AN ANALYSIS OF DESIGNS AND MATERIALS TO DETERMINE SOUND SCHOOL BUILDING CONSTRUCTION

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CHAPTER I

INTRODUCTION

The United States today is confronted with the greatest building program of all time. At no time in the history of the United States has there been a more critical need for new buildings to meet the needs of an increasing population and to replace the thousands of antiquated buildings in use today; especially is this true of school buildings.

Statement of Problem

The purpose of the study was to analyze the materials used in industry and school plant building in order to determine the types and designs of buildings which will best meet the needs of our schools both today and in the future. The critical need of our educational system for more buildings and better constructed and designed buildings makes such a study both timely and needful.

W. Earl Armstrong, associate chief for teacher Preparation in the United States Office of Education, presented the following figures concerning the needs of education:

> It is conservatively estimated that the public and private elementary school will reach a peak enrollment of 29,500,000 by 1957. The public and private high school is expected by 1957 to enroll 7,300,000 as compared with 6,400,000 in 1947. Assuming that this

> increase in enrollment by 1957 of about 10,100,000 over 1947 will be taught in classes of 25 pupils each, the need for teachers in 1957 will be greater than in 1947 by 404,000 teachers. This is about 40 per cent of the present number of elementary and secondary teachers.[1]

Harry Hewes, Information Officer of the Federal Works Agency, has ably presented the condition in our country today concerning school building.

> Tax-supported education in the United States is carried on today in the largest school plant in the world, in point of size, but lamentably inadequate in the matter of capitol structure to foster the principles of democratic education. Thousands of school buildings are ramshackle, archaic, and unsafe for human occupancy. Some antedate the War between the States. Many are eyesores, affecting pupils and teachers and the communities in which they unsteadily stand. The school building situation, low as it has been before, is currently at the poorest level in the history of American education.
>
> Against these monumental bronze and marble structures once built by tax-assessing school boards out of their booster megalomania, and the costly edifices carrying the over ornamented hallmark of an illiberal architecture that marked an earlier day, millions of American children are attending classes (often on half-day double sessions) in jammed up buildings that house unforgivable sanitary and fire structural hazards, in obsolescent structures that were never properly built for function, and in makeshift temporary quarters.
>
> By 1958 the school population will have increased 40 per cent over the 1947 enrollment, according to director J. C. Capt of the Bureau of the Census. Three million youngsters will enter school in 1949 to swell elementary enrollments further.
>
> In ten years, thirty-five million American children will be in school requiring at least 240,000 more elementary and secondary classrooms than now exists.
>
> The lack of urgently needed school building calls for staggering expenditures--11 billion dollars in a ten-year program, the Office of Education of the Federal Security Agency determined recently, and this estimate was paralleled by a 1948 survey by the Department of Economics of the McGraw-Hill publishing company. The American Association of School Administrators in regional conference in San Francisco in February, asked for a $12 billion school building expansion program to cover twelve years.

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[1]Fort Worth Star-Telegram, September 10, 1950, p. 14.

> The Twentieth Century fund estimated needs of elementary plant above at 9.9 billions, and since this estimate is in terms of 1940 prices, current prices would be considerably higher. In 1944 the National Educational Association reported a ten-year building need for public elementary and secondary schools to cost an estimated $12.9 billion in terms of 1940 prices.
>
> Former Commissioner George H. Fields of FWA's Bureau of Community Facilities, declared that the large volume of information available shows a need for a minimum of $7 billion of additional public elementary and secondary school plant facilities--not in ten years but in the 'immediate future'.[2]

The December issue of the Research Bulletin of the National Education Association reports data on school housing obtained in January, 1948. This bulletin, entitled <u>School Housing Needs in City School Systems, 1947-48</u>, in summarizing the results of the study, makes the following general statements:

> The facts presented in this bulletin made it unmistakably clear that a shortage of proper school housing in city-school systems is widespread and serious. A fifth of the buildings in use are fifty years old or more--two per cent of them eighty years old. More than half the nation's cities, if the data of this study are typical, have some schools that are overcrowded--accommodating on the average, about thirty per cent more pupils than these buildings were intended to serve. Such overcrowded conditions are especially frequent in elementary schools, and generally speaking, are more common in the larger cities than in the smaller urban communities. One city in ten has such limited facilities that at least part of the pupils have only half-day sessions, an arrangement that strikes especially hard in first and second grades, but in the various school systems, reaches all grades and all levels. Moreover, if present trends continue, it is predicted that the number of cities having to resort to half-day sessions is likely to double during the next three years. In this case well over twice the present number of pupils are likely to be affected.

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[2]Harry Hines, "FWA, Builder of Schools," <u>American School and University</u> (1949-50), p. 67.

> Portable or other temporary school buildings are in use in fifteen per cent of the nation's cities, and rented buildings (stores, churches, community halls, residences, and so on) in nine per cent. Twenty-four per cent of the cities report that they are continuing to use, on a special permit basis, at least one obsolete school building which has been officially condemned as unsafe, unsanitary, or otherwise unsuitable for school use.[3]

The 1949-50 issue of American School and University adopted the following article from the January, 1949, issue of the School Executive which states in a general way our school plants' needs.

> A building conditions approximately ninety per cent of what goes into it. Related to schools, this means that the school plant shapes to an overwhelming extent the educational development of the pupils who use it. Those who plan, design, and construct school plants, then are really molding the educational future not only for today but for decades to come. What a tremendous responsibility, what a glorious opportunity.
>
> America is confronted with the greatest school building program in history. Either thousands of new plants must be built in the immediate future or hundreds of thousands of boys and girls will be denied their birthright. The situation leaves little choice. Road construction may be delayed, factories can wait for a time, but the education of youth either must proceed on schedule or their opportunity is lost forever. Children cannot be put into cold storage to be brought out at a more propituous time.
>
> The need for new plants is overwhelming. Information pours in from all parts of the country. Houston, Texas, reports a thousand new families a week with no let-up in sight. Los Angeles, San Diego, San Francisco, and numerous smaller communities in the Far West announce great increases in population. New England is faced with rapidly rising enrollments, putting further burden on obsolete buildings, in many cases unsafe and certainly unfit to house modern programs.

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[3]Research Division of the National Education Association, "School Housing Needs in City-School Systems, 1947-48," XXVI, No. 4 (December, 1948), 165.

> The south is not only growing in population but a much larger percentage of its children are availing themselves of educational opportunity. The majority of present plants are worn out. Additional ones must be built. Even the midwest, which twenty-five years ago had kept its building abreast of the needs now finds itself behind and its present plants outdated and inadequate.
>
> Educational slums are found everywhere, especially in rural areas and large cities. Population is increasing as never before. The changing educational program demands additional types of facilities. Advances in technology and research have outmodeled even the top plants of a few years ago.
>
> The thousands of new educational plants which are being planned must be far better adapted for physical well-being and safety than any building now in use as well as contain provisions for a modern program. Boards of education, representative laymen, professional staffs, architects, and engineers must devote themselves untiringly to the task of planning and designing plants which will best meet tomorrow's needs. Anything else will be too little and too late. It is a tough job. Every new proposal and experiment must be carefully evaluated. All available knowledge, understanding, and technical know-how must be put to work.[4]

In the following paragraph William Bruce expressed the present need of school plant construction and the necessity to build now and not continue to wait for construction prices to decline. He stated as follows:

> The year 1948 should see a revival of school plant construction to a marked degree. It is criminal that in states where there is the highest industrial prosperity, children in considerable numbers should be housed in buildings which are fire hazards, that they should study in damp and unsanitary classrooms, and that half-day sessions should be tolerated. The enrollment in kindergarten and primary grades has risen measurably in practically all cities and the new entries are likely to continue at high levels for four or five years. All this means that it is seriously wrong to wait for the complete stabilization of the materials markets and

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[4]American School and University, "School Plant Trends," (1949-50), p. 11.

> building industry. The young children need adequate school housing now and it is the responsibility of the school boards to provide it.[5]

After 1948, prices in the building industries declined somewhat, but again climbed to new heights during the war production program.

The University of Texas published a survey covering the increase in elementary school enrollment and the need for more elementary teachers, as well as more classroom units. An extract from the survey follows:

> One fact is sure in Texas Schools today--the kids are coming! Just ahead of us is a period of unprecedented demand for increased facilities and teachers. Even a hasty glance at birth rate figures for the war and postwar periods indicates something of the seriousness of the problem.
>
> By the school year 1953-54, Texas will have nearly a million pupils in grades one through six--an increase of about a third over last year's enrollment.[6]

Although the preceding articles varied considerably on the estimated cost of educational needs over the next few years, all agreed that the condition is critical and that something must be done. The estimated cost ranges from eleven million to twelve million, nine hundred thousand dollars, in terms of 1940 prices, for the ten year period beginning in 1944. The figures become staggering when adjusted to the present construction costs.

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[5] W. G. Bruce and W. C. Bruce, "School Building Construction in 1948," <u>The American School Board Journal</u> (January, 1948), p. 54.

[6] The College of Education, The University of Texas, "Are We Ready for 'Em," pp. 4-6.

Delimitation of the Study

Since the heating and ventilation problems for buildings located in the colder climates are so different from those located in the warmer regions, the study was confined to the materials and types of buildings which are suitable to the southern part of the United States. The study was further limited to the public elementary and secondary schools.

Source of Data

Data for the study were obtained from textbooks on school building needs and construction; theses and dissertations dealing with the problem of school plant construction and design; state, national, and professional publications pertaining to school plant construction; and current periodical literature dealing with school plant design and construction.

Related Studies

The following studies are related to this study. Fritz Roberson, in a study entitled "A Study of Building Materials and Processes and Their Influence on the Design and Construction of Contemporary Small Homes," made in 1950, was concerned with materials and processes and their influence on the design and construction of small homes. This study will be concerned with materials and designs used in school plant construction. Roberson arrived at the following conclusions which are closely related to this study:

(1) Steel framing members produce a frame stronger and more durable than untreated wood against wind, insects, and decay.
(2) Stone and brick veneer construction, due to their lighter weight, have lessened the foundation requirements of the original solid masonry walls.
(3) Clay and Concrete tile, Brikcrete, and Dunbrik are materials which are lighter in weight, larger in unit size, and more economical in construction cost than brick or cut stone. Because of the lighter weight, less foundation is required; and because of larger units, labor costs are reduced.
(4) Asphalt, rubber, and asbestos tile are new durable flooring materials for bathrooms, kitchens, utility rooms, game rooms, and workshops.
(5) Strong laminated wood framing members have eliminated the necessity for conventional braced construction for wide span.
(6) Treated wood and steel are impervious to termites, fungi, moisture and fire, and allow the architect to design houses closer to the ground.
(7) Reinforced concrete has permitted the use of flat roof and cantilever construction. Greater freedom in forms may be obtained from poured concrete. The floor and foundation have been combined into one structured unit in the concrete slab, and houses can be built flush with the ground level.
(8) Acoustical materials have greatly improved the acoustical conditions in the modern home, and the patterns in these materials have given a new surface texture to the walls and ceilings.
(9) Laminated wood framing members have made possible large rooms without the use of supporting columns.
(10) Plate glass has enabled architects to design houses with large continuous surfaces, and even entire walls of glass. This use of glass not only admits an abundance of sunlight, but also creates the feeling of spaciousness without sacrificing the comfort of controlled climate.
(11) Glass block is another form of glass which has descriptive qualities and is suitable for a wall which will admit light, yet exclude cold, heat, glare, and noise. Glass block is an excellent material for the exterior walls of bath and dressing rooms where both light and privacy are desired.[7]

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[7]Fritz Roberson, "Materials and Construction Used in Small Homes," (Unpublished Masters thesis, Department of Industrial Arts, North Texas State College, 1950), pp. 87-90.

A study by Henry Bormann entitled, "Unit Costs of School Buildings," gives some very interesting conclusions regarding comparisons of the costs of school buildings. The following are some of the more closely related conclusions.

(1) Total cubature is the best measure of building size or capacity to use for estimating the cost of a proposed school building. Such estimates should be based on known costs of similar buildings. Cost per cubic foot is an unsatisfactory unit of cost to use for comparing school building costs.
(2) Cost per cubic foot of habitable cubature is the best unit to use for comparing costs in terms of efficiency of designing and planning.
(3) Cost per cubic foot of educational floor area, and cost per weighted pupil station are the best units to use for comparing school building costs in terms of educational serviceability.[8]

For the last two years, the State of Texas has been working on problems of ventilation and lighting at the Texas Engineering Experiment Station in College Station, Texas, headed by Executive Director Arthur W. Melloh. The program has brought together architects, physicists, aeronautical engineers, and $50,000. They have already arrived at some conclusions concerning the best lighted and ventilated classrooms. The next field of study will be acoustics.

The main testing instruments are a low velosity wind tunnel to reproduce air currents through scale models of buildings, an artificial sky made of plaster to test models for lighting under variable simulated natural skylight and on the wide stretch of a nearby airport, and a full scale experimental classroom which can be revolved on a track and re-fenestrated or re-roofed at will to test full scale effect.

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[8]Henry Bormann, Unit Costs of School Buildings, pp. 69-81.

In a test made on ceiling heights to determine the lowest ceiling height at which excellent daylighting could be achieved, a ceiling height of ten feet, six inches was found to be the best height.

Definition of Terms

"Framed building" indicates a frame or skeleton of timbers on which the interior and exterior of the walls are attached.

"Solid brick construction" is a type of construction in which both the interior and exterior walls are built of solid brick.

"Building materials" are all materials used in building construction.

"Bi-lateral lighting" pertains to rooms with daylight from two different directions.

"Uni-lateral lighting" pertains to rooms with daylight from only one direction.

"Design" is the deliberate ordering or planning of space, matter or activity for a given purpose.[9]

"Modular construction" is the use of the size of some one part as a unit of measurement by which the proportions of other parts of the construction are regulated.

"Cantilever construction" is the use of projecting beams of members supported at only one end by a retaining wall or column.

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[9]Goeffrey Holme, Industrial Design and the Future, p. 9.

CHAPTER II

CRITERIA FOR DETERMINING SOUND SCHOOL BUILDING PLANTS

From a study of the standards of school building as developed by a number of leaders in the field, the most outstanding ones have been selected to be used in determining a set of standards for evaluating materials and designs used in school buildings.

A recognized expert in the field of school building construction, N. L. Engelhardt, along with N. L. Engelhardt, Jr. and Stanton Seggett, in Chapter Three of their book, <u>Planning Secondary School Buildings</u>, established the following as criteria for high school building planning. Although this criteria applies specifically to high school building construction, each standard listed will also apply to the planning of an elementary school building.

I. Expansibility
    A. Expansibility of building
    B. Expansibility of departments
    C. Expansibility of service utilities
II. Ease of Circulation
III. Safety and Elimination of Hazards
IV. Sanitation
V. Flexibility in Building Planning
    A. Flexibility in architectural design
    B. Flexibility in exterior construction
    C. Flexibility of interior walls
    D. Flexibility in service systems
    E. Adaptability to constant use

VI. Durability and Maintenance
    A. Maintenance of site
    B. Supervision and testing
VII. Design and Beauty
VIII. Proper Acoustics in Schools
IX. Student and Teacher Comfort
X. Environment
    A. Attractiveness of neighborhood and elimination of such nuisances as industrial plants, railroads, odors, dust and noises
    B. Moral and social surroundings
    C. Relation to community setting
    D. Natural setting
    E. Exterior building and site atmosphere
    F. Interior building atmosphere
XI. Functional Distribution of Spaces
    A. Nonhabitable spaces
    B. Habitable spaces
        1. Building service and circulation
        2. Administration, staff and pupil service
        3. General units including auditoriums and gymnasiums[1]

N. E. Viles, Specialist for School Plant Management of the United States Office of Education, listed the following as criteria for planning school buildings:

I. Safety to life
    If we are going to compel the child to go to school, then we have a definite obligation to supply the maximum protection.
II. Health protection
    I separate the two primarily because of their importance.
III. Community and Curricular Adequacy
IV. The Economical Operation Conception
    A. Cost of erecting
    B. Cost of operation
    C. Cost of the school program in it
V. Esthetic Value
VI. Flexibility
    Flexibility of plans and ideas
VII. Expandibility
    Possibilities of expansion[2]

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[1]N. L. Engelhardt, N. L. Engelhardt, Jr., and Stanton Leggett, Planning Secondary School Buildings, pp. 23-38.

[2]N. E. Viles, An Outline of Modern School Plant, Proceedings of the Second School Plant Conference and Supplies Exhibition, p. 113.

The following was taken from a report of the Committee on School House Planning, a committee of the National Education Association, as criteria for testing the site plan and skeleton floor plan of school buildings.

I. Adaptation to Educational Needs
II. Safety
III. Healthfulness
IV. Convenience
V. Expansiveness
VI. Flexibility
VII. Aesthetic Fitness
VIII. Economy
   A. By determining scientifically the size needed for each room
   B. Duplicate use of rooms
   C. Elimination of waste areas[3]

The National Council on Schoolhouse Construction, a group that has made a notable contribution to planning school buildings over a number of years, lists the following as points that require emphasis in the planning of an efficient school building.

I. Optimum space allotments for instruction, administration, and auxiliary and community services
II. Flexibility in structural plan and building materials to the changing content and methodalogy of education
III. Comfortable and efficient seeing and hearing conditions
IV. Appropriate provisions for heating and ventilating
   A well-planned school building will reflect thoughtful consideration and deliberate decision on:
   a. Orientation for instructional rooms to achieve optimum easily controlled daylighting
   b. Reduction of vertical and horizontal student and material traffic to a minimum
   c. Functional variation of clear span, shape and size of rooms accommodate different instructional and activity needs of the educational program

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[3]National Education Association, Report of Committee on School House Planning, pp. 16-19.

d. Maximum conservation of school site area, consistent with pupil safety, for outdoor educational and research purposes
e. Maximum expansibility to provide for enrollment increases and expanded educational services
f. Maximum flexibility to permit reorganization of space to combat educational obsolescence of the building
g. Association of subject matter and service facilities to enhance coordination of functions and to minimize student traffic
h. Shielding work areas such as library and classrooms from noisy activities such as music, gymnasium, shop and playground
i. Protection of class, study, and assembly groups from disturbing odors from laboratories and kitchens
j. Provisions for orderly pupil traffic flow with a minimum of congestion
k. Building entrances located in recognized points where students, and visitors who come in automobiles, approach the campus
l. Limiting basement areas to those actually needed for building service. Basement areas should be entirely eliminated in all except exceptional cases
m. Maximum natural ventilation, especially in warm climates
n. Building materials chosen in consideration of the financial ability of the district, the estimated permanency of residences served, reasonable maintenance costs, beauty, and pupil safety
o. Interiors designed for the delight, comfort, and health of occupants.[4]

This report emphasized the thought that the characteristics of a school building and its floor plan should be such as to inspire favorable comment upon its suitability for educational purposes rather than its monumental grandeur.

B. T. Pittenger, Professor of Educational Administration, University of Texas, and Consultant for planning school buildings, summarized the standards for school plants in the following paragraph.

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[4]National Council on Schoolhouse Construction, <u>Guide for Planning School Plants</u>, pp. 6-7.

> School plants that are built today must be expansible, flexible, and even replaceable; and at least, on the high school level, as many as possible of their facilities must be available for multiple use. These plants must be presently adequate for today's needs, and must conform to the best known standards for health, safety, and efficiency.[5]

From a study of recent literature on school building design, a class at Pennsylvania State College Studying under William S. Vincent searched for ideas on possible future developments of school buildings to reflect modern and future educational practice in their design. These ideas were drawn together into the twelve following categories:

1. The emerging educational program needs more space.
2. The buildings which house the emerging educational program need to be flexible.
3. A greater degree of variability is needed in the modern school plant.
4. The building should be a teaching tool and an instrument of culture.
5. Tomorrow's school building should be better harmonized with its site.
6. The school should be a child's institution.
7. Schools should be built as communities.
8. A modern building must anticipate future educational practice.
9. Cooperative planning of the building is necessary.
10. The modern school must house an all-weather, all-purpose, all-season program.
11. The community may wish to make broader use of its school.
12. The building should be designed with public relations in mind.[6]

R. W. Rushton, Superintendent of Schools, Orangeburg, South Carolina, and G. Thomas Harmon, Architect, Columbia,

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[5]B. F. Pittenger, "Some Observations About High School Building Needs," American School Board Journal, CXVIII (January, 1949), 35.

[6]William S. Vincent, "Tomorrow's School Building," The School Executive, LXVII (February, 1948), 25-27.

South Carolina, in a detailed study of the needs of the Orangeburg School System, set up the following standards for the building program for the Orangeburg schools.

1. Suitable space for flexibility in teaching
2. A pleasant environment
3. Sanitation
4. Safety
5. Automatic controlled heating
6. Economy of construction[7]

The Twenty-seventh Yearbook of the American Association of School Administrators, a study devoted entirely to American school building, lists the following as principles for planning a school building:

> Basic to planning both the instructural and the auxiliary spaces in a school building, and in developing the school site as well, are certain principles related to the purposes the building is to serve and the efficiency with which it may be used. These seven principles are stated briefly in the paragraphs that follow.
>
> Curriculum Adequacy
>
> The plant must be planned to provide the facilities necessary for the efficient and effective accommodation of all the phases of the curriculum, extracurriculum, and community activities for which the plant is intended. The educational philosophy and the specific services of the particular school--elementary or secondary, specialized or nonspecialized--should be the starting point in the design of the building and the development of its site.
>
> Safety and Well-Being
>
> The school plant should be so planned as to protect the comfort, health, and safety of pupils, teachers, and all who will use its facilities. Lighting, heating, and ventilating should be in accordance with best practice. Stairways and other structural and service features should not only protect children from harm, but

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[7]R. W. Rushton and G. Thomas Harmon, "The Orangeburg Pattern for School Improvement," American School and University, (1950-51), p. 269.

should provide a healthful environment that will be a positive influence toward the best possible physical and emotional development for living, growing children and youth.

Interfunctional Coordination

The various units of a school plant should be located according to their functional relationships and special requirements. Each unit or portion of a plant may be well planned for its specific purpose, yet if the units are not put together with respect to their mutual relationships, the plant as a whole will be unsatisfactory. For example, certain rooms, because of their association, should be planned "en suite". The noisy units should be located so as not to interfere with quiet zones.

Efficiency and Utility

The school plant should be planned and assembled in a manner that will promote efficient school management and the convenience of pupils and the public in its use. Those units which are used most frequently by the public should be located for easy access from streets and parking areas. Units requiring delivery service, such as lunchrooms, shops, and coal-fired boilers, should be accessible to a service drive from a side street. Corridors, stairs, and entrances and exits should be designed in relation to peak loads of traffic to and from the various units of the plant.

Beauty

The entire school plant should be cheerful, attractive, and pleasing. The building mass does not need to be symmetrical, but it should have aesthetic balance. An open rather than a massive design, pastel rather than drab colors, spacious grounds, and ample window space will add much to the general attractiveness of a school plant.

Adaptability

A school plant should be planned for economical future adaptations to changing requirements. The building can be made more flexible by multi-use units such as all-purpose rooms in elementary schools, nonbearing partitions, open-end corridors, and interchangeable storage units. The building itself and its placement on the site should provide for future additions without interfering with traffic-flow efficiency, the association of related units, and aesthetic balance.

Economy

A school plant should be economical in original cost, upkeep, and operation. The total plant needs of the district should be considered so as to avoid undue cost of one project at the expense of other needed facilities. Economy, however, involves more than a mere reduction in dollar outlay. The expenditure of

> additional dollars is actually an economy if the educational return per dollar is increased or if maintenance costs are reduced.[8]

Although there is general agreement among the forward thinking experts in the field of school plant planning in determining standards, many buildings built in recent times do not reflect the thinking and planning that has been done. The general standards set up by the Committee on School House Planning in 1925, compare favorably with the very latest planning as done by N. L. Engelhardt and the National Council on Schoolhouse Construction in 1949.

Walter K. Cocking, editor of The American School and University, made a study of school building in 1949, and reported some very interesting observations. Among these is the regretable fact that many plants were designed and constructed during 1949 with little creative planning and little variation from buildings constructed in the 1920's and 1930's; however, the number of school plants designed and constructed with emphasis on today's needs and making use of today's know-how increased markedly in 1949. The approval given to newer conceptions of space design, technological features, and materials insures their continued use. Future buildings should be even more creative and daring, and provide ample evidence for the need of additional research and experimentation. The

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[8]American Association of School Administrators, American School Building, Twenty-seventh Yearbook, pp. 85-86.

fact that 70 per cent of the new buildings are one-story buildings, and many are of the modified campus type with larger and square classrooms, proves conclusively that much progress is being made.[9]

From the sources quoted previously and numerous other sources, the writer has selected the following as criteria for evaluating designs and materials for school buildings.

Educational Plan

Since all features of a school building directly or indirectly affect the educational plan, the buildings and equipment should always be considered accessories to the educational process. That the physical plant should be planned to fit the educational program is a rule which cannot be emphasized too greatly. Each school building should be especially planned for the particular program to be carried on within its walls. School building standards should never be considered a substitute for careful planning of each building according to the specific needs of the particular school.

Economy

Economy of building.--The critical need for new buildings for replacement of obsolete buildings and for added teaching space emphasizes the necessity of economy in school building construction. Economy of building must not come by the use

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[9]Walter D. Cocking, "Educational Building in 1949," The American School and University, (1950-51), pp. 41-48.

of inferior or untried materials, or by unskilled labor, but by: (a) designing as economically as possible, consistent with the function of the building; (b) cost-designing every possible structural combination for which materials are available; (c) reducing the total labor--especially on-site labor; and (d) testing all combinations of exterior and interior finishing materials to determine the simplest and most economical combination that will serve the purpose, stand punishment, and retain a pleasing appearance. Space utilization is a most important factor for consideration in building economy.

Economy of maintenance and operation.--Very careful consideration should be given to maintenance and operation in planning the school plant. By careful planning, numerous ways can be found to eliminate time and expense of maintenance and operation without increasing the material cost of the building.

Economy of school program.--The design of the building not only affects the cost of operation in dollars and cents, but also in time and effort of pupils, teachers, and administrative personnel.

Safety

All our efforts to educate the child are in vain if the life of the child is not protected. If children are to be forced to go to school, it is imperative that they be protected from harm by every conceivable method.

Health and Sanitation

A clean and sanitary environment is not only an important adjunct to the health of the children, but is also a valuable part of the educational program of wholesome, clean living. Proper sanitation suggests the need for well-lighted and well-ventilated spaces, the elimination of narrow courts, of inaccessible skylights, of congested toilet rooms, and of small storage cubby-holes.

Flexibility

Flexibility may be defined as the "adaptibility of the school plant to change its educational, social, and economic policies and conditions."[10]

Architectural design.--Flexibility suggests a design adaptable to all possible changes as time goes on. It also requires that changes do not affect the satisfactory completeness of the design at any stage of development.

Exterior construction.--The types of items considered here are location of exit, the butting of interior against exterior walls, the window arrangements, and the possible rearrangement of service, administration, or supervisory units.

Interior walls.--Interior walls and partitions between rooms should be of the non-load-bearing type and so constructed that they may be quickly and economically moved.

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[10]Englehardt, Englehardt, Leggett, op. cit., p. 32.

Flexibility in service systems.--The service systems, including heating, ventilating, plumbing, lighting, cleaning, and movable fixtures should be so arranged that shifting of the interior walls would not necessitate their rearrangement.

Adaptable to constant use.--The increasing use of the school building by the community makes necessary the segregation of facilities for some groups, provisions for cutting off parts of the building not in use, and extension of some facilities, such as toilets and other provisions growing out of local need.

School plant flexibility is made possible or more practical when spacious level sites are provided, end walls of instructional spaces are non-bearing curtain walls free from utility installations, plumbing installations are placed so as not to break up banks of instructional rooms, fenestration pattern is continuous along the entire wall rather than grouped especially for each room, heating and lighting services are engineered so that controls serve relatively small areas within rooms. Future needs are considered in installing utility supply services and movable equipment which is interchangeable, when dual use of rooms is emphasized, and when a rigid frame type of structure is used, eliminating bearing walls.

Should the base cost of construction of a flexible building be higher than conventional construction, if at least one future change is accepted as inevitable and the cost of such change with conventional construction considered a part of the basic investment, flexible partitions can compete economically with permanent construction. This means, then, that in addition to keeping pace with changes in educational concepts and programs, it is also possible to extend the useful life of a building and still maintain its efficiency.

Expansibility

The building should be so planned that it can be enlarged as needed without unnecessary cost and without cutting off the natural light and ventilation of any other rooms. When expansibility is provided for in the original plan of a school building, additions may be constructed without destroying the symmetry and unity of the building. Stairways, corridors, toilets, special rooms, heating plants, sewers, electric feeders, water mains, and in fact, the entire building should be planned with a view to future additions.

In any school building expansibility is greatly enhanced when a large site area is left undeveloped where building additions are logical, when a one-story, single loaded corridor type of plan is used, when corridors are carried through to outside walls or to very small temporary rooms wherever extensions are possible, when stairs are in separate enclosures off the corridor, where essential windows are not located in walls where extensions will go, and when all service units are planned in contemplation of future expansion.

Design and Beauty

Beauty in architectural design is reached through the development of balance and proper relationship of parts to the complete structure. The planning of natural lighting in modern school plants is an outstanding example of the relationship of function to beauty. The educational value of adequate natural lighting is not questioned. It promotes health and creates a desirable condition for the promotion of work and study. For these reasons, adequate natural lighting becomes a part of good design and beauty.

For the school plant to reach the objectives expected, those objectives must first be determined, and then the school building planned to facilitate the reaching of those objectives in every reasonable way. The school building design should represent the ideals of the educational program in inspiring the student to active participation in the experiences which the school offers. The location of the building, gayety in atmosphere, and achievement of a design of the present time will go far in stimulating the interest of the student in the values of education.

Good design carries with it the idea of comfort. One of our present needs is more study and planning in the addition of comfort to our buildings for both the pupils and administrative staff. A more comfortable atmosphere may be obtained by proper use of color, insulation, proper control of ample lighting and ventilation, control of noise by proper acoustical treatment of the building, and by equipping the building with comfortable fixtures.

By thoroughly exploring the possibilities in design and beauty, a pleasant environment may be created which will go far in aiding the child in his physical, mental, social, and spiritual development. Too, a pleasant environment will aid greatly in providing a situation which will encourage the best work of the teachers, supervisors, and administrative staff.

Durability and Maintenance

The following items will add to the durability and aid in the maintenance of the building:

1. Architect, school administrator, school custodian, and school maintenance men should cooperate closely in the selection of building materials.

2. Materials should be non-absorbent.

3. The exterior materials should be selected on the basis of their ability to withstand the weather conditions.

4. Excessive expansion of materials should be guarded against.

5. Materials which are easy to clean and which are not affected by knocks, scratches, and pencil marks will in general be the most durable.

6. Metals which rust or corrode are considerably cheaper but replacement costs more than outweigh the initial cost of more durable materials.

7. Maintenance of plumbing and electric wiring will be made easier if long runs of pipe and conduit are eliminated

and if they are stacked for vertical runs at convenient and accessible points.

8. Simple plumbing equipment of standard design using durable and easily cleaned materials will reduce maintenance costs.

9. The durability of electric lighting equipment will be increased by using materials which give satisfactory illumination and which do not crack, break, discolor, or collect dirt and dust.

10. Fixtures should be simple in design, standard in construction and unbreakable.

The following check sheets may be used as an aid in evaluating school building designs and materials.

A. Educational Plan

1. Does the physical plant meet the educational needs of the pupils?
2. Does the school plant provide for the educational and social needs of the community?
3. Have provisions been made to make good instruction possible?
4. Have the necessary facilities been provided for all phases of the curriculum?
5. Have proper provisions been made for extra-curricular activities?
6. Have provisions been made for the recreational activities of the pupils?

7. Are the various units located according to their functional relationships and special requirements?

B. Economy

1. Have light weight, economical materials been used where practical?
2. Has an effort to reduce labor costs been made in the selection of materials?
3. Has natural lighting and ventilation of the building been emphasized in the plan?
4. Has space utilization been stressed in the plant design?
5. Have materials been used that provide for clean, wholesome living?
6. Does the design conserve time and effort of pupils, teachers, and administrative personnel?
7. Has the building been designed as economically as possible, consistent with the function of the school plant?
8. Are building and grounds easily supervised?
9. Have waste spaces been eliminated?
10. Have dual purpose rooms been used where practical?

C. Safety

1. Has the safety of the inhabitants of the building been of major importance in the selection of the design for the building?
2. Have all reasonable precautions for safety been taken in the selection of materials?

3. Is the school plant safely protected from the heating plant?

D. Health and Sanitation

1. Does the design provide for happy, comfortable living?

2. Has a comfortable, pleasant atmosphere been created by the interior finish?

3. Are inhabited spaces adequately lighted to prevent eye strain?

4. Are rest rooms and shower rooms well lighted and ventilated?

5. Has comfort and health of the inhabitants of the building been emphasized in designing the ventilation of the building?

6. Have facilities been provided for health education?

7. Are noisy, odorous areas properly located with respect to classrooms and administrative offices?

E. Flexibility

1. Does the exterior construction--the butting of interior against exterior walls and the window arrangement--allow for rearrangement?

2. Are partition walls of the non-load-bearing type and so constructed that they may be economically moved?

3. Are the interior fixtures movable so that they may be easily rearranged?

4. Are the service systems, including heating, ventilating, plumbing, lighting and cleaning so arranged that shifting of interior walls would not necessitate their rearrangement?
5. Has adequate provision been made for community use of the building without interrupting the school program?

F. Expansibility

1. Have service units been planned in contemplation of future expansion?
2. Has the building been so planned that it may be enlarged without unnecessary cost to the existing structure, and without cutting off the natural light and ventilation of any other room?
3. Has possible expansion of the building been considered in the selection of building materials?
4. Are future changes possible without destroying the satisfactory completeness of the design?

G. Design and Beauty

1. Has beauty been given proper emphasis in the selection of materials?
2. Has beauty been achieved in the design by balance and proper relationship of parts to the complete structure?
3. Does the building and its surroundings have an inviting appeal to the pupils?

4. Have useful features, rather than oranmentation, been used to achieve beauty in the design of the school plant?

5. Do the buildings harmonize with the school site?

H. Durability and Maintenance

1. Does the building design permit economical operation of the plant?

2. Have materials been used in the building that are easily maintained?

3. Have durable materials been used throughout the building plant?

4. Have metals that do not rust or corrode been used throughout the building?

5. Have vertical plumbing and electrical lines been stacked at convenient and accessible points?

6. Have plumbing and electrical equipment of standard design been used?

7. Have standard, unbreakable fixtures been used where desirable?

CHAPTER III

AN ANALYSIS OF POSSIBLE DESIGNS AND MATERIALS FOR SCHOOL BUILDINGS

Design

In the break away from the old traditionalistic type of school building, a number of different designs have arisen which deserve careful consideration in the selection of the school building design. Inasmuch as such factors as climate, locality, finances, size, and present and future educational needs must be considered in determining the best plan for any given situation, educators and architects agree that no particular design will serve best in all localities and situations. There are, however, a number of desirable features in each type which make them worthy of consideration.

The American Institute of Architects classifies buildings in the following five groups according to type of construction:

Type A - A building constructed entirely of fire-resistive materials, including its roof, doors, windows, floors, and finish.

Type B - A building of fire-resistive construction in its walls, floors, stairways, and ceilings, but with wood finish, wood or composition floor surface, and wood roof construction over fire-resistive ceiling.

Type C - A building with masonry walls, fire-resistive corridors and stairways, but with ordinary construction otherwise: i.e., combustible floor, partitions, roof, and finish.

Type D - A building with masonry walls, but otherwise ordinary or joist construction and wood finish.
Type E - A frame building constructed with wood above foundation, with or without slate or other semifireproof material on roof.[1]

The most expensive type of construction is the A group, according to this classification, while the least expensive is the E group. The argument has frequently been made that, when cost of operation and maintenance are considered over the lifetime of a building, types A and B are most economical. Unfortunately adequate information is not available to answer this argument.

<u>One-story buildings</u>.--Schools are no exception in the general trend toward horizontal and single story construction. A one-story building may be planned as one building or as a number of buildings connected by open or closed passageways. There is even a trend toward the "campus plan" where entirely separate buildings are assembled in a harmonious scheme, over a period of years.

Among the many advantages of one-story buildings are:

1. Readily accessible use of the outdoors in relation to the indoors
2. A much safer plant than a multi-storied building
3. A cheaper structure to build
4. Easy to isolate noisy and odorous activities and concentrate certain sections for easy community use
5. Much more flexibility
6. Elimination of stairs and stairwells

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[1]Walter S. Monroe, "School Plant," *Encyclopedia of Educational Research*, revised edition, p. 1105.

7. Expansion in size when additions are necessary
8. Adequate daylight and ventilation more easily achieved[2]

It is no longer true that multi-storied buildings are more economical than one-story buildings. In a study by the American Association of School Administration entitled, "American School Buildings," the conclusion was that multi-story buildings of fire resistive construction throughout will be more economical than one-story structures, if the same standards of construction are applied to the one-story structure.[3] But it is not necessary to apply the same standards of construction to a one-story building to insure a safe secure building.

In an article entitled, "A Cost Study of School Plan Types" by Alonzo J. Harriman and Philip Gatz, school architects of the State of Maine, published in the March, 1949 issue of the Architectural Record, the conclusion was that the most economical school to build is a single-story wood construction, the double loaded corridor type with a pitched roof, and continuous skylight down the middle of the building. In all cases studied, wood construction was found to be cheaper than steel. It was noted, however that for classroom spans over thirty feet, steel is probably cheaper.[4]

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[2]American School and University, "School Plant Trends," (1949-50), p. 115.

[3]American Association of School Administrators, "American School Buildings," Twenty-seventh Yearbook, (1949), p. 208.

[4]A. J. Harriman and Philip Gatz, "A Cost Study of School Plan Types," Architectural Record, LV (March, 1949),111.

To achieve adequate daylighting for the square classroom strongly advocated by educators and architects for teaching convenience and shortening of the building perimeter, a type of monitor window has been adopted. William Arid Johnson and Associates, architects in the state of Washington, contend that a series of transverse beams of laminated wood to carry the monitor windows is a cheaper method to span a thirty foot room than conventional joist construction for a room of twenty-four feet span.[5]

Another favorable feature of one-story buildings, especially for the elementary grades, is the inviting, homelike environment that may be created through this type of structure.

However desirable the one-story building may be, there are densly populated areas where such a building is not practical. In some of the crowded areas of the big cities, building space is not available. P. I. Prentice, editor and publisher of the Architectural Forum, proved by arithmetic in the October, 1949, issue that New York City could pay eight dollars per square foot for land and still save money on a one-story building program.[6] In the December issue of the same year he admitted that the one-story building could not

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[5]William Arid Johnson, "Transverse Framing Makes Top Daylighting Economical," Architectural Record, CV (March, 1949), 126.

[6]Architectural Forum, "Schools," XCII (October, 1949), 85.

solve the problem when the land to build on was not available, as is the case in a few of the more densly populated areas of our larger cities. However, few of our schools in the South and Southwest are confronted with this problem.

Walter D. Cocking, editor of The American School and University, and Robert L. Hooper, after a detailed study of the outstanding schools in America built since 1945, arrived at the following conclusions:

> For many years the American public has accepted milti-storied school buildings. The massiveness of the school in the community seemed to reflect the hoped for quality of the educational program.
>
> Today communities are planning schools for people and programs. The hazards of fire and accidents are strong factors in reducing the number of stories and thereby eliminating stairways. The educational program is strengthened, and the emotional setting for children enhanced by the one-story structures. No longer can it be said that single-storied buildings necessarily cost more than multi-storied buildings.
>
> Of the elementary schools considered outstanding, seventy-seven per cent are single-storied structures. Only twenty-three per cent have two stories, and none has a greater number of stories.
>
> A similar trend to reduce the number of stories is noted in the secondary schools. Of the secondary schools considered outstanding, thirty-four per cent are one story; forty-nine per cent two stories. Only seventeen per cent of the secondary schools considered to be outstanding have three stories.[7]

Home school unit.--The need for and the advantages of the Home School Unit is explained clearly by P. I. Prentice in the following quotation from the Architectural Forum.

> The size of schools themselves is also undergoing significant change. Thirty years ago, many school officials were convinced that the large school was the most

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[7] W. D. Cocking and R. L. Hooper, "America's Outstanding School Building," The American School and University, (1950-51), p. 177.

> efficient educational unit. Since 1940, however, educators have had some second thoughts about the relation of bigness and efficiency as far as education is concerned.
>
> Like practically all educators, Engelhardt believes that to put one thousand small children into a single giant elementary school is a pretty dreadful thing to do. He introduces what he called the Home School Unit, a building intended to house not more than three hundred children and to have a more domestic appearance.
>
> More complete parent-teacher relation can best be brought about by the small neighborhood school. The tendency toward more decentralization of living areas and larger plots for each home has created longer distances between home and school.
>
> These factors, in many cases, have pointed to the need for housing younger children in a small school within easy and safe reach of their homes. The Home School Unit is an intimate part of the neighborhood life and is a gathering point for children and adults. It is the simplest and usually the least expensive of all types of schools. Since it houses only the kindergarten and primary grades, no auditorium or gymnasium is necessary. The site may be relatively small. The building should be one-story in height with direct access to the outdoors from each room.[8]

From both an educational and an administrative view, evidence indicates that the most efficient educational unit is the medium-sized school, a school with at least one classroom, and not more than three per grade. This size unit seems to provide the best balance between the personal and communal needs of students. From an administrative point of view, the medium sized school supports enough students to make practicalbe the installation of expensive teaching equipment which smaller schools cannot afford. Educators also find that the medium-sized unit is administratively more efficient than larger schools, especially with regard to such

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[8] <u>Architectural</u> <u>Forum</u>, <u>op</u>. <u>cit</u>., p. 83-88.

changes as school bus service, maintenance and supervision. The medium-sized school is also better adapted to serve as a neighborhood center, a function that is being assigned more and more to school buildings.

Finger plan.--The finger plan is really a tree plan, based on a trunk corridor with side branches. It rests upon radical standardization of classrooms, absolute insistance that all classrooms share the best orientation to sun and air, and that daylight for all of them be available from the open-corridor side as well as the main window side. The plan is not only flexibly interchangeable within itself, but extensible indefinitely outward like a tree, by growing at branch ends and by sprouting new branches. Its defect is its over-extended lines of communication. A two story finger plan, such as that used for a New Orleans grade school, shortens the line of communication as well as saves on the land costs.[9]

To shorten the line of communication, the Middle West adopted the double loading corridor type, depending on later technological developments to get adequate daylighting into all classrooms. Such methods as clerestory windows, skylighting industrial type saw-tooth roof with clerestory windows, plastic bubbles, and sunken corridor roofs with windows above have been employed to increase daylighting of the

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[9] Architectural Forum, "Two Story Finger Plan Trims High Land Costs," XCV (January, 1951), 104-106.

double loaded corridor type building. All these type of roofs are more complicated and expensive to build than the simple roof possible on the single-loaded corridor type building. An alternate of this plan is the placing of the rooms in a zig-zag outline increasing the area of the window space.

Some schools, as the Edgemoor Road Elementary School,[10] Delaware, have extended a number of wings from a centrally located office space as a hub, giving the building the appearance of a huge star. In this particular school, window walls of the classrooms alternate between a circular, triangular, and octangular shape in an effort to secure proper light and ventilation.

The campus plan.--The campus plan has many desirable features. A campus type school composed of complete units can be built as funds are available instead of all units being built at one time. These units would provide for flexibility not obtained in an integrated building. This type school would lend itself to maximum function and economy, as each new unit would have benefit of the latest methods at the time of construction. Many conventional schools are making use of this plan to isolate the noisy units, such as shops and agricultural units. If arranged in a formable manner, the buildings may be connected by an open or closed corridor for protection from the weather.

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[10] American School and University, op. cit., p. 115.

The round school.--A Round School plan[11] was designed by architect Nowicki for the _Architectural Forum_ as a radically economical plan type for the 1950's to explore. According to Nowicki the round plan has terrific efficiency in use of area and perimeter. In a plan used for comparison with substantially the same provisions as a rectangular plan, the area is roughly fifteen thousand square feet compared to twenty thousand and the perimeter is four hundred forty feet against six hundred twenty-four for the rectangular plan. The fact that round plans have not been adopted is attributable to deficiencies in building technology, not to intrinsic demerit. Architect Nowicki drew this plan with the idea that the structural system might be the Youtz-Slick invention, being engineered by Fred N. Severud and tested at Tom Slick's Southwest Research Institute. In this method, the raised roof of the central playroom auditorium would be poured as a concrete slab on the floor and lifted up hydraulically, using the six hollow posts as cylinders. After that, each of the classroom segments would be raised in similar fashion, each on three posts. For the outside curved walls the roof and floor would supply an easy guide; and each of the classroom walls being a single masonry panel with no window framing or other interruption, it would be cheap and direct to build.

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[11]_Architectural Forum_, "Schools," XCII (October, 1949) 134.

Light for this plan of construction comes in through plastic bubbles in the roof and two ceiling high glass doors which give glances into the natural surroundings. The interior lines of communication are short with the gallery of the playroom and auditorium serving as the corridor.

The rectangular shaped building.--In the same issue of the Architectural Forum as previously cited, a plan was presented as the "Forums School for 1950."[12] This plan has a combination gymnasium and auditorium at one end of the rectangular shaped building. The standard twenty-four by twenty-four foot bay is used throughout the plan, and does not change at corridors, since all partitions are independent of structure. Hence the corridor may be any desired dimension. In this instance the hall is sixteen feet wide to serve as lunchroom, recreation room, and possibly as study hall and library. This particular feature is planned for the new high school building at Pilot Point, Texas, where the hallway is eighteen feet wide. The author states that the twenty-four foot span can be built economically in wood, steel or concrete, including certain tilt-up methods.

To shorten the building periphery, which would cut down on expense of building, maintaining, and heating outside walls, the classroom has been turned around, exposing the short ends instead of the usual long sides. To gain daylight for all parts of the school, despite the greatly increased

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[12]Ibid., p. 134.

distance of central areas from the outside wall, the architect has resorted to the industrial method of top-lighting, assuming that an industrial manufacturer can develop a suitable plexiglass or other plastic bubble, mounted on a cylinder ready-made for insertion into any kind of roof deck. This method of getting daylight into all parts of the building does away with complicated roof breaks and on-the-job flashing such as present-day clerestory, high dormer, or skylight windows demand.

To eliminate corridor waste, the corridor has been shortened by turning the classrooms so that the short end is exposed, and the corridor widened to use for a general purpose lunch, recreation, exhibition and general purpose room. Each room has an outside glass door entrance to lessen corridor traffic and give some outdoor view.

This plan, which shows the probable trend in economical school buildings, emphasizes the following favorable characteristics: (1) absolute standard bays; (2) compact plan; (3) short periphery; (4) short communication lines; and (5) corridors put to redoubled use.

Since the preceding plan was presented, the shop and drawing areas of the Keokuk High School,[13] Iowa, have secured daylight through the roof by use of a large plastic bubble, similar in appearance to the noses on World War II bombers.

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[13]F. L. Cochran, "Significant Departures in Secondary School Design," The Nation's School, XLVI (February, 1941), 44-47.

This method was also used in the library to supply additional light.

Although transportable schools are too large and technical a problem to go into in this study, some schools, such as Seattle, Washington, consider the transportable school a solution to the problem of shifting school population.

Materials for School Buildings

Materials for framing.--The principle types of framing being used in school buildings are wood, steel, and structural concrete. Each type will be discussed in the order listed. The term "frame building" generally applies to a building where floors, walls and roof are of wood. This type of building may have the exterior wall of wood siding, brick veneer, asbestos siding, stucco, or stone veneer. The economy of the frame building both in materials and labor have made it very popular for one story and small school buildings. Wood adapts itself well to the buildings of the one story "campus" plan, the "finger type" plan, and the "neighborhood school". Since steel is probably more economical than wood in multi-story and wide span buildings, and since wood is combustible and creates a fire hazard in multi-story buildings, the use of wood in such buildings has been limited primarily to trim, mill, and cabinet fixtures.

Laminated wooden beams and arches are being widely used for buildings of wide spans and high arches as chapels, auditoriums, and gymnasiums. These beams and arches are made up of the desired number of one or two-inch materials and glued together under high pressure. Such members have great strength, are warp resistant, have a favorable fire rating when properly treated, and may be treated with chemicals on the market for fungi and insect control, and in some instances are economical to use. It is not necessary to cover these beams and arches as they may be left exposed without detracting from the beauty of the building. Laminated arches may take the place of both rafters and wall studs. Beams and arches of this type are quite often covered with a decking of two inch tongue and grooved boards to which the roof and siding are attached. Ceiling materials may be attached directly to the under side of the decking, leaving the beams exposed, or, if acoustical or insulation treatment is not desired, finishing materials may be applied directly to the exposed decking. Walls may be given the same treatment where arches are used. Laminated beams and arches, as well as wooden trussed roof framing, may be ordered in needed sizes and shapes ready to be erected at the building site, aiding in the speedy erection of the building framing.

Although laminated beams and arches increase the span possible for wood framing, Alonzo J. Harriman and Philip Gotz,[14] in a study of the costs of the different school plan types, found that for spans of classrooms of over thirty

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[14]A. J. Harriman and Philip Gantz, op. cit., p. 111.

feet, steel would probably be cheaper than the conventional pitched roof type building of wood. Steel has many advantages as the framework for a building. It has great strength, lasts indefinitely, is quickly erected, is well adapted to the free-standing column rigid frame type construction, and, during normal times, is plentiful in supply. Laminated wood beams and arches gained much of their popularity during World War II as a substitute for steel. It is likely, however, that steel will continue in short supply for a number of years.

The Great Lakes Steel Corporation has developed a practical, usable method of adopting steel to light framing construction. They have developed a product to replace the stud, joist, and framing in general called "Stran-Steel". The distinctive feature of "Stran-Steel" is the nailing groove that provides a way for ordinary materials to be nailed to the steel structure. The producers of Stran-Steel list the following advantages for their product: It is fungus, termite, and fire proof; does not warp, twist, or shrink; has great strength which can be easily determined; and is uniform in quality. Stran-Steel requires no special planning and carpenters familiar with wood framing are well qualified to erect Stran-Steel framing using ordinary tools.

Welding has done much to speed up the erection of steel frame buildings. By welding the steel members together, riveting has been practically eliminated.

Many schools in recent years have employed the rigid frame type of construction, supported by round steel columns.

In this type of construction, the skeleton is erected first and then the roof. The rest of the building may then be completed with protection from the weather. Continuous window walls or non-load-bearing walls may be erected without interference from the columns by locating the walls inside of the line formed by the columns. Many buildings are completely framed with steel, but much of the use of steel is in conjunction with wood and masonry structures.

To meet the need for lighter and more economical construction, manufacturers have developed preformed concrete joists and beams that may be delivered to the construction site and lifted into place with machinery. The use of preformed beams and joists, because of the high cost of shipping, would be considered only in localities near such a plant. The growth and expansion of plants specializing in ready-mixed concrete, precast beams and joists, and concrete building blocks has been tremendous in the last two or three years, and these plants will probably be able, in a short time, to supply all areas where building is being done.

Along with concrete joists, a hollow tile-like unit for filling the spaces between the joists has been developed to form the ceiling and sub-floor for the upper floors of a multi-story building. A concrete slab may be poured on the upper side for the floor, and ceiling materials may be attached directly to the smooth ceiling. The hollow tile-like space between the ceiling and floor serves as an insulation and sound deadening as well as a load-lightening space.

Entire buildings are now being built of concrete, reinforced with steel, by the tilt-up method. Wall slabs are poured on the ground and lifted into place with hoisting equipment, saving many hours of labor and much form material. These slabs are set in place and the columns poured, tying the wall slabs together. Then, by use of the precast beam and tile, the entire building may be speedily and economically erected. It is entirely possible that by this method, concrete buildings which have been the most costly building, may become our most economical type of permanent construction.

Materials for walls and ceilings.--Some of the most significant construction methods developed in the postwar period were in the use of concrete. Insulated precast slabs for walls and floors were employed. The principle of densification was recommended to overcome cracking and checking caused by shrinkage. Roof slabs poured over floor slabs at ground level were hoisted up columns and anchored at the desired level. Light weight corregated steel panels replacing forms for floors and roofs contributed to lighter, more rapid construction.

The Yountz-Stick lift-slab building method which casts roof and upper floor concrete slabs on the ground and then raises them into place with automatic lifting equipment was used in a building to house the physics department of the

Southwest Research Institute at San Antonio, Texas. O'Neal Ford was the consulting architect. Other buildings, using this method of construction are contemplated for the Trinity University Campus.[15]

Some of the advantages claimed for this method are speed of erection, elimination of complicated forms, and economy through speed of erection and re-use of forms. After the roof has been raised and anchored, other work may continue on the building with protection from the weather. In connection with this method of pouring and erecting the roof and upper floors of the building, wall slabs may be poured on the ground and lifted into position.

Cement is the only major material used in building construction which has not advanced markedly in price since 1940. Also, this material has been available and in good quantity in most sections of the country. These reasons undoubtedly have influenced its increased use in columns and spans as well as entire exterior surfaces. An accelerated use of concrete in future buildings is forecast by Walter D. Cocking, editor of the American School and University.[16]

The development of light weight aggregates has done much to increase the use of concrete. Since some of the aggregates

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[15]Progressive Architecture, "1951 Design Survey," XXXII (January, 1951), 53.

[16]W. D. Cocking, "Educational Building in 1949," American School and University (1949-50), p. 41.

weigh only one tenth as much as sand, the weight of concrete spans are considerably lightened by its use. Although light in weight, this light weight concrete has considerable strength and is highly recommended for roof and floor fills.

A volcanic rock has been ground and used in the making of a lighter and stronger concrete block. Sold on the market as "haydite," this concrete or cinder block is stronger and less likely to crack than the original concrete block.

The Detroit Public Schools have successfully used the pumice or cinder block for several years. Since the block is in hollow tile form, it has good insulation qualities. Being of large sizes, the tile is easily and quickly laid, reducing labor costs in erection. Plastering of the inside wall, which is a costly finish, has been eliminated by simply painting with a non-bridging paint, leaving its porous surface open for the good acoustical effect it has in absorbing sound. The exterior surface may be either plastered, sealed with a water-proof mixture and painted, or faced with brick. Since it is also more economical than clay tile, the cinder block has become very popular for building school buildings.

Although hollow cinder block is in many ways an excellent material for interior partitions, it has the disadvantage of transmitting much of the sound which impinges upon it. However, R. H. Esling and E. R. Bascom of the Physics Department of Wayne University, Detroit, Michigan, found that the transmitted sound through the cinder block wall with plaster on one side was low enough to be lost in the background noise of an average classroom.[17]

H. M. Shaw of the N. C. Products, Incorporated, Raleigh, North Carolina, in an effort to control the tendency of concrete block buildings to crack, has developed an expansion joint which deserves attention. By a simple change of the molds, blocks are made with two vertical keyways in the ends that are to be joined. A vertical line joint is formed by the use of half blocks in every other course. The blocks with two vertical keyways are then laid with wooden strips approximately one inch by one and one-fourth inches and as long as is convenient. They are placed in the keyways, forming a double seal against moisture, but allowing an opening and closing of the vertical wall joint without damage to the wall. The joint is then sealed with a rubberized caulking material that compensates for expansion and contraction of the wall.[18]

A very recent development in the use of concrete has many possibilities. This development is a method of spraying concrete on wire mesh to form curtain walls. This method would be especially useful in forming circular and uneven wall surfaces where forms would be difficult to build. Increased use of this method will be encouraged by the

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[17] R. H. Esling and E. R. Bascom, "Cinder Block: Sound Transmission," Progressive Architecture, XXXI (August, 1950), 89.

[18] H. M. Shaw, "An Expansion Joint for Concrete Blocks," Concrete, LVIII (June, 1951), 31.

development of inflated forms upon which the concrete mixture may be sprayed. When the desired wall thickness has been secured and sufficiently dried, such a form could be deflated and removed through a window or door. Especially would this type of construction be useful in the construction of buildings with oval and dome shaped concrete roofs. Such forms are now in the experimental stage, and it remains to be seen how successful they will be.

For floor and roof installations, a concrete plank which is light-weight, nailable, and easily cut in the field, is being manufactured. The plank is composed of cellular Portland cement concrete of a selected mix and reinforced by two full length courses of steel mesh. The planks have a smooth even surface on all sides and edges are generally tongued and grooved. These planks have been used in a number of school buildings in the Northeast. As far as use is concerned, they are still in the experimental stage. Ready formed, reinforced concrete beams and joists are being manufactured using the light weight aggregates in the mixture.

A most popular building method, especially for small buildings, is the solid slab foundation with walls of reinforced concrete, concrete masonry, brick, frame, and other types of construction. One of the principal advantages of this method is that the slab may shift with the soil without damage as would result with a conventional foundation. Other advantages are that the slab is fireproof and impervious to termites and rodents. The floor may be used natural, colored, or covered with wood, asphalt tile, linoleum, rubber tile, or terrazzo. Radiant heating coils may be imbedded in the slab to eliminate cold floors. The slab floor may be used to tie the classroom to the outdoors, a particularly desirable practice for the smaller grades in climates where extensive use may be made of the outdoors.

A corrugated building panel, consisting of a core of celotex cane fiber insulation, to which a non-combustible, cement-asbestos facing is bonded on both sides by a vapor-resistant, moisture proof adhesive, is finding use for roof decks, partition walls, curtain walls, and even for outside walls. This type of material has been used on the gabled end of a new gymnasium building on the North Texas State College campus at Denton, Texas. Similar materials may be bought with a smooth instead of a corregated surface. These panels are rigid, preformed panels, light weight and easily handled. Their smooth, hard, stone gray surfaces have a high light reflection value with an attractive interior and exterior finish. These panels are easily and quickly fastened to wood or metal frames with nails or clips.

The large number of out-dated brick school buildings of today bear testimony that brick is one of our most durable building materials. However, since the needs of education are rapidly and continually changing, the trend is away from heavy massive school buildings and toward light simple structures. The light simple structure is the result of the use of repetitive bays; non-load-bearing partitions; fewer and larger building products; and speedy erection techniques.

Brick, made of clay and fired in a kiln to an intense heat, has been in short supply because of the inability of the brick companies to supply the demand. Bricklayers have also been scarce and the wage scale is high, adding tremendously to the cost of brick buildings.

The most common use of brick is in the construction of brick veneer buildings. Brick is used for the outer skin with a back-up wall of tile, concrete, concrete block, or wood frame. Frequently such a wall has a cavity between the brick face and the back-up wall. This cavity is frequently filled with a waterproof insulation to prevent moisture seeping through the wall and also for insulation purposes. Such walls are usually plastered on the inside.

"Brickcrete," a compressed concrete mixture closely simulating brick, is less costly and lighter in weight than brick. Because of its lighter weight, the size, weight, and cost of footings and foundations required for such a building are less than that required for brick. "Brickcrete" is made in color to resemble brick, highly resistant to water, and may be had in either brick or tile form. Its chief uses are for interior four-inch and veneer walls.

Harvey Miller,[19] an architect in Washington, District of Columbia, advocates the use of brick without mortar

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[19] Harvey Miller, "Dry-Joint Masonry," American School and University, (1950-51), pp. 377-379.

between them. As proof that mortar is not needed, he refers to old buildings of the Romans, Persians, and Egyptians, where mortar was not used between joints of sun-dried brick and stone. Between the back-up wall and the brick, a one-half inch space is left for grout mortar to aid metal ties in joining the walls together. He claims that a man can lay ten times as many brick a day using this method, that an experienced man is not needed to lay the brick, and that freezing temperatures do not delay construction.

Another popular building material of ceramics closely related to brick is tile. It too, is a product of clay and is fired and finished much in the same way as brick. Structural face tile can be used for single unit structural walls or for veneering and offers many of the advantages of brick. Tile is permanent, light in weight, and economical to use in building because its large size and light weight permit rapid construction, and it is economical in maintenance. Another advantage over brick is that it is hollow, producing a trapped air insulated wall. This feature aids in preventing water penetration and capillary attraction.

Tile is produced in a number of forms such as structural tile, face tile, glazed tile, and glazed structural facing tile. Structural tile may be used to form a structure in conjunction with concrete or as a back-up wall for brick. This type of wall is rigid and permanent, decay and termite proof, fire and wind resistant, and economical in cost and maintenance. Face tile is given a texture similar to brick for exterior use. Such a wall resembles brick, although the tile is larger than brick. Glazed structural facing tile have one face with a slick glazed finish for the interior side. Many schools are using this type for corridor, rest room, classroom, and shower room walls, particularly below wainscot level. The particular advantages of this type wall is the ease of maintenance. The hard glazed surface is easily cleaned and does not require painting, nor is the surface easily damaged. The surface is not affected by moisture, therefore, it makes a good wall surface where the humidity is high. Facing tile, which is attached to the wall for a protective finish, is a thin flat tile, available in many colors and shapes. In addition to square units, standard items include octagons, hexagons, elongated hexagons, pentagons, fish scales and many other shapes. These are used as wainscoting, both indoors and out, building fronts, fountains, pools, vestibules, mantels, rest rooms, and shower rooms.

Plastic and metal tile are available but are useful chiefly for repair or redecoration. The cost is such that it is probably more practical to select clay tile, especially in new buildings.

There has been a tendency in the last few years, particularly in the elementary schools, to use wood for room and corridor wall surfaces. Large size building panels of plywood produce a rigid wall with a pleasing appearance and are easily and quickly erected. The use of a rigid type frame with non-load-bearing walls have made this type of wall very satisfactory. The increased use of wood for classroom and corridor walls has developed along with the one-story type building, in which the danger to the life of the child from fire is negligible.

Plywood is being extensively used for wall, floor, and roof sheathing, as well as for concrete forms. Manufactured in large panels, it is economical to install. It has great strength and rigidity and is warp resistant. Manufacturers of plywood claim that one-quarter inch plywood has practically the same loss in sound transmission as one-half inch gypsum plaster on wood or metal lath .

Plywoods are available with a veneered face of hardwoods for beautiful, decorative finishes. These panels have the same characteristics as the more common fir plywoods with the beauty of such hardwoods as oak, mahogany, maple and walnut. Thin layers of hardwoods have also been glued under heat and pressure to cotton sheeting for the covering of curved surfaces to obtain a wood finish.

Wood will long be a favored building material for schools, especially for inside use due to its beauty and charm and the warm, friendly atmosphere created by a wood surface. Although wood lends itself well to the construction of small schools and "neighborhood schools" as well as schools of the finger-type plan, the continued need for painting of exposed surfaces and the high insurance rate offset, to some extent, the cheaper cost of construction.

According to W. D. Cocking, editor of the American School and University, several educational buildings used aluminum as an exterior wall surface in 1949, and, he predicts there will be an increased use of this material in the future.[20]

Steel has also found its way into school buildings for walls. Use has been made of steel walls in the demountable, transportable pre-fabricated schools of Great Britain, designed to solve their acute shortage of school buildings after World War II.

Increasing use is being made of pre-fabricated steel wall panels complete with insulation and electrical outlets for removable partition walls. The high purchase cost is at least partly offset by the fact that the partition may be removed and replaced easily and quickly at little cost of labor. The changing need for space makes this feature highly desirable and worthy of consideration for our school buildings. Since these panels come pre-finished with baked-on enamel in a variety of colors and patterns, the wall and finish is durable as well as decorative. These same type panels with outside finishes have been used some, principally by industrial companies, for outside walls. Many advantages, such as speed of erection, ease of maintenance, durability, strength, and flexibility are claimed for this type of construction.

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[20]Cocking, op. cit., p. 41.

As a result of research and scientific planning of our school buildings and of discoveries and developments in the glass industries, light is receiving more and more emphasis in school plant planning. Although there is evidence that some unwise uses have been made of glass in building, greater percentages of wall areas are being devoted to glass. Bi-lateral lighting is becoming common, especially in one-story buildings where it is easy to design celestory windows. Use of directional glass blocks is increasing to insure proper lighting in all parts of the room. The developing trends toward greater interior flexibility has helped to bring full fenestration as an accepted design in most new elementary and secondary school buildings. The rigid frame, non-bearing wall type construction has made possible continuous fenestration, that is, windows continuing without a break for curtain or partition walls. Partition walls may then be rearranged to come between any two windows. This method adds to flexibility of room arrangement as well as eliminating dark places in the room caused by blank spaces between windows. It also simplifies and speeds up construction.

Although much of the present design with respect to lighting seems to be based on beliefs and prejudices, the State of Texas has been working on problems of ventilation and lighting at the Texas Engineering Experiment Station in College Station, Texas, headed by Executive Director Arthur W. Melloh. The first reports are to be publicized this summer.

William Arid Johnson,[21] along with many other architects and engineers believes that glass not only provides more and better daylighting, but that a square foot of glass costs less than a square foot of masonry, and that continuous fenestration is economical. Much less labor is involved in putting up large pieces of glass than in putting up a wall, and daylight is cheaper than electricity.

"Thermopane," a product developed by the Libby-Ownes-Ford Glass Company, is composed of two panes of clear flat glass with one-half inch of dry air sealed between for insulation purposes. This type of glass reduces the heat loss in cold weather and the amount of heat that enters in warm weather. "Thermopane" may be fabricated with varied types of flat glasses, including polished plate, sheet, heat absorbing, and patterned glass, to meet special requirements. Complete window walls with sliding glass doors that may be opened to form an open classroom are becoming increasingly popular especially in the elementary grades.

Glass building blocks are molded with a hollow center with a partial vacuum, giving them good insulating qualities. The blocks are manufactured in six, eight and ten inch squares which are four inches thick. They are quickly laid with mortar between the joints. They are especially popular where a maximum of light is needed.

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[21] W. A. Johnson, "Economy in Schoolhouse Planning and Construction," <u>American School and University</u>, (1949-50), p. 47.

Glass blocks that direct light to the part of the room where it is needed most are finding wide usage in our new school buildings, especially those that have window walls on the South where plate glass would have too much glare. A popular method of construction is the free standing rigid type frame, with continuous window strip for vision and ventilation and directional glass blocks above the vision strip. The glass blocks direct the light to the ceiling where it is reflected to the floor on the side of the room away from the windows. Directional glass blocks are sometimes used below the window strips to direct light to the floor. These types of glass blocks eliminate the need for awnings and blinds to control glare. Where properly designed, glass has done much to achieve beauty in school building.

Until recent years, it was generally assumed that walls above the wainscot and ceilings in all the larger school buildings would be plaster. Only in the very small schools of frame construction was there a variance from this type of construction. Here quite often the walls and ceiling would be of beaded ceiling or other wood materials. It is not uncommon now to find school buildings that let the roof be the ceiling, or ceiling materials attached directly to the under side of the roof deck. Quite often the interior wall is painted cinder blocks, a practice which has much merit. However, there has been no let-up in the development of new materials for walls and ceilings.

As has been previously mentioned, an effort is being made to develop luminous ceilings from glass which in itself gives off light. Other attempts have been made to use corrugated plastic for ceiling material with light coming from above through arrangements of skylights, clevestory, or monitor windows. This arrangement creates the problem of controlling the heat from the sun in warm weather and making use of it during cold weather.

A number of materials in tile form, usually twelve inches square, for finishing walls and ceilings are available. One type of tile is manufactured from finely ground pure cork, the granules of which are coated with a fireproof binder. This tile may be cemented by adhesive directly on a solid backing, nailed to wood furring strips with fiber splines, or may be installed by any standard metal suspension. The factory painted finish has high light reflectivity and may be cleaned with a standard wall paper cleaner. The surface may be painted and repainted without noticeably affecting the acoustical efficiency. Spray painting is preferable to brush painting, but either method may be used. According to manufacturers of this product, it will not harbor vermin or permit fungus growth, is non-combustible, and has a high noise reduction coefficient.

Another tile of this type has a fibrous composition and is drilled to one-eighth inch of the back with numerous three-sixteenth inch diameter holes. The purpose of the drilled holes is to absorb sound. The noise reduction coefficient is slightly less than cork but is not affected by repeated painting. In comparison to cork, the fiber tile is economical in cost and maintenance. It has a high, glareless light reflection factor, is an efficient barrier to the passage of heat, and is suitable for all installations where the humidity is not excessive. The square and rectangular units permit a variety of designs for ceilings of any type. It may be cemented to plaster, gypsum board, or concrete. If applied on a new building, the finish plaster coat may be omitted. It may be nailed to a solid wood surface or to wood furring strips. There is a saving on the insurance rate when this type of ceiling is applied to gypsum board instead of open furring strips.

A perforated metal unit containing a mineral sound absorbing pad wrapped in flame-proof paper is a very desirable, slthough somewhat expensive finishing material. This incombustible acoustical treatment is easily maintained and has a very high sound absorption. Unperforated units are available for border effects and as a design treatment where sound absorption is not needed. This tile can be washed and repainted repeatedly without loss of acoustical efficiency. Its smooth, white, pre-finished surface gives high light reflection without glare. It is installed with standard metal suspension.

A tile which is finding popularity as an insulating and sound absorbing unit is the cane fiber tile. It is a light weight rigid unit combining excellent acoustical efficiency with a durable smooth surface. The perforations assure repeated paintibility and ease of maintenance. The fibers are treated to insure moisture resistance and resistance against termites and dry rot. This kind of material is available in a large unperforated sheet. It is being used as an insulation under wood siding and roofing.

Still another type of tile is composed of mineral fiber with a binder to form a rigid tile with a universal rating of incombustibility. It is also perforated, giving it high acoustical absorption and the ability to receive numerous paintings without ill effects.

Somewhat different in appearance is a cast gypsum product which provides a rigid, lightweight, sound absorbing incombustible tile. It has a uniformly fine textured porous surface and is available in white, as well as many pastel shades. A similar tile has fissures varying in size and location in each tile.

A perforated panel board and asbestos board may be used for a cheaper installation. Made in large sheets, they are usually used for facing for rock wool units.

Flush ceiling lighting units have been designed to work with ceiling tile units. Tile may be removed and replaced with the lighting unit.

A tile fabricated from selected wood that is shredded, then toughened by a hard-setting cement binder, has extreme strength and durability. It retards fire, is sanitary and easily cleaned. It is impervious to mold growth and decay and can be sawed like wood. It is not brittle nor easily broken in handling, and has an artistic textured surface. It is factory painted in standard ceiling colors and can be redecorated again and again with any good interior paint with no appreciable loss of sound absorption. It may, as other tiles, be cemented to plaster board, nailed to furring strips, or attached to metal supports mounted on two by two inch wood furring strips. Strip mounting has the highest noise reduction factor.

Closely resembling marble, a tile is manufactured by processing filaments of stone into a light-weight, highly sound-absorbent unit. With a fissured surface like stone, no two tile are identical in texture. Each tile is finish-painted at the factory. This tile has a high noise reduction coefficient, high light reflectivity, and serves to retard fire. It is not recommended for areas of high humidity or below wainscot height.

Gypsum board, commonly known as "sheetrock," comes in large sheets, commonly four feet by eight feet. It has a gypsum core with layers of long fibered paper on each side for strength. It has a smooth surface which may be painted or finished with a plaster texture. As is the case of cane fiber board, gypsum board is too easily damaged to be used on the lower walls or in areas of high humidity. Gypsum board will not buckle or warp, is non-combustible, and may be sawed and nailed like lumber.

Masonite is another of the more popular wallboard materials. It is manufactured by the Masonite Corporation of Chicago, Illinois. Masonite is made of wood chips exploded into fiber under high pressure steam. The product thus produced is known as lignecellulose fiber. The explosion process produces fine woody fibers of varying lengths coated with lignin, which is the natural binding agent of wood. When tempered, Masonite has a hard, slick finish which completely seals the pores so that moisture and dirt cannot penetrate, making it easy to keep clean. Tempered Masonite may be used in places of high humidity where other wall boards are not satisfactory.[22]

Acoustical plaster provides a simple solution to the problem of applying a sound absorbing material to any type of surface, flat, curved or irregular. It is easily troweled on either flat or irregular surfaces. It may be applied to any clean surface. In a natural color of brown which may or may not be painted, it produces a stippled finish to wall or ceiling. It may be painted any color by the use of a standard non-bridging resin emulsion paint. It is non-combustible, light in weight, and does not harbor vermin nor permit fungus growth. It is a good insulation and has a high noise reduction coefficient.

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[22] Sweet's Catalogue Service, Sweet's File-Architectural, Section 13 1/6.

Materials for floors.--The flooring in any school building makes up for a large part of the construction costs and the maintenance of floors throughout the life of the building will take a considerable portion of the general maintenance budget. Floors will do much to give the building a nice, sanitary appearance as well as determining to some degree the amount of usable light in the room.

J. J. Collins has set eight requirements for a school floor. They are as follows:

> 1. If it is a wood floor it must be obtainable. The latest reports of the Maple Flooring Manufacturing Association indicate that the sixty million feet of maple and birch flooring milled during the past fourteen months are but one-sixth of the required demand.
> 2. The floor should be reasonably noiseless.
> 3. It should be comparatively easy to maintain and repair. Schoolmen have come to consider asphalt tile floors as the easiest to repair because new tiles can be inserted to replace worn ones.
> 4. It should be resilient, yet it should have sufficient rigidity to provide safety and stability.
> 5. It should be durable and should not receive the impressions of weighty objects too easily. This is one of the faults of linoleum, asphalt, and rubber tile, and in some cases pine.
> 6. Flooring should be reasonably economical; not only in the cost of the material itself but also in labor costs.
> 7. The floor should have a pleasant appearance, one in keeping with the use of the particular room. Asphalt tile and linoleum lend themselves readily to design in various rooms.
> 8. Flooring should be relatively safe from slipping. It should have a smooth surface that is neither porous nor susceptible to stain.[23]

The presence of moisture is one of the greatest difficulties with wood floors. If the new milled stock has not

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[23]J. J. Collins, "Planning School Floors," American School and University (1950-51), p. 341.

been properly dried, it will warp, spread and twist. The same will happen if flooring, properly dried,is installed over an area where moisture is heavy. If the floor is installed so that it cannot breath, it will dry-rot regardless of its quality.

Wood floors are warm, resilient and reasonably quiet. They do not show marks or scars. Installation costs are less than for many other types of flooring. However, wood floors are expensive to maintain, do not retain a good appearance, and require frequent waxing. Worn floors are dangerous because of splinters and uneven surfaces. Quartered oak and fir splinter easily and also stain easily. Wood floors are somewhat noisy and can develop squeaks, particularly in frame buildings.

Pine and maple have been used most frequently for school floors, with maple taking a strong lead in the last twenty-five years. Birch is in the same class with maple and either, if properly cared for, will outlast the life of the building.

Another type of flooring is masonite tile, which is made of chips exploded under high pressure and compressed into boards.[24] These boards are laminated in somewhat the same fashion as plywood. This type of flooring is expensive but presents a hard surface and has long-wearing qualities.

Parquet flooring is made of squares of wood backed with canvas. Each square is made of a series of small boards in

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[24] *Ibid.*, p. 342.

six-inch lengths. Installation of this flooring requires trained specialists. While it produces an attractive appearance, the cost of installation and maintenance does not warrant its use in school buildings.

Of all the manufactured stone floors, concrete is the most often used. It is mixed not only as a floor itself, but as a sub-floor. Concrete is a mixture of rock, sand, and cement. Mixture, composition, curing, and finishing decide the quality of the concrete floor. One of the greatest difficulties with such a floor is its tendency to dust as a result of wear; however, the floor may be treated with a liquid hardener or sealer to prevent dusting. Unless it is properly cared for it will check and pit. This flooring can be colored at installation, thus eliminating continued painting.

Probably the greatest use of concrete in modern building insofar as flooring is concerned is as a sub-floor. Basements and corridors, storage rooms and locker rooms where there is matting laid on the floor are also constructed from this material. It is fireproof and comparatively easy to install, not requiring any skill such as the laying of tiles. There is a tendency to use a form of concrete flooring in large blocks which are pre-cast outside of the building and lowered into the proper place by a crane where they are locked by special fittings.

The present trend in buildings is to lay the entire floor in one major operation on each level, then set up the divisions of rooms after which the top flooring material is laid. This saves on forms and transportation of material, giving the entire level a clear surface.

One of the newer ideas is a lightweight cellular concrete made of cement and light weight aggregates. It is universally honeycombed with blown air cells which makes it light, sound-resistant, fire-retardant and resilient. This removes considerable weight and brings its construction cost down to the level of wood while providing the additional advantages mentioned above. In a six-inch cellular concrete floor, the total weight per square foot amounts to approximately twenty pounds. Concrete floors are reasonably inexpensive to install and will give long and hard wear if properly installed and cared for. Unfortunately, they can be noisy and are hard to walk or stand upon.

A second type of manufactured flooring is the terrazzo floor. While probably the most attractive of the floors of this class, it has several disadvantages. It will split and crack. It can become very slippery, especially when wet. It is susceptible to acids and alkalis, but is easy to clean. Terrazzo is a mixture of marble and granite chips with cement. The chips are "floated" to the surface and, when the floor has properly set, are ground to a high polish by a machine.

Strips of brass are inserted in the mixture, laying the floor off into squares or designs which may be varied as to shape or color.

Terrazzo flooring is fireproof and not affected by moisture to any great degree. It has a hard smooth surface and is long wearing. On the other hand, stains are hard to remove. Alkali cleaners cause it to dust and bloom. Acids will corrode the floor and pit it. It is seldom used in classrooms because of its "cold" surface. It is not resilient and has a tendency to show cracks due to building settling.

Tile is another type of manufactured stone. It is found in various lobbies, lavatories, and on walls. Tile flooring is used with satisfaction on stair risers and treads. Most tile floors are alkaline and may powder if not treated. In view of the joints which may be affected by acids or alkalis which do not affect the tiles themselves, the weakness of this type of floor is principally in the joints. These floors are susceptible to rust stains.

Ceramic tile has a variety of uses in the modern school building. It is used with great success in lavatories and in places where a high standard of sanitation is required. There is a great range in colors and designs; it is durable, fire-resistant, and reasonably easy to maintain except for direct repair which requires the services of an expert. Tile floors are cold and noisy under foot. Laying the tile is the work of a specialist.

The principal types of composition flooring are linoleum, cork, mastic or asphalt, and rubber. Linoleum is made up principally of oxidized linseed oil, cork, resin, and coloring. As a general rule, battleship linoleum is accepted as best in quality because it is thickest. Inlaid patterns may be secured and many attractive designs are obtainable. Linoleum is well adapted to use in kindergartens, libraries, offices, and other places where the wear is comparatively light as to traffic lanes and where attractive design is sought.

Linoleum is easy to install and may be laid over old floors, either wood or concrete. It is an insulator against heat and cold. It is resilient and quiet. There is a wide range of colors and patterns and linoleum is reasonably easy to maintain. The heavier grades will give good service for at least five years and many have been in service for as many as twenty years, depending upon wearing conditions. It is not recommended for floors in direct contact with the ground. It will warp if heavy weight is placed upon it for any length of time.

Cork floor material is made of cork fragments bound together with a mastic binder. It is very resilient and reasonably durable when given proper care. It is used principally for its acoustical properties in such places as kindergartens and libraries. Unfortunately, it will absorb stains rapidly and easily.

Asphalt tile and asphalt flooring are becoming generally accepted as one of the best types of flooring for school buildings. In recent years, manufacturers of asphalt tile flooring have overcome the difficulty of combining wearing quality with coloring. This flooring may be secured in colors from solid black, containing the most asphalt, to solid white. Available in tiles or rolls, it may be laid successfully under moisture conditions, below grade if necessary. It is reasonably warm, resilient, and non-slippery. Cigarette burns will not permanently injure this floor; ink will not stain it; and it is almost fireproof. It resists acids, alkalis, and electricity. Several schools, among them being Pilot Point High School, Pilot Point, Texas, have used asphalt tile for a gymnasium floor at a considerable saving in dollars.

Rubber flooring has a non-porous surface, with good wearing qualities. It can be installed over any smooth, dry and hard surface. It is resilient and impervious to dirt, moisture, fire and acid, and is alkali-resistant. Colors will not wear off and it is hard to stain. However, it is subject to expansion and contraction, easily injured by oils and greases, will scar from weighty objects, and will soften from excessive heat. Laying of rubber tile is similar to the laying of linoleum tile except that the cement is placed upon the tile instead of the sub-floor.

Kentile, Incorporated, a company which manufactures among other products, cork, asphalt, and rubber tile, gives the following approximate cost comparisons in an advertisement in the May, 1951, issue of The Architectural Forum.

> Asphalt tile--twenty-five cents per square foot for standard one-eighth inch thickness for one thousand square feet.
> Cork tile--fifty-six cents per square foot for three-sixteenth inch thickness for one thousand square feet.
> Rubber tile--sixty-two cents per square foot for one-eighth inch thickness for one thousand square feet.[25]

The Bureau of Standards of the United States Department of Commerce tested a number of flooring materials for wearing quality. The purpose of the test was to determine the best type of flooring for post-office workrooms. The materials tested are listed in order of the least amount of wear. Linoleum and rubber tile showed the least wear, with maple and asphalt blocks in second place, concrete in third place, end grain pine, end grain fir, and quartersawed red oak in fourth place, plain magnesite and asphalt in fifth place, and concrete surfaced with one to three mortar in sixth place with a tremendous amount of wear.[26]

Materials for roofing.--The built-up roof is probably the most popular of all types of roofs among school buildings. Its popularity lies in the fact that it is adapted to roofs of very low pitch, that it provides a long lasting roof, that it can be quickly applied, and that it requires little maintenance. The typical built-up roof requires a strong

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[25]Architectural Forum, XCV (May, 1941), 239.

[26]Monroe, op. cit., p. 1106.

smooth deck. From three to five layers of felt are used in the build up. The first two are laid in tar or asphalt and nailed to the deck. The other layers are mopped on with tar or asphalt and covered with poured tar or asphalt and gravel or slag. Approximately three hundred pounds of slag or four hundred pounds of gravel are used for each one hundred square feet of roof.

A built-up roof may be applied over a deck of poured or pre-cast concrete, poured gypsum, book tile, approved insulation, or wood. The felt may be saturated with either tar or asphalt. If felt is applied over insulation materials, the insulation must be firm, capable of withstanding traffic without crushing, and of a type that will withstand nails.

The built-up roof is practical and inexpensive and it does away with the wasted space and material built into gabled roofs. It is not affected by moisture or temperature. From the standpoint of fire-protection and economy, Johns-Manville,[27] a pioneer in the roofing field and manufacturer of a complete line of built-up roofing products, recommends an asbestos built-up roof as the most satisfactory for school service. In the build-up process, an asbestos felt is used instead of asphalt or tar saturated felt. The asbestos felt does not support combustion and therefore provides a marked superiority in fire resistance over the ordinary roofing felt. Because

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[27] American School and University, (1950-51), p. 543.

this type of roof has a smooth surface, there is no excess weight of slag or gravel.

In the past, practically all homes and small schools used wood shingles. These shingles are commonly made from redwood, cedar, and cypress. Composition shingles of felt, saturated with asphalt, and asbestos shingles made of cement and asbestos have practically replaced wood shingles in home building as well as small school building. The insulation value is one of the advantages claimed for wood shingles.

The asbestos shingle has the advantage of being fire-proof as well as being a long-life roofing material. It is not damaged by moisture nor temperature. They are available in a variety of colors which are impregnated in the shingle.

Asphalt shingles are less expensive than asbestos shingles, but are not as durable. They are made from a long-fibered felt thoroughly saturated with asphalt and specially blended to insure water-proofing and insulation against wind. They may be purchased in a variety of colors and shapes, with interlocking systems to prevent the wind from blowing off the shingles. A coating of mineral granules has been added to the top surface of the material for fire protection, and simulated wood grain and wood colors have been introduced to give the finished roof an appearance of wood shingles. The result of this development is that a building may be covered with an attractive roof at a very reasonable cost.

Composition shingles are better adapted to low-pitch roofs than wood shingles. The greater the pitch, the less likely a shingle roof is to leak. Wood shingles are not recommended for a roof with less slope than six inches of rise for twelve inches of run. Five inches of rise for twelve inches of run is recommended for a composition shingle roof, but they may be used satisfactorily on a roof as flat as three inches of rise for twelve inches of run.[28]

The use of metal roofing materials has been sharply curtailed during recent years. Critical metals, such as brass, copper, lead, aluminum, and steel were reserved for defense purposes during World War II. For a short time after the war, these metals were plentiful, but due to re-armament of our own country and our allies' countries, these metals are again on the restricted list. In addition to these metals being restricted, the great need for buildings and the lack of sufficient funds to meet the high building costs, along with the high cost of such materials, all combine to almost prohibit the use of metal roofs.

Copper has much in its favor as a roofing material. It is strong, rigid, and the least chemically active of commonly used commercial metals. This last feature gives it high resistance to corrosion from air, water, and acid solutions. It is a long lasting metal, easily worked, and requires little

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[28]Fritz D. Roberson, Materials and Construction Used in Small Homes, p. 53.

maintenance. It makes a light weight roof, thereby reducing the weight of heavy supporting structures.

Aluminum has many of the same advantages as copper, and in addition has a high heat reflectivity. It is much lighter in weight than copper, thereby requiring less roof bracing than copper. In addition to the V-crimp and corregated type aluminum roofing, a clapboard siding may be used as roofing. It is identical to the aluminum siding that is made to appear as wood siding when painted. The roof may be either painted or unpainted.

Steel sheets with protective coatings, similar to galvanized steel, are available, and probably the most commonly used of metal roofs. Although heavier than aluminum, steel is less easily damaged by storm or hail.

Also available as a roofing material is a corrugated sheet of cement and asbestos, the same materials as are used in asbestos shingles. It is a rigid, inorganic, fire resisting, and vermin-proof material. This type is made to be used for walls and roofs.

A method of fusing asbestos to sheet metal by means of a zinc alloy has been developed. The asbestos is imbedded in the metal, becoming an integral part of the sheet. The sheet of metal then has the characteristics of asbestos, such as endures the most severe weather, corrosive fumes, and excessive heat.

Another type of roof which has a long life with little maintenance is the tile roof. Very similar to the tile roof is the slate roof. Both require a waterproof covering underneath, such as asphalt felt. Both are laid on the felt with nails to hold them in place. They have enough weight within themselves to lay in position. Both are adapted to pitched roofs, and each will probably outlast the building. The clay tile is a fined clay as brick and clay building tile. The slate tile is natural slate rock cut to shape. The disadvantages are the high cost and their heavy weight, requiring a heavily braced roof.

In many instances, lighting is being provided for in the roof design. For many years, industrial plants have employed sky-lights, monitor windows, and sawtooth roofs to improve daylighting. Developments in plastics have increased these efforts to secure more and better lighting. Large plastic bubbles have been used on the roof to secure more light. A large part of the roof of the Southgate Elementary School[29] of Seattle, Washington, has been devoted to lighting. Along either side of the ridge of the corrugated aluminum roof panels of corrugated translucent plastic were inserted. Beneath these are hung adjustable metal louvers and then another layer of corrugated plastic panels to form the classroom's ceiling.

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[29]Architectural Forum, "School with Controlled Daylighting," XCVI (July 1951), 158-161.

The ceiling only covers the center portion of the room. The rest of the roof has no ceiling. Each of the three elements in the "lighting plenum" is a diffuser. The louvers are controlled by reversible electric motors. These are automatically activated by photo-electric cells located inside the room. They may be manually controlled by the teacher to darken the room for a movie or during a rest period. When the light level in the room drops below the desired level, a second set of photo-electric cells turns on incandescent lights hung from the ridge pole within the plenum.

Efforts are under way by lighting companies to develop panels of glass that give off light. They have not yet been successful to the point of lighting classrooms with sufficient light, but even this may be possible in the near future.

CHAPTER IV

APPLICATION OF CRITERIA TO POSSIBLE DESIGNS AND MATERIALS

One-Story Buildings

This chapter will be an application of the criteria for sound school building design and materials developed in Chapter II to the possible designs and materials for school buildings discussed in Chapter III. The materials will be grouped for convenience but the possible designs will be evaluated separately.

A. Educational Plan

1. The physical plant meets the educational needs of the child better than a multi-story building by creating a more home-like environment and by permitting better use of the outdoors.
2. The one-story building meets the educational and social needs of the community better by each unit being more accessible to members of the community than the multi-story building.
3. Provisions for good instruction in addition to the use that may be made of connected outdoor areas are benefits of this type of structure.

4. Necessary facilities may be provided for all phases of the curriculum.
5. Extra-curricular activities should be provided for in this type of building.
6. Outdoor recreational activities may become part of the daily routine, directly connected with the classroom activities of a one-story structure. In addition, provisions for indoor activities during inclement weather may be provided.
7. The one-story unit provides for the location of various units according to their functional relationships and special requirements.

B. Economy

1. Use of light weight economical materials is possible in the one-story building.
2. Materials are applicable in this type of structure that reduce labor costs; for example, prefabricated partition walls, large size wall boards, precast concrete planks, precast beams, wall slabs and others.
3. Natural lighting and ventilation may be achieved in ways impossible in a multi-story structure. Top lighting by plastic bubbles, monitors, clerestory windows, and plastic sheets in the roof are limited to one-story buildings.

4. Space utilization is more complete in the one-story plant by the elimination of stairs. More site space is required for the one-story building than for a multi-story building.
5. This type of structure encourages the use of materials for clean, wholesome living.
6. Time and effort of pupils, teachers, and administrative personnel will be conserved if properly planned. More lateral travel is required but vertical travel is eliminated.
7. The lowest cost per square foot is obtained in one-story buildings according to W. D. Cocking.[1]
8. The building and grounds of a single story building are more easily supervised due to the readily accessibility of each room to the outdoors.
9. There is no necessity for waste spaces in the one-story plant.
10. The use of dual purpose rooms is applicable to the one-story building.

C. Safety

1. The one-story building has an excellent rating for safety. Fire is not a hazard in a one-story

[1]W. D. Cocking, "School Plant Trends," School Executive, LVIII (January, 1949), 37-9.

structure with individual entrances, since the entire building may be emptied as quickly as one room.

2. Materials that cause flash fires should not be used.
3. In a one-story building, the heating plant can be more or less isolated from the rest of the building.

D. Health and Sanitation

1. This type of structure is adaptable to happy, comfortable, living through the friendly, home-like design.
2. An abundance of natural lighting encourages the use of color to create a pleasant, comfortable atmosphere.
3. An abundance of natural lighting and ventilation may be economically supplied in a single-story school plant.
4. Shower rooms and rest rooms are more easily lighted and ventilated than in multi-story structures.
5. Comfort may be emphasized in planning this type of building.
6. Health facilities may be equally well provided in either a one-story or multi-story building.

7. Odorous and noisy areas are more easily isolated in one-story structures.
8. Less acoustical treatment is necessary in a one-story building where noisy activities may be isolated from the quiet areas.

E. Flexibility

1. Window arrangement and movable interior partitions may be so designed as to allow for economical rearrangement of one-story buildings.
2. A one-story structure is especially adapted to non-load-bearing partition walls which may be so constructed as to be economically moved.
3. Interior fixtures of either single or multi-story buildings may be movable for rearrangement.
4. Both types of buildings may also have the service systems so arranged that shifting of the interior walls will not necessitate their rearrangement.
5. The one-story structure in this wide spread arrangement is better adapted for community use without interrupting the school program than the compact arrangement of a multi-story building.

F. Expansibility

1. Service systems of either type should be planned for future expansion.

2. The one-story plant is better adapted for enlargement without unnecessary cost and interference with the rest of the building than a multi-story structure because of the smaller wall area concerned, no stairways to interfere, and low height of the building.
3. In either type of building, materials may be used to allow for future expansion.
4. The one-story building, if properly designed, will allow for future changes without destroying the completeness of the design.

G. Design and Beauty

1. With the wide range of materials that are adaptable to a one-story design, emphasis may be placed on selecting materials to produce a beautiful building.
2. Balance and proper relationship of parts to the complete structure is possible through the many variations of one-story building types.
3. The low, homelike structure of the one-story building has an inviting appeal to the pupils.
4. Useful features, such as the use of glass for lighting and ventilation, along with a minimum of ornamentation, may achieve beauty in a single story building.

5. The one-story structure may be easily made to harmonize with the building site.

H. Durability and Maintenance

1. The one-story building may be designed for economical plant operation. Only in very cold climates where heating is a serious problem is a multi-story building justified for economical plant operation.
2. From the wide range of materials suitable for single story construction, materials that are easily maintained may be more easily selected than for a multi-story building.
3. Similarly durable materials may be selected.
4. Metals that do not rust or corrode may be selected equally well in either type of building.
5. Plumbing and electrical lines are more easily located for accessibility in one-story structures since fewer vertical lines are necessary.
6. Standard plumbing and electrical equipment should be used in any type of building.
7. Neither is the necessity of using standard electrical equipment limited to any type of building.

There is almost universal agreement that, in areas where land is available and not excessively expensive, the one-story building may be built more economically and will meet the needs of our school better than a multi-story building.

According to _American School Buildings_, the budgets of school districts will not finance the construction of Class A building, buildings built entirely of fire-retardant materials, also, an emphasis on flexibility of school structures tends toward the use of building materials more flammable than those found in Class A structures. For these two reasons structures less fireproof than Class A are normally justified provided safety of the occupants of the building is assured. It is also stated that it is essential that school buildings of two or more stories be of at least approximate Class A construction.[2] If the preceding statements are true, then one-story buildings seem to be the only answer for schools with limited funds for building.

The Home School Unit

A. Educational Plan

This type of school being a one-story school, fulfills all requirements of the educational plan as shown for one-story buildings.

B. Economy

1. Light weight economical materials are practical for this plan.

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[2] American Association of School Administration, _American School Building_, 27th Yearbook (1949), p. 169.

2. Labor costs may be reduced as for one-story buildings.
3. Natural lighting and ventilation are characteristic of this school type.
4. This plan meets the requirement of space utilization.
5. Special emphasis for materials for clean, wholesome living are characteristic of this plan since this school was designed for the kindergarten and first three grades.
6. Time and effort of teachers, pupils, and administrative personnel is conserved since the original plan by Engelhardt was for not over 300 pupils.
7. This plan is simple and usually the cheapest of all types of schools, since an auditorium and gymnasium are not necessary.
8. The Home School Unit meets the standard of easy supervision of building and grounds.
9. There is no necessity for waste spaces in this construction plan.
10. Dual purpose rooms may be provided where practical.

C. Safety

1. Safety of the inhabitants from fire is assured by individual classroom entrances.

2. Being a special design for small children, safety is of primary importance in the selection of materials.
3. As in all one-story buildings, the heating plant may be safely located in respect to the building inhabitants.

D. Health and Sanitation

All items of health and sanitation are met by this building plan as in the one-story building.

E. Flexibility

There is no variance from the standards of flexibility as fulfilled by the one-story building.

F. Expansibility

All elements of expansibility are met as for the single story plan of school building.

G. Design and Beauty

All elements of design and beauty are included in the Home School Unit the same as for the one-story structure with added emphasis on creating an uninstitutional, domestic appearance.

H. Durability and Maintenance

The Home School Unit, as planned by Engelhardt, is large enough to permit economical operation and meets all requirements of durability and maintenance as did the one-story structure.

The Finger Plan

A. Educational Plan

The finger plan meets all requirements of the educational plan as previously discussed for one-story buildings.

B. Economy

1. The finger plan meets the standard for use of lightweight economical materials since, due to its design, heavy materials are not needed.
2. This plan is especially applicable to the use of rapidly applied, prefabricated units and building materials covering large areas, thereby reducing labor costs.
3. This plan is definitely outstanding in meeting the standards for natural lighting and ventilation.
4. Space utilization is stressed in the finger plan design.
5. This plan encourages the use of materials that provide for clean, wholesome living.
6. The finger plan does not meet the requirements of conserving time and effort of pupils, teachers, and administrative personnel. It is second only to the campus plan for over extended lines of communication.

7. It is generally agreed that the double-loaded corridor plan is a more economical design than the finger plan.
8. The building and grounds are especially easy to supervise when the open type corridor is used.
9. Waste spaces do not need to occur in this plan.
10. Dual purpose rooms may be used as with other plans.

C. Safety

1. Safety to the inhabitants of the building is increased by individual classroom entrances, a feature of the finger plan.
2. This plan may be economically constructed with wood, steel, or concrete framing according to the desire of the school. Fire-retardant materials may be used for interior partitions.
3. In this type of plan, the heating plant may be easily segregated from the classrooms for safety.

D. Health and Sanitation

The finger plan is exceptional in this respect, an abundance of light and ventilation being one of the chief items for which this plan is outstanding. It is also an outstanding design for locating noisy and odorous areas properly. All other items are satisfactorily met and these mentioned outstandingly so.

E. Flexibility

1. This plan is conducive to rearrangement of partition walls.
2. Partition walls are of the non-load-bearing type that may be moved economically.
3. Interior fixtures are recommended to be of the movable type.
4. Service systems are also recommended to be arranged so that shifting of partition walls will not necessitate their rearrangement.
5. The arrangement of the finger plan is exceptionally good for community use without interference with the school program.

F. Expansibility

The finger plan is especially outstanding for expansibility in that it may grow at branch ends or sprout a new branch. This plan ranks high in all items of expandibility.

G. Design and Beauty

1. Materials of beauty may be used as the building may be framed of wood, steel or concrete, with a wide range to choose from for the other materials.
2. Beauty may be achieved in such a structure by balance and proper relationship of parts to the complete structure.

3. This type of building can be made to have a most inviting appeal by tying the classroom to the outdoors by window walls and sliding glass doors.
4. By the proper use of glass and glass blocks, beauty may be achieved without resorting to extensive ornamentation.
5. In most instances, the building can be made to harmonize with the site by proper planting and landscaping.

H. Durability and Maintenance

1. The finger plan does not meet this requirement as well as a more compact plan in that there are more outside wall spaces to be heated and longer service lines.
2. Easily maintained materials should be used.
3. Durable materials should be used throughout the building.
4. As in any other type of building, metals that do not rust or corrode should be used.
5. Plumbing and electrical lines are easily arranged in this type of building.
6. Standard plumbing and electrical equipment should be used throughout.

7. Standard fixtures, unbreakable where necessary, should be installed.

Because of the long outside wall line, long foundation line, and long service line, the maintenance of this type of building is not as economical as a more concentrated type of building.

The Campus Plan

A. Educational Plan

The campus plan of school building construction favorably meets all requirements of the educational plan.

1. This plan is especially conducive to the location of the various units according to their functional relationships and special requirements.

B. Economy

1. Light weight, economical materials may be used where practical.
2. Materials may be used to reduce labor costs.
3. This type of building plan can make full use of natural lighting and ventilation.
4. Space utilization may be stressed in the campus plan.

5. Materials may be used that provide for clean wholesome living.
6. The campus plan does not meet the requirement of conserving time and effort of pupils, teachers, and administrative personnel due to the large building site required and the wide range of buildings.
7. Neither is the requirement that the building be designed as economically as possible, consistent with the function of the school plant met, as there are building designs that do meet all the standard requirements which can be constructed more economically. However, one feature of economy is that as each building may be constructed separately and as needed, the newest construction methods and material developments may be used.
8. The plan does not meet this requirement since buildings and grounds of this nature are harder to supervise than a conventional building.
9. Waste spaces may well be eliminated from this type of construction.
10. This plan may meet the requirement of using dual purpose rooms where practical.

C. Safety

1. This plan is an especially safe building plan due to the buildings being scattered and lack of congested areas.
2. This requirement is particularly well met as the heating plant may be a separate building.

D. Health and Sanitation

The campus plan may provide for all requirements of health and sanitation, and is especially conducive to plentiful daylighting and natural ventilation.

E. Flexibility

The first four requirements of flexibility can be provided for with the campus plan.

5. This plan is especially adapted for use by the community without disrupting the school program.

F. Expandibility

This plan is fully expandible, since when more room is needed, another building may be built, providing an adequate site has been selected.

G. Design and Beauty

Assuming that planning of the building and building arrangement and selection of site have taken into consideration further development, the campus plan meets all requirements for design and beauty.

H. Durability and Maintenance

The campus plan does not meet the requirement of economical plant operation and maintenance as by nature of the arrangement, the maintenance and operation of many buildings will not be as economical as an integrated unit.

The campus plan has many admirable features but until schools in general have more funds available for school building, it seems probable that this plan will remain the exception and not the rule.

The Round School

A. Educational plan

All items under educational plan may be adequately met by this experimental round school.

B. Economy

1. Since the interior walls are curtain walls, lightweight economical materials may be used where it is practical to do so.
2. An effort to reduce labor cost is made in supposing the roof to be constructed by the Yountz-Slick method, that is, poured on the ground and raised up six hollow columns to position. The

ceilings of classrooms would be poured and raised by the same method.

3. This building does not meet the requirement of natural ventilation. Daylighting is achieved by plastic bubbles from the roof.
4. Space utilization is particularly emphasized in this plan, with the gallery of the playroom and auditorium serving as a corridor.
5. Materials may be used that provide for clean wholesome living.
6. This design stresses the conserving of time and effort of pupils, teachers, and administrative personnel.
7. According to architects, this is a very economical plan in that much material is conserved by using the circular plan. The circle contains a larger area according to its perimeter than any other geometrical design.
8. The building and grounds of such a building would be very easily supervised.
9. One of the main characteristics of this plan is the elimination of waste spaces.
10. Dual purpose areas are planned in the combination play room, hall, and auditorium.

C. Safety

1. Safety of the inhabitants may well be provided for in this building plan.
2. Materials suggested for this building insure safety to the inhabitants as all outside walls, roof, and floor, may be of masonry construction.
3. The heating plant would necessarily need to be inclosed in complete fireproof materials to protect the inhabitants of the building since, in such a design, the heating plant cannot be isolated.

D. Health and Sanitation

1. There would be a question on this type of building providing for happy, healthful living in the absence of outside windows. A full length glass door opens from each outside corner of each classroom, providing the only view to the outside.
2. A comfortable, pleasant atmosphere may be created by the interior finish.
3. Inhabited spaces are lighted from above, the auditorium by continuous clerestory windows under the roof and the rest of the building by plastic bubbles in the roof.
4. Rest room and shower rooms are well lighted and mechanically ventilated.

5. The health and comfort of the inhabitants through ventilation is provided mechanically.
6. Provisions are made for health education.
7. Noisy and odorous areas cannot be isolated. Acoustical treatment and mechanical ventilation are necessary.
8. The building may be made comfortable and healthful in regard to acoustical qualities.

E. Flexibility

1. The exterior construction allows for rearrangement since outside and partition walls are non-load-bearing and there are no windows, only the outside doors, to interfere. All other items are provided for with the exception of community use of the building.
7. Individual rooms could be used by the community without interference with the school program, but use of the auditorium would be impossible without some interference, since it is located in the center of the combination hall, playroom, and auditorium.

F. Expansibility

The circle plan could provide for none of the expansibility requirements. It is a complete structure within itself with no satisfactory method of expansion. The only method of expansion would be construction of another building.

G. Design and Beauty

1. Materials could be used with which beauty might be achieved.
2. Beauty can be achieved by balance and proper relationship of parts to the complete structure.
3. Although unusual in appearance, such a building and site could have an inviting appeal to children.
4. Useful features may be used to achieve beauty in this design.
5. By proper landscaping, the building could be made to harmonize with the site.

H. Durability and Maintenance

1. To the normal cost of operation must be added the additional cost of mechanical ventilation, an expense prohibiting economical operation of the plant. All other items of plant durability and maintenance are favorably met by the circular building.

Since the round school is a radical departure from the accepted building types, the public probably will be long in accepting it, although the plan does have much to recommend it. Educators will probably object to the absence of window space in the plan.

Forum's School for 1950

A. Educational Plan

1. This proposed plant has the physical requirement for the educational needs of the pupil.
2. This design may well provide for the educational and social needs of the community through use of the combination gymnasium-auditorium and the library and classrooms.
3. Provisions have made to encourage good instruction with adjoining play areas for the younger pupils, display areas in the multi-purpose hall, and special purpose classrooms. All other standards of the educational plan may be equally well provided for since these standards depend on adequate planning rather than the design of the building.

B. Economy

1. The plan meets the standard of the use of lightweight economical materials since all partition walls are independent of structure.
2. An effort to reduce labor cost has been made by use of the repetitive twenty-four by twenty-four foot bay, which does not change at corridors.

The elimination of windows and use of prefabricated plastic bubbles ready to attach to openings in the roof are labor saving as well as material saving devices.

3. The standard of natural lighting has been met by the plastic bubble, but natural ventilation has not been provided for as mechanical ventilation is required in the plan.
4. Space utilization has been stressed by the combination gymnasium-auditorium and the multipurpose hall which may be used as study hall, library, recreation area, lunch room, and display area.
5. Materials that provide for clean wholesome living may be used.
6. Time and effort of teachers, pupils, and administrative personnel would be conserved by a compact unit by which the hallway is shortened. The short side of the classroom has been turned out, shortening the length of the building and shortening travel time between areas.
7. This design has been presented chiefly for its economy. The use of the repetitive bay, petitions independent of structure, plastic bubbles for lighting, classrooms turned with short side

out to shorten building length, and extensive use of the hallway are all features designed for economy of building and maintenance.

8. This building and grounds would be more easily supervised due to the wide hallway and shorter building length.
9. Waste areas have been eliminated.
10. Especially good use has been made of multiple use of spaces.

C. Safety

1. Safety to the inhabitants of the building has been emphasized by the wide hall and the outside door to each classroom.
2. The building is so designed that it may be satisfactorily framed of wood, steel, or concrete. Fire retardant materials may be used throughout the building.
3. The school plant is protected from the heating plant by enclosing the heating plant in a fire-resisting room.

D. Health and Sanitation

Adequate provision has been made for all items of health and sanitation. Mechanical ventilation has replaced natural ventilation and must be depended on to remove unpleasant odors from all areas.

E. Flexibility

The first four items are provided for by the construction of all interior walls independent of the structure of the building. The hallway, as well as rooms, may be made any width due to this construction.

5. Community use of the auditorium would not be desirable during school hours, due to multiple use of the hall.

F. Expansibility

Due to the double loaded corridor type of building and the main entrance being located next to the auditorium, the opposite end of the building could be extended and meet all the requirement of expansibility.

G. Design and Beauty

This building plan and arrangement allows the builder to meet every requirement of design and beauty.

H. Durability and Maintenance

1. The building design would permit economical operation of the plant with the exception of mechanical ventilation. It is possible that savings in building costs and maintenance of such a plant would justify the added expense of

mechanical ventilation, however this is a technical problem that cannot be answered here.

All other items of durability and maintenance depend on the selection of materials and arrangement of service systems, problems that have not been worked out in this suggested design but that are no more difficult to solve for this plan than for any other type.

The chief objection to this plan will probably be to the very limited vision strip provided only by the outside glass door. Plastic bubbles as suggested for top lighting have been used as noted on page ten of Chapter III.

Materials for Framing

The three principal types of materials used for the supporting framework of school buildings are wood, steel, and concrete. Solid stone and brick walls have not been included in this discussion. All three will be applied in a group to the criteria for evaluating building materials.

A. Educational Plan

1. Physical plants may be constructed from any one or any combination of all the materials under discussion that will meet the needs of the pupils.

2. By the proper use of wood, steel and concrete for framing, school plants may provide for the educational and social needs of the community.

   All other items of the educational plan may be equally well met by all the framing materials under consideration.

B. Economy

1. Wood most nearly meets the need where light-weight, economical materials are required for framing. For classroom spans of over thirty feet, steel is probably more economical than wood or concrete.
2. The labor scale for carpenters is less than for skilled steel or concrete mechanics. Such methods as precast concrete beams and joists, tilt-up walls, roofs poured on the floor and raised to position, and "stran-steel," are all methods of reducing on the site labor costs. All of the materials equally meet the requirements of the other item with the exception of number seven.

7. The size and type of building determines to some extent the material that is most economical. All three are within the range of satisfactory building materials with wood the most

economical, steel second, and concrete third in the cost of building. A wood frame buildings carries a higher insurance rate than either a steel or concrete one.

C. Safety

1. Both steel and concrete, being non-combustible, are safer in regard to fire than wood, however, wood is not a fire hazard in a one-story building which has individual outside entrances.
2. In other respects, all three are safe building materials.
3. Concrete is the favored material for safely enclosing the heating plant.

D. Health and Sanitation

1. Any one or all of the materials may be incorporated in a design which provides for happy comfortable living.
2. Any of these materials may be used for framing with the desired interior finish.

All the remaining items of health and sanitation may be provided for in building framed of wood, steel or concrete.

E. Flexibility

1. A completely flexible interior is more readily achieved with wood and steel framing since less

bulk is required than when a concrete framework is used.

2. Curtain walls and partitions walls that may be economically moved may be used in conjunction with wood, steel or concrete framing, but more readily with steel or wood framing because of easier methods of attaching to these two materials.
3. Movable interior fixtures do not depend on the kind of materials in the building framework.
4. Service systems may be arranged so that shifting of the interior walls will not necessitate their rearrangement in a building framed of steel, wood, or concrete.
5. The materials for framing of the building do not affect the provisions for community use of the school plant.

F. Expansibility

1. The type of framing materials will not influence the selection of service units.
2. A building that has been framed of wood or steel may be more easily tied on to for expansior purpose than one framed of concrete.
3. Concrete framing is difficult to tie to, while steel or wood framing may be welded and nailed or bolted to the existing structure.

4. The type of framing materials does not affect the completeness of the design of the school plant.

G. Design and Beauty

Any of the framing materials may be used in the building frame construction and meet all standards of design and beauty.

H. Durability and Maintenance

1. Economical operation of the plant does not depend on the framing materials used in the structure of the building.
2. Since the framing structure is not exposed, maintenance of the framework is not required except in cases of building failure due to poor materials or workmanship.
3. Steel and concrete are very durable materials, while wood must be protected from moisture, termites, and dry rot.

The other items do not apply to framing materials.

Materials for Walls and Ceilings

For convenience, wood, including plywood, glass, steel, concrete, brick, structural tile, and the pumice or cinder block will be grouped together for application to the criteria for sound school building materials. Panel boards composed of wood composition boards, gypsum board, asbestos-cement panels, and cane fiber boards will be grouped together for evaluation as a sound school building material, and the numerous kinds of composition tile will be considered in one group for this purpose.

A. Educational Plan

1. The proper use of wood, glass, steel, concrete, brick, tile and cinder block may all contribûte toward developing a physical plant to meet the educational needs of the pupils.

2. Similarly, combinations of these materials are necessary for meeting the educational and social needs of the community.

   The other items do not apply to material use in school buildings.

B. Economy

1. Wood, glass and cinder blocks meet the requirements of light weight, economical materials for walls.

2. The use of large panels of wood and glass, large cinder blocks, and tile reduce labor costs.

3. Many architects do not consider the use of glass blocks and glass walls as extravagant to insure an abundance of light and ventilation.

4. The use to be made of these materials must be considered in choosing the desirable ones to insure space utilization.
5. Such materials as glass to secure plentiful daylight, glazed tile for hallways and classrooms to at least wainscot level and in shower and rest rooms, plywood, brick, and painted cinder blocks may all contribute to clean wholesome living.
6. By using plywood or glazed tile at least below wainscot level, lightens the efforts necessary to keep that portion of the room clean, conserving the time of pupils and teacher.
7. Large sheets of plywood, dimentioned lumber, glass, tile and cinder blocks meet the requirement of economy. Concrete, brick, and steel may be considered economical wall and ceiling materials when maintenance and insurance costs are included and costs are compared for the average life span of the buildings.

Eight and nine do not apply to materials.

10. Dual purpose rooms are more practical when suitable materials for the various activities are chosen.

C. Safety

1. The safety of the inhabitants of the building may be insured by the proper use of any or all of these building materials.
2. The fire resistant materials, brick, concrete, tile, cinder blocks, glass and steel, all meet the requirements of safety in regard to fire. Wood and wood panels may be treated with chemicals to retard fire, however, wood is not a fire hazard in a one-story building with individual classroom entrances.
3. Walls of cinder blocks, cement and steel meet the needs for safety in protecting the plant from the heating unit.

D. Health and Sanitation

1. This one does not apply to materials.
2. Any of these materials may be finished to create a pleasant atmosphere inside the building. Wood is favored in some quarters for its quiet beauty and home-like effect.
3. Plate glass, glass blocks, and plastics all contribute to assure adequate daylight.
4. Glass and plastic meet the need of materials to light and ventilate shower and rest rooms.
5. Windows of glass may serve the double function

of light and ventilation. Wise use of glass and plastic for a plentiful supply of light and ventilation increases the comfort and aids in maintaining the health of the inhabitants of the building.

6. Any number of these materials may be used to provide space for health education facilities.
7. Any of these building materials might be used to isolate noisy and odorous activities.

E. Flexibility

1. Any of these materials might be used in the exterior wall construction in such a way as to allow for interior rearrangement.
2. Wood, wood panels, glass, tile, steel panels, concrete and cinder blocks all might be of the non-load-bearing type, however, concrete, cinder blocks and tile are too hard to remove to rank with the rest of the materials in this respect.

   All the other items of flexibility refer to building design.

F. Expandibility

1. This item does not apply to materials.
2. This item also applies to design.
3. Again buildings of wood and steel walls may be expanded more readily than those of brick, tile,

and cinder block, due to the difficulty of connecting to this type of building.

4. This item applies to the design of the building.

G. Design and Beauty

1. The natural color of wood, brick and face tile meet the requirements of beauty and design. Concrete, cinder blocks, and steel panels may be finished to meet the requirements of beauty.
2. This item does not apply to materials.
3. Glass may be combined with wood for a very inviting appeal, especially to small children. Steel, concrete and cinder blocks may all be combined with glass to create a building with an inviting appeal.
4. Glass and glass blocks may be used to replace much ornamentation to achieve beauty in the school plant design.
5. By careful selection, at least one of these many materials will be appropriate for the school site.

H. Durability and Maintenance

1. This item applies to the building design.
2. Appropriate materials may be chosen from this group that are easily maintained, such as concrete, brick, face tile, steel, and glass brick.

Wood requires regular painting for the outside walls, but on the inside walls, wood with a natural finish is easily maintained.

3. Tile, concrete, steel, and cinder blocks are all durable materials. Wood lasts indefinitely when protected from the weather, termites, and dry rot.

4. Metals that have been coated to prevent corrosion are available, as well as materials that are corrosion resistant within themselves. Items five, six, and seven apply to plumbing and electrical lines.

   As indicated at the beginning of this section, gypsum board, masonite, cane fiber board, and the cement-asbestos panel boards will be evaluated together.

A. Educational Plan

These various boards, used in appropriate places may all contribute to the construction of school building which meets the standards of the educational plan.

B. Economy

1. All of these materials are lightweight materials, the cement-asbestos board being the heaviest and most expensive of the group. Masonite is second

in order of expense with gypsum board third and the cane fiber board the least expensive.

2. All of these large panels, commonly four feet by eight feet, are quickly erected and tend to reduce labor costs.

Three and four do not apply to these materials.

5. These materials may be used in a way to provide clean, wholesome, living. All of these boards, except the cane fiber board, provide a smooth surface which may be painted or given a textured finish. Masonite may be used in areas of high humidity.

6. Masonite provides the hardest, slickest surface of the group, qualities that reduce maintenance time and effort.

7. Intelligent use of these materials will contribute to an economically designed school. The cement-asbestos board may be used for curtain or partition wall as well as outside wall. Tempered masonite may be used below wainscot height in hallways, classrooms, and offices for a cheap, easily cleaned surface. It may be used above the wainscot level in shower rooms, locker rooms, rest rooms, and dressing rooms. Gypsum board

and the cane fiber board may be used above wainscot height in dry areas.

Eight and nine do not apply to materials.

10. Masonite and the cement-asbestos board may be used where clean and durable surfaces are required, such as is sometimes necessary for dual purpose rooms.

C. Safety

1. The proper use of these materials will aid in constructing a building of safe design.
2. None of these materials are highly inflammable but all are combustible with the exception of the cement-asbestos board. The gypsum core in gypsum board is not combustible but the paper covering will burn, allowing the core to crumble. All of these materials are reasonably safe for one-story construction.
3. None of these materials are suitable for protection from the heating plant. They are all too light in weight and thickness, and all, with the exception of the cement-asbestos board, combustible.

D. Health and Sanitation

1. This item applies to the building design.
2. All these building panels may be given a finish

to create a pleasant comfortable atmosphere. The cement-asbestos board has a grey color which requires no finish. All the other panel boards may be painted any desired color.

The remaining items apply to building design.

E. Flexibility

1. This item applies to building design.
2. These materials are suitable for non-load-bearing walls and may be incorporated in walls that may be economically moved. The cane fiber board is soft and so easily damaged that it's salvage value is low but the original cost is so low that it may be discarded with small loss.

The remaining items do not apply to these materials.

F. Expandibility

Number one applies to service systems.

2. If cement-asbestos panels have been used for the outside wall covering, the necessary panels may be removed to tie the new structure to the old building.
3. This board is the only one of the group suitable for the outside wall covering and meets the requirements for possible future expansion.

G. Design and Beauty

1. Beauty may be achieved by the proper use and finishing of all of these materials.
2. This one is not applicable to materials.
3. Cement-asbestos panels may be used in creating a building that will appeal to the pupils.
4. For the corregated effect and for additional strength, the cement-asbestos board may be bought in corregated form for outside wall and roof covering, and may be incorporated in the building design to achieve beauty.
5. The use of this type panel might be helpful to harmonize the building with the school site.

H. Durability and Maintenance

1. This number applies to design.
2. Masonite meets the need for an easily maintained material. The cane fiber board and gypsum board are soft and easily damaged. Cement-asbestos boards are hard and brittle and may be broken.
3. Although it will break, cement-asbestos board is not affected by time or weather conditions. Cane fiber board and gypsum must be protected from abuse.
4. The remaining items do not apply to these materials.

A variety of wall and ceiling materials having a varied range of insulating and acoustical qualities is available and widely used today in school buildings. These materials are in tile form and in sizes of twelve inch squares and twelve by twenty-four inch rectangles. They are made of cork, cane fiber, perforated metal, mineral fiber, cast gypsum, wood fiber, and lightweight stone which resembles marble. Acoustical plaster will be included in the group of materials.

A. Educational Plan

These materials may contribute to the requirements of the educational plan through helping to provide a more comfortable building through sound control.

B. Economy

1. These materials are all rather light in weight and range from economical to expensive in the following order: cane fiber, gypsum, wood fiber, stone, mineral fiber, cork, and metal.
2. The materials can all be applied economically in regard to labor as compared with plastering. Acoustical plaster is more quickly applied than regular plaster but it must be skillfully applied to produce the desired acoustical effect.

3. These materials, with the proper applied finish, contribute much to good lighting through proper light reflection.
4. Space utilization may be increased by careful selection from these materials to obtain the desired acoustical qualities for noisy areas.
5. Any of these materials meet the requirement for clean, wholesome living.
6. These materials are easily cleaned, a feature that will conserve time and effort of teacher and pupils.
7. All prices of tile are available from the economical cane fiber to the metal unit containing insulation, permitting the architect to select the type to fit the needs of the school.
8. The wasted space between the ceiling and roof has been eliminated in some instances by leaving the roof deck for the ceiling or by covering with an acoustical tile.
9. This item is not applicable to these materials.
10. Better use of dual purpose rooms is obtained by proper acoustical treatment with wall and ceiling tile or acoustical plaster.

C. Safety

1. This item applies to building design.

2. When ceiling tile is applied over gypsum board instead of to open furring strips, the fire insurance rate is lowered but the sound absorbing quality is less. The mineral fiber, metal, metal fiber, and acoustical plaster are all non-combustible and safest from the standpoint of fire.
3. None of these materials are desirable for enclosing the heating plant.

D. Health and Sanitation

1. These materials aid in designing a happy, comfortable living area by helping to control the lighting and acoustics of the building.
2. All these tile may be purchased with the desired finish put on at the factory. The perforated tile may be repainted several times without reducing the acoustical qualities of the tile.
3. By the selection of the color of the tile to produce the desired light reflection from the walls and ceiling, inhabited areas may be adequately lighted provided and adequate amount of daylight is available.
4. These materials do not meet the requirements for places of high humidity.

Five and six do not apply to these materials.

7. The location of noisy areas is simplified by use of these materials.

E. Flexibility

1. The use of these materials will not affect the exterior construction.
2. Although these materials are primarily for ceiling construction, they may be used on non-load-bearing walls that may be economically moved. The remaining items of flexibility apply to these materials.

F. Expansibility

Should these materials be used as wall surfaces, the tile can be removed from the wall without serious damage and replaced on another wall.

G. Design and Beauty

1. These materials provide for beauty in the texture, design, and color of the tile. Acoustical plaster has a pleasing textured appearance that may be painted any desired color, however repeated painting lowers the acoustical quality. The remaining standards of design and beauty apply to the design of the building.

H. Durability and Maintenance

1. This number does not apply to materials.
2. All of these materials provide for easy maintenance since the painted surfaces may be

cleaned or repainted when necessary.

3. All of these materials meet the requirements of durability. All of the perforated tile may be repainted without loss of acoustical qualities, a characteristic not found in non-perforated tile and acoustical plaster.

Materials for Floors

Only the flooring materials suitable for school floors are included in this evaluation. These materials are wood, concrete, terrazzo, tile, and composition flooring, including linoleum, cork, asphalt, and rubber.

A. Educational Plan

1. The selection of an appropriate floor for each area of the school building will aid in the development of a school plant that will meet the educational needs of the pupils. Wood and composition flooring are preferred for classrooms. Concrete, terrazzo or composition flooring for hallways, concbete, tile, or asphalt for outdoor floor areas, and tile for rest rooms, shower rooms, and stair risers and treads.

2. A school floor suitable for both school and community use will help the school plant to provide for the educational and social needs of the community. Asphalt tile is suitable for general

purpose hallway floor to be used for a study hall, library, play area, and lunch room as it is a reasonable quiet, long wearing, and non-slippery. Concrete is also suitable for such a floor.

3. Warm, quiet, light colored, non-slippery floors help to make good instruction possible. Composition flooring materials meet these requirements. Concrete is cold and noisy. The coldness of the concrete floor may be controlled by imbedding heating pipes in the floor. The floor of outside play areas may be warmed in this manner during cold weather. Wood floors are warm but noisy.

The remaining items of the educational plan do not apply to materials.

B. Economy

1. Asphalt tile and asphalt flooring, wood, and lightweight cellular concrete all meet the requirements of economy. While wood is the cheapest floor installation, the insurance rate is higher and more maintenance is required. Lightweight cellular concrete is sound-resistant, fire-retardant, and resilient, and the construction cost is near that of wood. This type of

concrete makes a good base for asphalt, cork, or rubber tile.

2. Highly skilled labor is not required for any of these flooring materials except tile.

   Three and four do not apply to materials.

5. Wood and composition flooring meet the requirements for outside use as well as for the inside floor.

6. Floors that are easy to keep clean conserve time and effort of teacher and pupils. Tile, wood, and concrete floors are all reasonably easy to keep.

7. The most economical, satisfactory floor is achieved by pouring a concrete slab on grade and covering with asphalt tile. According to Mr. Key, Superintendent of the Pilot Point Schools, $2800 was saved in their building by using asphalt tile instead of wood over a concrete sub-floor.

C. Safety

1. A concrete slab floor included in the design of a building is one means of protecting the building and inhabitants from fire.

2. While asphalt tile will burn, it is fire-resistant when laid over a concrete base. Concrete, terazzo, cork, and tile are all fire-resistant floors.

3. A non-combustible floor of concrete is the only suitable floor and wall for protecting the school plant from the heating system.

D. Health and Sanitation

1. Happy, comfortable living is aided by light colored, quiet, warm floors. Wood meets the other requirements but it is noisy. Concrete is hard and cold. Composition floor tile have the qualities to the standard for happy, comfortable living.
2. A light colored floor aids in creating a pleasant atmosphere in the classroom where contrasts play an important role in good seeing conditions. Wood with a natural finish, light colored composition flooring, terrazzo, and concrete painted an appropriate light color all meet this requirement.
3. As light colored floors help create a more pleasant and comfortable atmosphere, so do they aid in conserving the light present eye strain. All these flooring materials may be had in colors that will meet this requirement.
4. Light colored tile conserve the light present in rest rooms and shower rooms.

The remaining items are not applicable to materials.

E. Flexibility

Flexibility of the interior of the building is increased when the floor is laid and partition walls erected on the finished floor. Then partition walls may be moved without affecting the floor surface. The composition tile floors are especially appropriate for a flexible arrangement as they can be cut and fitted to any remaining space and they may be easily replaced when damaged.

F. Expansibility

Any of these flooring materials are appropriate for a building planned for expansion.

G. Design and Beauty

Wood, composition flooring, terrazzo, tile, and colored concrete floors all meet the requirements of beauty for school room floors when the appropriate color and pattern is selected.

H. Durability and Maintenance

1. All of these materials, when used in appropriate places, aid in economical plant operation.
2. Little maintenance is required for the composition flooring materials or for concrete that is colored at installation. Terrazzo wears well but stains are hard to remove from its surface. Repair of ceramic tile requires a

specialist. Wood floors require frequent waxing, do not retain a good appearance, and are difficult to repair.

3. Concrete, terrazzo, tile, hardwood, and composition flooring all meet the requirements of durability. Linoleum or cork are not used in areas of heavy traffic.

The remaining items do not apply to flooring materials.

Materials for Roofs

Built up compostion roofs of asphalt saturated felt, asphalt and gravel, wood shingles, metal, composition shingles, metal, corregated asbestos, slate, and tile roofs will be evaluated in this group.

A. Educational Plan

The roof contributes to the educational plan of the school to the extent that it adds to the appeal of the building and comfort of the inhabitants of the school plant.

B. Economy

1. The metal roofs of aluminum, copper, and steel are all rather lightweight but expensive roofs. A roof built up of asbestos felt, is light in weight since it has a smooth surface with no excess weight or slag or gravel and is claimed

by the manufacturer to be economical for schools. Composition shingles are lightweight and economical but are easily damaged, and as is true of wood shingles, cannot be used on flat roofs. Slate and roofing tile are both heavy and expensive.

2. The built-up roof meets the requirement of economical labor since special skill is not required for this type of roof. The large metal and asbestos roof sheets are economical in regard to labor. Slate and tile do not meet the standard for economical labor. The composition and wood shingle roof require skill to prevent leaking. The remaining items of economy do not apply to roofing materials with the exception of numbers seven and nine.
7. The built-up roof meets the requirement of economical design since the near flat roof is an economical design in the use of materials.
9. The flat roof eliminates waste spaces between the ceiling and roof, especially if the ceiling is attached to the roof deck. The built-up roof is the appropriate cover for a flat roof.

C. Safety

1. Number one applies to building design.

2. For safety from fire, the asbestos built-up roof ranks high. Metal, tile, slate, and asbestos roofs all are non-combustible within themselves.

3. A roof of metal, slate, tile, or asbestos meets the requirement to protect the school plant from the heating unit.

D. Health and Sanitation

A roof meets the requirements of health and sanitation to the extent that it protects the inhabitants from the weather. The insulating value is one advantage claimed for wood shingles.

E. Flexibility

Flexibility of the building interior is increased by a rigid frame which holds up the roof independently of the walls. The built-up roof is adapted to this type of roof which is normally flat or near flat.

F. Expansibility

A roof of wood or composition shingles and a built-up roof are better adapted to building expansion than other types of roofs in that they may be joined to other roofs with little damage to the existing roof.

G. Design and Beauty

To meet the standards of design and beauty, the type of roof and materials of the roof must be selected to harmonize with the rest of the building. This is not difficult to do with a wide range of materials from which to select the desired effect.

H. Durability and Maintenance

1. A properly designed roof construction with an appropriate cover will help to make possible the economical operation of the school plant.
2. All the materials under discussion, with the exception of wood and composition shingles have a short life in comparison to other types of roofing materials.
3. A metal, asbestos, built-up roof, slate, and tile meet the requirement of durability. Wood and composition shingles, with the exception of asbestos shingles, do not meet this requirement.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study was concerned with designs and materials used in the construction of school buildings. The purpose of the study was to analyze the different types of designs and materials available for school building construction and to determine the designs and materials that most nearly meet the needs of education today and in the immediate future. The study was divided into five chapters which are briefly summarized in the following paragraphs.

Chapter I introduces the study and presents the critical need for more and better buildings to meet the educational need of the increasing school population. Many of the buildings in use today are fifty years old. More than half the nation's cities have schools that are overcrowded. Many schools are forced to have half-day sessions, particularly in the lower grades, a regretable condition that is likely to increase. Twenty-four per cent of the cities reported in a national survey that they are using at least one obsolete building which has been officially condemned as unsafe, unsanitary, or otherwise unsuitable for school use. By the school year 1953-54, Texas schools are expected to enroll nearly a million pupils in grades one through six -- an increase of about a third over the 1949-50 school year enrollment. Studies by leading educational organizations have indicated a need of approximately twelve billion dollars for a ten year period beginning in 1944, in terms of 1940 prices.

Chapter II is concerned with the development of criteria for determining sound school buildings. The works of prominent educators and organizations that have made a study of school building were studied and the following standards selected as criteria for determining sound school buildings.

A. Educational Plan

B. Economy

C. Safety

D. Health and Sanitation

E. Flexibility

F. Expansibility

G. Design and Beauty

H. Durability and Maintanence

Chapter III is a discussion of designs and materials suitable for school building construction. The one-story building is a distinct favorite in school building construction with the advantages of ready accessibility to the outdoors, adequate daylight and ventilation more easily achieved, elimination of stairs and stairwells, flexibility and expandibility more easily achieved, easy to isolate noisy and odorous activities and concentrate certain sections for easy community use and a much safer plant than a multi-storied building. The statement that it is a more economical structure is a debatable one, the economy depending on the availability and cost of the building site, climate, and the size of the building, and the kind of materials used. Studies that have been made seem to indicate that the most economical structure to build is a one-story, double loaded corridor type building. The one-story open corridor type building has many advantages and approaches the double loaded corridor type for economy. The round school is an experimental design with interesting possibilities.

Concrete is the only building material that has not risen sharply in cost during the last few years. New developments in concrete construction methods have reduced labor costs, speeded up construction. Concrete beams, joists and columns are precast and delivered to the building site. Light weight aggregates are used in the concrete mixture to reduce the weight of beams, joist and roof and floor slabs. Concrete building blocks and concrete tile and brick are being used increasingly in the construction of school buildings.

Brick and ceramic tile are extensively used, the principle objection to their use being the high labor cost of brick buildings.

Wood is still a popular building material and the cheapest type of construction for small buildings. The higher insurance rate and continued maintenance costs offset, to some extent, the cheaper construction costs.

Glass plays an increasing role in school building design and construction. Larger areas of plate glass and glass blocks are being used to secure more and better distributed light. Plastic sheets and bubbles are being used to secure light through the roof. Clerestory and monitor windows are used extensively to secure better lighting.

Metals continue to increase in use in school buildings. Steel is particularly adapted to the rigid frame type building which supports the roof independently of the wall structure. Although metals are expensive wall and roof covering, they are light weight and durable.

Chapter IV is an application of the criteria to possible designs and materials to sound school building construction. The criteria was applied to each type of design separately but the materials were grouped according to their use in the building structure and evaluated as a group.

Conclusions

The information obtained seems to justify the following conclusions.

(1) One-story buildings more nearly meet the needs of education than multi-story buildings in areas where adequate building sites are available.

(2) Multi-story buildings should be of fire-resistive construction throughout the building to protect the inhabitants from fire.

(3) A wood frame building is the most economical type

of construction for small school buildings, but because of the higher cost of insurance and maintenance, this type of building is not justified from the standpoint of economy.

(4) The single loaded open type of corridor building closely approaches the double loaded corridor type of structure in economy.

(5) The one-story school building with individual classroom entrances need not be of fire-resistive materials to protect the inhabitants of the building from fire.

(6) The rigid steel frame type building that supports the roof independently of the walls is a durable and economical type structure and increases the flexibility of the building by allowing the walls to be light weight curtain walls that may be rearranged when necessary.

(7) Square classrooms are desirable and the construction is made practical by the use of laminated wood and steel beams.

(8) Masonite, plywood, asbestos board, and composition boards are economical and durable when properly used. They permit faster construction and reduce labor costs.

(9) By combining the floor and foundation into one structural unit, the concrete slab lowers the building height, speeds up construction, and reduces the cost of labor. Through this saving of time, labor and materials, the concrete slab is a desirable and economical type of floor structure for a school building.

(10) The concrete floor slab is an economical and effective way of tying the classroom to the outdoors, a particularly desirable building feature for the kindergarten and lower elementary grades.

Materials

(1) Asphalt tile is a very satisfactory flooring material for classrooms, hallways, offices, general purpose rooms, and possibly for gymnasium floors from the standpoint of economy, beauty, wearing quality and maintanence.

(2) The pumice or cinder block is an economical building material but is too difficult to remove for a flexible wall.

(3) The built-up roof of felt and asphalt or tar covered with slag or gravel is the most practical roof covering for flat or near flat roofs of school buildings.

(4) New developments in concrete mixtures and construction methods have reduced labor costs, speeded up construction, and reduced the weight and bulk of concrete. Concrete construction, which has been the most expensive type of building may become one of our more economical and practical types of building.

(5) Composition wall and ceiling materials are produced which serve the three purposes of sound control, insulation, and decoration and are obtainable in a variety of qualities to fit the budget.

(6) The use of large sheets of glass and glass blocks to obtain comfortable, attractive classrooms with an

abundance of daylight and natural ventilation is not extravagant.

Recommendations

The information obtained seems to justify the following recommendations:

(1) Since new materials and construction methods are continually being developed, it is recommended that a periodic study be made of these new developments and this information be made accessible to the public.

(2) The school superintendent in most school systems is responsible for the building program; therefore, it is recommended that a course in planning school building be included in the required courses for an administrative certificate.

BIBLIOGRAPHY

Books

American Association of School Administrators, American School Building, Twenty-seventh Yearbook, Washington, D. C., American Association of School Administrators, 1949.

Cocking, Walter D., American School and University, twenty-second annual edition, New York, American School Publishing Corporation, 1950.

Cocking, Walter D., American School and University, twenty-first annual edition, New York, American School Publishing Corporation, 1949.

Engelhardt, N. L., Englehardt, N. L. Jr., and Leggett, Stanton, Planning Secondary School Buildings, New York, Reinhold Publishing Corporation, 1949.

Holme, Geoffrey, Industrial Design and the Future, New York, The Studio Publication, 1934.

Monroe, Walter S., Encyclopedia of Educational Research, revised edition, New York, The Macmillan Company, 1950.

National Council on Schoolhouse Construction, Guide for Planning School Plants, edited for the National Council on Schoolhouse Construction by Ray L. Hamon, Washington, D. C., Educational Research Service, 1949.

Sweet's Catalogue Service, Sweet's File-Architectural, New York, Division of F. W. Dodge Corporation, 1947.

Reports

National Education Association, School Housing Needs in City-School Systems, 1947-48, Washington, D. C., National Education Association, 1948.

National Education Association, Report of Committee on School House Planning, Frank Irving Cooper, Chairman, Washington, D. C., 1925.

University of Texas, Are We Ready for 'Em, Austin, College of Education, 1950, pp. 4-6.

University of Texas, An Outline of Modern School Plants, Austin, College of Education, 1947, Pp. 46-47.

Articles

Bruce, W. G. and Bruce, W. C., "School Building Construction in 1948," The American School Board Journal, CXVI (January, 1948), 54.

Cochran, F. L., "Significant Departures in Secondary School Design," The Nation's Schools, XII (February, 1951), Pp. 44-47.

"Design Survey, 1951," Progressive Architecture, XXXII (January, 1951), P. 53.

Esling, R. H. and Bascom, E. R., "Cinder Block: Sound Transmission," Progressive Architecture, XXXI (August, 1950), 126.

Harrigan, A. J. and Garz, Philip, "A Cost Study of School Plan Types," Architectural Record, CV (march, 1949), 126.

Johnson, W. A., "Transverse Framing Makes Top Daylighting Economical," Architectural Record, CV (March, 1949), 126.

Pittenger, B. F., "Some Observations About High School Buildings Needs," American School Board Journal, XCVI (January, 1949), 35.

"Schools with Controlled Daylighting," Architectural Forum, XCVI (July, 1951), 158-161.

"Schools," Architectural Forum, XCII (October, 1949), 85.

Shaw, H. M., "An Expansion Joint for Concrete Blocks," Concrete, LVIII (June, 1951), 31.

"Two Story Finger Plan Trims High Land Costs," Architectural Forum, XCV (January, 1951), 104-106.

Vincent, William S., "Tomorrow's School Building," The School Executive, LXII (February, 1948), 25-27.

Newspapers

Armstrong, Earl W. and others, "Educators View Public Schools," Ft. Worth Star-Telegram, September 11, 1950, P. 20.

Unpublished Material

Roberson, Fritz D., "A Study of Building Materials and Processes and Their Influence on the Design and Construction of Contemporary Small Homes," Unpublished Master's thesis, Department of Industrial Arts, North Texas State College, 1950, P. 95.