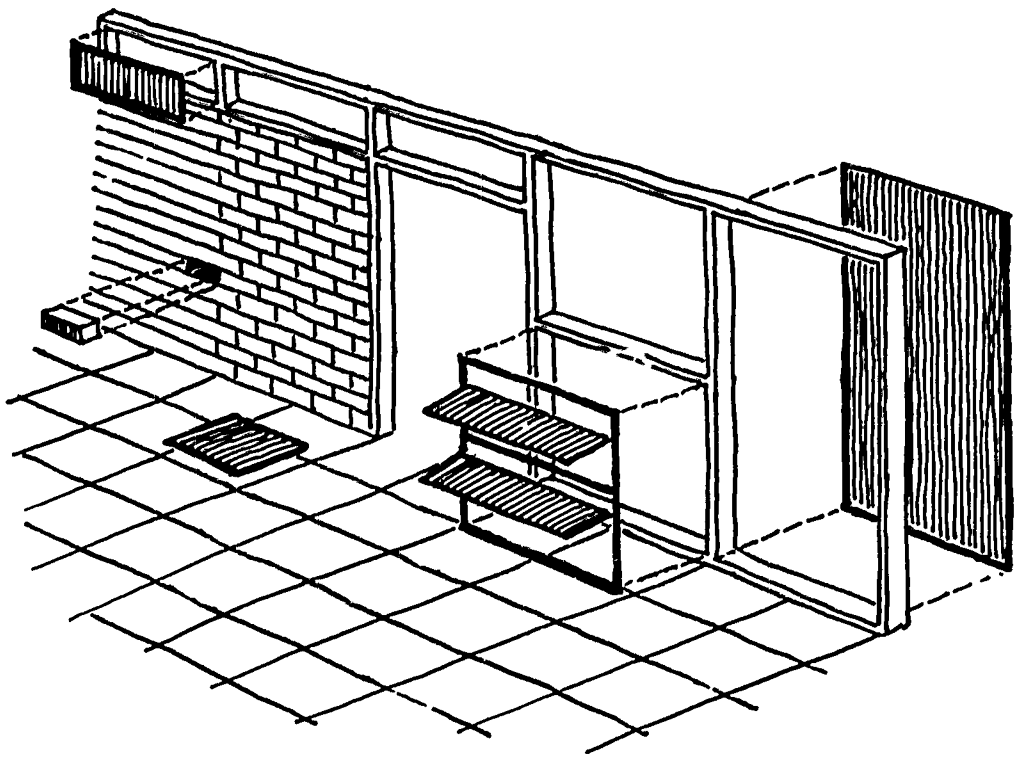
SMALL-SCALE plans, elevations and sections ordinarily give only nominal and grid dimensions (from gridline to gridline in multiples of four inches, using arrows at both ends). Dimension-arrows thus indicate nominal faces of walls, jambs, etc., finish floor, etc., coinciding with invisible gridlines, which are not drawn in at such small scales.



LARGE-SCALE detail drawings actually show these same gridlines drawn in, every 4 inches. On these details, reference dimensions give the locations of actual faces of materials in relation to the grid.

45.

Modular Materials include a great variety of products so sized as to "fit in" with each other without the waste of cutting to fit on the job. Such "modular" materials include brick, block, tile, windows, doors, panel materials of many sorts, as well as a great many items for interior use.



46.

Modular Details are simply the architect's detailed drawings of how the various materials are to be fitted together and how they relate to the reference lines established in the overall layouts.

"Modular Measure" is the name given to this system of dimensioning, detailing and material sizing for the elimination of waste. Its general adoption for school building use is earnestly recommended for the economy is can produce. Additional information is available from the Modular Building Standards Association, 2029 K Street, N.W., Washington 6, D. C.

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ACKNOWLEDGEMENTS

Grateful acknowledgment is made for the assistance and counsel of the many people involved directly and indirectly in the preparation of this booklet, and in particular the devoted members of the Advisory Committee, whose names have been listed earlier herein.

In addition, we greatly appreciate the willing cooperation of the following architectural and business firms in permitting the reproduction herein of certain illustrations, as listed below:

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Fig. 9 — Portland Cement Association

Fig. 11 — Timber Structures, Inc.

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