THE USE OF WOOD IN THE ONE STORY MICHIGAN SCHOOL

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THE USE OF WOOD IN THE ONE STORY MICHIGAN SCHOOL

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TABLE OF CONTENTS

CHAPTER

CHAPTER I

INTRODUCTION TO THE STUDY

Purpose

The major purpose for initiating this study was to evaluate the present usage of wood or wood products in the one story Michigan school, thereby determining why these products were partially or entirely eliminated from present or future buildings and to assess the possibility of increasing their markets in the future.

It was evident that wood products had been largely replaced as structural framing and finish materials in this field by competitive items from the various metal, plastics, and masonry industries. But the validity of such inroads was questioned since the competitive industries produced a maze of conflicting reports on their products and their competitors'. It was therefore deemed necessary to discover the actual reasons and logic behind the selection of materials in various components of the school structure.

One definite restriction had been placed on the interior usage of wood materials by the State Fire Marshal's office. This action, in the form of a mandatory fire safety specification necessary for the Fire Marshal's and subsequent state approval of a new building, prohibited certain classes of combustible materials. A further restriction of wood as a structural item based solely on the opinion of architects and school administrators presented another barrier. The soundness of these actions was studied to determine what alternative, if any, are feasible for regaining a portion of these lost markets.

Importance of the Study

The importance of this study stems from the increasing needs placed upon the public educational system within the state of Michigan. The enrollment in primary and secondary public schools rose from 1,384,939 in October 1955, to 1,625,051 in October 1959. This represents a seventeen per cent increase over the year 1955. Enrollment projections for the year 1965 place 1,922,411 children in our public schools or an increase of thirty-eight per cent above 1955.

Closely following this enrollment trend is the subsequent demand for housing these students. The increase in the number of students between 1955 and 1959 represented a need for 11,000 additional classrooms based on thiry children per room. Not only has the state constructed new buildings and additions for these new students but it must continually replace outdated structures. This combined requirement produces an ever present and expanding market for building materials.

From the year 1955 to and including 1958 the state of Michigan invested over 275 million dollars for new complete school buildings. This figure excludes the costs of any additions to existing structures. Between July 1, 1958, and June 30, 1959, another 83 million dollars worth of complete new buildings were approved for construction by the Michigan Department of Public Instruction. Although these figures do not indicate the value of materials utilized in construction they do present a measure of market size and potential growth.[1]

In contrast to this rising field of school construction the products from the lumber industry used within school buildings have steadily diminished. Prior to the influx of one story schools in Michigan the majority of school buildings constructed from 1920 to 1940 depended on wood products for various components. These structures were frequently multi-storied, utilizing solid masonry or brick veneer and wood frame walls. Flooring systems frequently used wood joists, subflooring, and a hardwood, finished floor. Further structural usage of wood was found in wall partitions and some roof construction. The majority of interior walls and ceilings were then finished with plaster. Double hung windows in varying width combinations and heavy panel doors, interior and exterior type, with a clear finish were typical wood products common to schools of this era. An abundant display of wood trim items and cabinet work either in pine or hardwoods such as oak,

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1 "School Enrollment Study", Department of Public Instruction, Lansing, Michigan, 1959.

maple, birch, or beech completed these structures.

Although these structures were adequate and functional there were certain disadvantages caused by design and construction. Some of these faults were rectified through more efficient usage and design while others were left unsolved. Various materials, construction methods and designs not improved or properly used, gradually decreased as favor items.

Following World War II a rapid influx of new products coupled with a trend toward one story designs created stronger competition among building products. Influential individuals within the school construction field were more inclined to use highly promoted new products to satisfy the increase in educational space requirements. This process has evolved to the present status, whether justified or not, of Michigan schools being constructed of predominantly masonry, metal, plastics and other synthetic products with only token quantities of wood products. Although this situation exists today there are seemingly still sufficient qualities common to certain wood products, essential for proper school construction, to regain portions of this market. The lumber industry must correct certain problems and change various misconceptions but the potential within this state alone should provide the necessary incentive.

Preview of the Study

The material within this study has been subdivided into three main categories. An outline of essential procedures necessary for the construction of a school building is included under Chapter II. Since the majority of these actions is initiated by the school administrative staff this chapter will be centered on such activities. Other essential groups, such as architects, are discussed in the chronological order by which the school staff calls upon them for their services. The major function of this chapter is to indicate at what time and by whom materials are selected. Also certain functions are mentioned which will have an indirect bearing on this selection.

A general discussion of qualities desired within a school building material constitutes the second phase of writing and also acts as an introduction to Chapter III. Materials are selected for construction by the number of functions or qualitites they possess and the extent to which they fulfill these requirements. In the field of school construction a certain weight has been placed on various properties as a basis for selection. This largely predetermines competitive advantages. The relative merit and basis for stressing these certain functions are presented.

Chapter IV is a study of the component parts within the building and the materials selected for them. This will involve competitive materials and the reasons for selecting these items as opposed to wood products or other competitive non wood materials. The merits and disadvantages of wood for each component part are presented to ascertain the reason for the use or nonuse of wood and its future potential in each of them.

Limitations of the Study

This thesis was limited to one story school buildings due to two major reasons. A greater amount of data and opinions concerning materials within this type of structure is available. Furthermore, over ninety per cent of present schools constructed in the Michigan area are of one story design. Those buildings of a multi-storied arrangement are usually constructed due to a restriction of site size of expense.

Secondly, wood products are restricted in nearly all areas of a multi-storied structure by paragraph 7.1 of the Fire Prevention Section in School Bulletin 412 issued by the State Fire Marshal's office. The item states that "All school buildings of more than one story must be of fire resistant construction, with all steel structural members protected by materials which will afford at least one hour resistance to fire".[2] This one restriction is based primarily on safety during a longer evacuation time. Any study concerning wood in these structures would be controversial and restricted largely to the merits of this bulletin.

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[2] "Fire Prevention Section School Bulletin 412, Department of Public Instruction, Lansing, Michigan, 1959.

This does not mean that multi-storied schools are not functional in design or restricted to non-combustible materials. But the popularity of one story designs with fewer governmental restrictions on wood products enables a more thorough and less controversial study. Further research should be conducted by the lumber industry with a report on the potential of wood products in multi-storied structures.

All data collected for this study was obtained from sources directly or indirectly related to the public school system. But the problems of parochial and private institutions are of such similar nature that a direct application to this report should be considered.

This study does not develop a detailed analysis of school philosophy in the fields of architectural layout or engineering design. Heating, plumbing, electrical design, lighting and room arrangements are discussed where direct application to materials exists. Each of these fields constitutes an entire study by itself for personnel in the school administrative or architectural fields. But these areas do affect material selection to the extent that relative trends are presented for a more adequate correlation of factors.

Furniture and other movable items within a school building are only briefly mentioned. Here again, the design, construction, and arrangement of furniture within schools would present sufficient material for a separate study.

Advantages of One Story Schools. Certain factors have caused the one story design to increase in popularity in Michigan and the remainder of the United States.

Perhaps the first and foremost of these reasons is the elimination of stairways in the structure. This reduces the traffic congestion which usually centers in such areas and at the same time prevents a multitude of accidents from occuring. Movement of heavy teaching aids or other materials is facilitated by one level of traffic. Stairways are expensive additions in the building both from the standpoint of space requirements and construction details necessary for a fire safe building. Here again, the safer and more expedient means of egress during possible fire presents an advantage to one story construction.

Excavation and foundation requirements for multi-storied buildings are expensive and time consuming items. The simplicity of one story foundations eliminates costly materials and labor which are often of a specialized nature.

A light, simple framing detail presents one more economical measure favoring one story schools. This simplicity presents a more flexible design and the advantage of isolating various units which may distract teaching areas. The problem of overhead noises in multi-storied areas presents an annoying and costly item should the situation be corrected.

These factors condone one story construction but the multi-storied building also has its advantages. Economy can be realized in these structures mainly from a basis of land requirements. Land availability and initial cost of city property establish the reason for multi-storied city schools. Buildings will also have a more economical heating cost per volume of space due to a reduction in exterior ceilings and wall space. Expensive roof maintenance is also reduced by a common cover for many classrooms.

But when site considerations are of a reasonable nature the other inherent factors of one story construction will favor this type. This can be supported by the present popularity of this design throughout the state.

Sources of Data and Treatment of the Findings

Material for this report was obtained by two means: a search of current literature and a series of interviews with personnel associated with school construction. The major object in both methods was to find information that was directly applicable to school construction in Michigan. During the course of research no indications of a similar study were evident.

Sources for the search of literature included the Michigan State University library, College of Education's library, all prominent lumber industry trade associations, the National School Boards Association, Ohio School Boards Association, Federal Security Agency, National Fire Protection Association, Underwriters' Laboratories and various manufacturers of products utilized in school construction.

The majority of information in both libraries dealt primarily with educational specifications, studies of various functions and theory of education and school design. Although this material was of little value due to its indirect applications, one book on materials was discovered which contributed to the report. This text, "Saving Dollars In Building Schools", prepared for the Ohio State Board of Education was a study of school construction in the neighboring state of Ohio. Evaluations of various construction methods and materials on the basis of performance and cost were the major contributions to this paper. Information on roof construction alternatives was of value but neglect in comparing wood products with more popular materials in other components proved to be a void for this report.

An evaluation of the Fire Marshal's School Bulletin 412 Revision was aided by information obtained from the various fire prevention organizations. The recommendations of these organizations has undoubtedly influenced Michigan's rulings. The validity of such recommendations was in turn studied through various reports and interviews conducted throughout this state.

Although a large amount of information was obtained from various lumber associations only a limited portion was used for this report. Many examples of the advantages of wood as used in school buildings were cited but their applications to the state of Michigan were questioned. The South, West Coast, and other miscellaneous areas in this nation may use a predominence of wood products in school construction but certain conditions, not found in Michigan, undoubtedly produce favorable markets. A strong industry influence in the lumber producing areas coupled with an abundance of materials and economical transportation rates create strong competitive advantages. Other areas throughout the country not having these factors may also vary in labor supply and costs, building codes and regulations, or climatic conditions. It was therefore necessary to eliminate such items not common to Michigan and to only use material that is not influenced by economic or geographic factors.

Manufacturers of products which would be used in conjunction with wood products were also contacted for information. Cost, application and various advantages of certain preservatives, paints, and fire protective items were of use to this report.

News items in Lansing and Detroit newspapers related to school construction were collected from the period of December 1959, to May 1960. These items were useful for their information and as an indication of productive sources for future interviews.

The second and most important phase of research consisted of a series of more than fifty interviews with various personnel representing different phases of school planning and buildings. In each case, an appointment convenient to the person being interviewed was established by telephone or personal conversation. Before the meeting a questionaire was developed to act as a guide for the interview. Since different fields were sampled, the questionaire was altered to discover the duties of the person, his obligation to school building, and his opinions and reasons for favoring certain construction methods or materials. This guide for the interview did not always delve into every area of importance but during the course of conversation these items would generally develop automatically. In general, the person interviewed was encouraged to talk freely and the outlined questions were only used to better guide the conversation or obtain comments on points not mentioned. A similar pattern of conversation was developed in each field of sampling and after a few such meetings it was felt that all important items were outlined on the questionaire.

Notes were taken during each conversation and later transcribed to more legible items and patterned chains of thoughts. Further areas or concerns to interview were mentioned and added to a rostrum of further interviews. In nearly every case the interview with each person developed into a conversation lasting from one half hour to an hour or more. The congenial and helpful manner of all persons interviewed was somewhat unexpected since, in many cases, this time constituted a nonproductive area in their business schedule.

In all interviews the author attempted to separate opinions from more factual statements. General opinions that did exist were evaluated as to their soundness and associated patterns of thoughts were grouped from each source of information. Before the writing of the paper was started, all interviews were grouped as to their source and thoroughly reviewed for useful data pertinent to each phase of the report.

Interviews were started by arranging appointments with various state officials in the Capital and personnel from the Department of Education at Michigan State University. This was necessary in order to recognize the general pattern followed by school construction and the roles played by everyone concerned. Influences, restrictions and trends of building in this state were also determined at this time.

From this starting point it was evident that interviews with school superintendents, board members, architects, contractors, material distributors, the State Fire Marshal, insurance agents, and other indirectly associated sources would adequately cover the planning phase and uncover reasons for various preferences in school building.

The school superintendent, or special assistants in the building and design department found in larger districts, were best acquainted with the needs and desires of their district, and chosen as the best source of material. This was substantiated by opinions obtained during the initial interviews and also after a few school board members were interviewed. Board members readily admitted that their position did not place them in constant contact with the district's needs as did the superintendents or his special staff members.

Michigan has divided its school systems into four classes and representative samples of each type were made. For reasons of convenience, six districts of class four size were sampled within a twenty mile radius. These districts; Okemos, Haslett, Mason, Holt, Grand Ledge and Williamston represent rural communities, those with a small industrial influence, and types acting as suburban areas. Lansing, Jackson, and East Lansing were the class three districts sampled. Grand Rapids, Flint, and Detroit were interviewed and represent the only class two and class one districts found in Michigan.

Since architectural firms have the greatest influence on material selection, over twenty sources were interviewed. Here again, for reasons of convenience the majority of the firms were from East Lansing and Lansing. But also included were men practicing in Flint, Grand Rapids and Battle Creek. These firms represented sole ownerships, partnerships, small firms and large interstate companies.

To augment information obtained from the architectural firms, various building material distributors and construction companies were contacted for interviews. The major item sought was an estimate of local building costs typical of Michigan. Although some cost data was secured, it was felt that a compotitive status prevented this material from being divulged by these firms. In addition, information on advantages and trends of various materials was secured.

The State Fire Marshal was interviewed to gain a better understanding of recent material restrictions and the reasons for adopting such measures.

The cooperation of various members of the National Lumber Manufacturers Association was useful. Although certain prejudices for wood construction will exist in this type of personnel, their aid in preparing a course of interviews was useful. They too had realized the declining usage of this material and suggested sources who might explain the reasons for this trend.

CHAPTER II

PROCEDURES AND PERSONNEL INVOLVED IN SCHOOL CONSTRUCTION

The development of a school building is a synthesis of various skills and tasks preceding actual building from five to ten years. The majority of these items are usually accomplished during the twelve month period prior to construction. Various functions are necessary for proper development to occur and should follow a chronological pattern designed to have each following job dependent on and aided by a past project.

The organization is the responsibility of the school administrative staff with some supervisory and regulatory authority exercised by the state. Whether the school district performs these activities or an outside firm, the coordination still remains with the administrative staff. Variations in this planning do not depend on the number of steps to be followed but on how thorough each item is developed.

Classification of School Districts

Michigan has classified its school districts into four categories based on a school census of enrollment of students between five and twenty years of age. Class four districts are areas under 2,400 students and composed of small agricultural towns or surburban districts of larger cities. Class three ranges from an enrollment of 2,400 to 30,000 students such as in the cities of Lansing, Jackson, or Battle Creek. Flint and

Grand Rapids are the only class two districts, having an enrollment between 30,000 and 120,000 students. Detroit dominates class one district by exceeding 120,000 students.

Since population varies among the four classes of school districts the needs for educational housing will also vary. This in turn produces different methods of accomplishing the school planning procedures. Although various methods may be employed the same steps are still used by all districts.

This variation in methods is most evident when comparing class four districts with class one and two. Class three districts are an intermediate type but usually follow patterns similar to the larger areas. A constant demand for new schools in the larger districts substantiates the establishment of permanent planning departments within the administrative staff. The smaller districts will establish new planning committees for each new building campaign due to their sporadic and cyclic housing needs. Personnel on these committees are composed of full time school employees, school board members, and hired technical consultants.

Cyclic Building Programs

The development of a school building within a small district necessitates the establishment of a new planning committee for every program. When construction of the building is started the majority of the functions carried by the planning committee are completed and the group gradually disbands.

Although each program may contain some variations in personnel the composition is fairly similar as are the duties and tasks of each new group.

One of the key members in the planning committee is the school superintendent. The nature of his job enables him to be a prime source of information concerning growth of the community and its present needs. In essence the superintendent coordinates all of the school administrative departments and usually has all of these groups reporting to his office. Not only will he develop new school policies and procedures but his link with maintenance and performance records of existing buildings will be of value. Information on other districts is also secured by his office.

Members of the school board of education constitute another segment of the planning group. These members are elected officials acting as representatives of the community. Primarily the board's first duty is to establish a competent school administrative staff. Once this is accomplished they then act as a governing body on such matters as school policies, expansion programs, and other developments. During a school building program these members may display partialities for various construction methods due to their personal occupation. Although these items may be interjected for discussion by the group, logical reasons for adopting such ideas or materials must be presented.

Further representation from the community may be included by selecting prominent, interested and beneficial citizens to act on the planning committees. Although this action may have exceptional merit, few citizens are actually willing to give their time for such duties. Generally, this source of aid is not used extensively in Michigan.

The opinions of teachers is valued for expansion programs. Their main interest is in educational planning of the new building. Such items as size of rooms, building layout, or special education facilities are placed before teachers for their comments and approval. This consulting work is logical since these are the people who must live and work within future schools. Teachers may have some opinions concerning various materials but they are more interested and better versed on educational systems.

Custodians of existing structures may be included. Their knowledge on the performance of present buildings would act as a supplement to the superintendent's material. Greater efficiency in the operation of a new plant may develop by having the custodial staff participate in planning the building.

Various school planning consultants are receiving greater use and recognition by building committees. These originate from an educational staff in the state government, a college, or university department. Their major function is to determine what facts are needed for school planning, how to obtain these facts and their interpretation. Further aid is provided by planning educational systems and housing of these systems. A study of the educational needs in the community of Grand Ledge, Michigan, was developed by the Department of Education of Michigan State College during 1954. This program evaluated the community's school system and its future needs, and then presented suggestions for its proposed building program. The report provided the Board of Education with a foundation to work from and proved to be an important step toward present school systems.

The architect completes the make up of the planning committee. His major function outside of the committee is to design a structure which will adequately and economically house the proposed educational system. To accomplish this goal it is imperative to have the architect working with the committee on its educational specifications. In this way he will be thoroughly acquainted with the thinking of the group and with all phases of the educational program as it is developed. The majority of material selections are the responsibility of the architect. Members of the committee realize that his training and experience best qualify him for this duty. In planning for buildings he will be of particular help in such matters as evaluation of existing buildings and site location.

Educational Planning for the School Building. The development of school policies and systems to be used in the new structure always precedes architectural planning due to its foundational aspect. In essence, the building is only a means to house our educational system and must conform to these requirements. Forming the educational program around a building places architecture before education and defeats the purpose.

One of the initial tasks of the committee is to determine the educational needs or desires of the community. From this primary survey an official educational program is developed. Such items as the general purpose of the school building and groups to be served by the building are determined.

It is important at this stage of discussion to mention the additional uses a school building may serve other than daytime education. A large number of communities are developing adult educational and vocational training programs which place added requirements on school plants. Many districts use the school structure for a community center. One of the most noted examples of community use of school buildings.is found in the Flint school district. Adult education, club meetings and recreation groups place 52,000 children and adults within their schools every night.[3] This number exceeds the 37,000

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[3] Gies, Joseph, "Flint Proves: It's Fun To Keep Fit", This Week Magazine, May 3, 1959, p.6.

daytime students. In planning its community schools, Flint gives top consideration to community facilities. Each of its newly erected buildings contained a kitchen, auditorium, and gymnasium planned with the needs and size of the neighborhood in mind. Various other communities in Michigan are now developing similar programs of placing this responsibility on its school system.

Upon completing the official educational program, the area to be served by the new school is established. This is then tied with the community's long range educational program. The future needs of the area are estimated and proposed schedules for future development are established. Flexibility of the structure will be incorporated into the final plans for these extra burdens providing cost is not excessive.

Once the grade level of children is established further refinements are necessary. The extent of special services to be included are discussed. Such items as special rooms for speech, art, music, and athletics are considered. The merits of libraries and auditoriums are weighed in relation to the desired educational system to be developed.

Throughout the entire educational planning program the financial capacity of the community determines its decisions. The budget will be the final determinant in the selection of any educational system and its housing scheme. The actual amount of money and the purposes to which these sums will be used are the most influencial items in adopting any plan, building, or material.

Architectural Planning of the School

Selection of the Architect.

After the board of education has decided that a building program should be initiated, one of its first tasks is to hire a qualified architect. This will enable his experience and knowledge to be utilized during primary planning.

An architect is selected on a basis of reputation, his availibility for consulting services, and previous buildings he has designed. This information is usually gathered by the superintendent in such forms as questionaires directed to the architectural firm and to his past clients and from a study of his past work. Once selected, the architect becomes an integral part of all committees and committee work an integral part of planning. Selection at an early stage is therefore imperative.

Selection of the Site.

An early joint responsibility of the architect and other planning members is to select the site for the proposed building. In most cases the site has been secured by farsighted school administrative and board actions. This is usually accomplished from one to ten years prior to the building for reasons of economy in securing such sites while they are still in an undeveloped state. Should alternate parcels of land be available for the

proposed building the best site is selected in terms of the educational goals to be accomplished and its compatability with the actual building.

Preparation of the Drawings. As ideas for the educational system are formulated, the architect gradually evolves a scheme of layout. Final determination of the educational specifications may depend in part on architectural designs necessitated by financial restrictions. Frequent committee approval on various alternative designs is essential for preliminary work.

The preliminary plans constitute the most vital stage in the evolution of building plans. In these initial studies the architect must solve all of the major problems that confront him, and determine the scheme or layout of the building and future extensions. Working drawings are merely a development of the preliminary drawings offering a study of details.

During this period it is the responsibility of the architect to recommend the type of construction and the materials to be used. He is usually abreast of new developments and materials in the construction field and of their relative merits. Nearly all communities that have not had recent experiences in school construction will place complete dependence on the architect for correct material selection. Even districts that have recently constructed school buildings will often place entire confidence on the architect's decisions. Various objections or preferences to certain items may be presented to the architects but these specifications represent a minority of the items. In general, class four districts and the somewhat smaller class three districts rely upon the architect for the majority of all material decisions.

Approval of the Drawings. The architect must first submit the working drawing and specifications to the local school district for approval since they are held responsible for the building program. Next the plans and the written approval of the local district are placed before the Michigan Department of Public Instruction. This department will determine the adequacy of the plans in accordance with the provisions of the School Building Law and such other measures as efficiency of the site, educational usefulness of the building and health and safety standards. Often to avoid confusion, the preliminary drawings and outline specifications are also submitted to this group for suggestions which might be incorporated on the working plans.

The major restrictions placed by the Department arise from the School Building Law. This measure, Act 306 of Public Acts of 1937 as amended, places certain performance standards on the basis of inducing safety within the structure. A recent revision from the State Fire Marshal's office, incorporated in Bulletin 412, sets forth the mandatory fire safety provisions of school building construction. Not only are severe restrictions placed on combustible materials in multi-storied

structures but several areas within one story members are also barred of such items. Since it is not required by law that the State Fire Marshal's office approves plans and specifications the Department of Public Instruction will act in their place on plan approvals. The Fire Marshal's office is required, however, to inspect each building twice during construction. One inspection is made of the building's structural framing and the second on the completed building.

One other approval is required from the Department of Health. Usually, this will be made by the County or District Health Department and will cover such items as sanitation and food handling facilities.

When the final approval from all agencies is obtained direct actions toward building may be undertaken.

Financing the New Building. Since the means of handling financial matters may be of a fixed or varied nature, actual planning of this item may occur at various times in the program. In general, the concluding steps of the building process involve the implementation of the program through adequate financing of the required school facilities. It is important that all of the necessary legal steps be taken throughout the entire planning period, and this is particularly imperative in connection with financing.

School building construction in Michigan is financed for the most part in one of three ways: (1) out of current tax receipts on a pay-as-you-go basis, (2) from current tax receipts which are accumulated in a building and site sinking fund, or (3) by borrowing money through the issuance of bonds. In the first two methods, money is derived from special taxes placed on the community. To adequately cover school expansion by this means it is necessary to have an area with considerable taxable wealth or relatively small and cyclic needs for school building capital.

The more widely used method in this state is the issuance of bonds. All districts financing buildings by this method are required under the Municipal Finance Act of 1943 to incorporate correct legal procedures such as seeking council of a certified bonding attorney.

Of greater significance is the need for the community members to certify this indebtedness. Citizen's approval will require the circulation of information concerning both educational and building proposals. This need must be presented in such a manner as to assure the citizen that funds used are for a valid and logical purpose and are accomplished in the most efficient manner possible. The architectural firm may formulate a brochure or phamplet on the educational and building details to accomplish this purpose.

Rejection of the bond issue during elections will require various alterations in the proposed structure in order to comply with a tighter budget. Such changes usually occur in the form of eliminating special educational rooms and materials, reducing space requirements or the substitution of cheaper building materials. To avoid this possibility, accurate budget limitations during planning should be employed, followed by an effective method to thoroughly acquaint the public with the purpose and methods of the program.

After the bond issue has been passed and funds voted to retire the bond according to a schedule, the board of education should advertise for bids on the sale of the bonds. Here again, the architect and the school administrative staff should produce and effective method of presenting the necessary information to prospective bidders. Bids are collected and those that present the lowest cost to the district over the entire period of indebtedness are usually accepted.

Construction Procedures. The relative infrequency of major material decisions during the construction phase, reduces its importance for this decision. For the most part the contractor's major function is to construct the proposed building in accordance with specifications and drawings provided him by the school district. A brief outline of various obligations submitted by the planning committee and architect should suffice.

The initial item to accomplish before construction can proceed is to disseminate information on the proposed building for the consideration of various construction firms. An outline of the type of construction, location and time for bids to be submitted is essential. This information will be carried in such media as local newspapers and building reports produced by organization such as F. W. Dodge, and builders and traders associations. Concerns that are interested will indicate their desires by requesting a copy of specifications and working drawings.

Sealed bids and a certified bond covering the bid are submitted to the board on a predetermined date. The job is awarded to that firm having attained the lowest, reasonable bid.

Once the project has been started, supervision of the construction will be necessary. The architect will periodically accomplish this service. The purpose of this function is to assure correct interpretation of the plans and specifications and to avoid any substitution of materials or methods of construction. The degree of experience and reputation of a contracting firm coupled with the complexity of design will determine the extent of supervision necessary.

Variation in Procedures Common to Large Districts

Due to a continuous demand for new school structures, the larger districts throughout this state have developed specialized departments within their administrative staffs. An increased budget allotment permits these additions. Although costly, in the long run they produce greater efficiency in planning and subsequent economical results.

This efficiency results from having the various departments continually measure the present status, progress, and alterations occurring in their areas. Community expansion, school policies, school layout and design, engineering, and architecture are a few of the various departments found in larger school districts. These personnel work under the superintendent and thereby allow this man to devote more time to decisions on major policies.

During the educational planning stages, districts such as Detroit, Flint, and Grand Rapids will eliminate citizens' committees, teachers, and custodians and only make limited use of the board of education members by changing their function to that of an approval board. Preliminary educational specifications will be developed by the districts' technical departments, school consultants and the superintendent.

Class three areas still maintain board members as an integral part of their committees. This is due to the fact that class three districts represent a transition between the smaller and larger school systems and have limited their degree of specialization to various assistants to the superintendents.

Architectural representation is still utilized on both planning committees to enable better coordination between education and design. But due to the specialized study of materials and construction the architect may have certain standards set before him. These standards, written or oral, may mention actual materials desired or rejected by the district but more often are set up as performance codes. Although these standards often parallel certain state restrictions and suggestions, the greater volume of material represents valid information derived from past experiences. In no way do they discourage the use of new products which the architect may suggest. The hiring of an architect indicates their desire to incorporate individual design within each structure.

Until two years ago, the city of Detroit had only used private architects as a source of drafting skills. The majority of their buildings had incorporated a 1930 vintage style of architecture which was developed and used by their own staff. An awareness of advantages gained by other districts using newer methods has caused them to change their current building program to one that utilizes all skills of private architectural concerns. Certain performance standards are being developed but will be used only as a general outline.

Grand Rapids has gained much respect from various architectural firms by establishing a concise statement of design standards. This was formulated in 1951 by a Collaborating Architect's Committee composed of seven firms which were to share equally in Grand Rapids multi-million dollar school expansion program. Proposed design standards which would meet the requirements and desires of school administrative staffs were developed by architects for the use of architects. The results of this program are stated in a recent revision of the original standards: "Concrete, factual results are now evident in this unique pilot experiment of close collaboration between seven architectural firms for overall standardization of a multiple school building program. It appears that actual economies have been effected; maintenance costs held to a minimum and a reasonable uniform esthetic appearance realized, yet flexible enough to permit each architect an individual characteristic touch."[4] Statements from this source concerning qualifications for materials will be used in other portions of this paper.

One other area which larger districts have improved is field supervision of the construction job. This has been deemed necessary through errors of the contractor and the architect. Frequent attempts on the part of the contractor to substitute or omit certain materials has caused the school district to place their own superintendent on the job. This person usually is a full time member of the district maintenance staff.

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[4] Buikema, Benjamin J., "Revised Design Standards for Elementary Schools", Board of Education, Grand Rapids, Michigan, 1954.

Mistakes on working drawings or specifications may cause further need of a supervisor. One general area in which school authorities find fault with the architect is a failure to specify thorough information on material installation or finishing. Often, failure of these items may not be caused by the material itself but traced to improper installation. Although these may be due to neglect on the contractor's part, adequate detailing is of primary importance.

CHAPTER III

THE PROPERTIES OF SCHOOL BUILDING MATERIALS

In the field of school construction, certain properties are desired of the materials used as structural and finish items. The competitive advantages of a material depends to a high degree on the number of qualities it may contain and the extent to which it accomplishes these factors. Furthermore in school construction there are individual characteristics and problems common to these structures which place varying weights on the qualities of a building material. This in turn is again varied by the people interpreting the needs of these public educational buildings. Such people, whether superintendent, architect, fire marshal, or school consultant, finally arrive at a system by which they will evaluate materials.

Although such systems are made in the best interest of the school district, the accuracy of weighing or classifying the qualities of a material may be questioned. A tendency to allow such factors as personal opinion, industrial promotion or inadequate information to influence decisions will exist with the final outcome of some qualities being stressed too strongly or others not even considered. The dynamic status of our educational systems produces many new concepts and changes which also should be constantly evaluated as to their effects upon materials.

In evaluating this means for selecting materials it is evident that unfair considerations do exist but for the most part this system is a sound basis for determining which materials are best suited for school structures. Wood products have suffered losses in school construction as a result of these standards. A few components have received unfair judgment because of the improper stressing of qualities not common to these items. For the most part, wood products have decreased either due to a lack of information concerning these items or to a lack of sufficient qualities necessary to condone usage.

Initial Cost of the Material

The problem of providing ample space at a low initial cost produces one of the greatest problems for Michigan's school system. Restrictions on building funds coupled with the yearly increases in school enrollment require initial costs per square foot to be at a minimum. This monetary standard will be directly related to the cost of various materials. School districts throughout the state are constantly demanding the selection of materials which will adequately enclose a premium of space at reasonable, generally minimum, costs.

Not only is there a problem to reduce this initial payment but secondary complications also arise during attempts to have the taxpayer approve these expenditures. Should sinking funds be used, the initial action of levying certain taxes for this purpose will still require the voters' approval. But more often bonds are used and the voters' direct approval of each building is required. Even with full information on all the prospective buildings assets, the initial amount of indebtedness is still a prime determinant of a bond's acceptance.

A reminder at this point concerning value is important. Initial cost may be of great importance but at the same time the quality of construction should not be neglected. False economy through the use of cheap construction materials will only result in the need for increased sums at later dates due to repair, refinishing or replacement. It is urged that districts obtain economy through the rational selection and use of materials possessing sufficient qualities to merit their usage.

With this constant concern over monetary limitations it is of interest to note the general trend in cost of school building construction in relation to other increasing costs. In the past twenty years the cost of school buildings has increased 150% whereas the cost of all other buildings averaged 210%. A list of other increases during this period are as follows:

General construction	275%
Home construction	225%
Materials and components for construction	200%

Automobiles	200%
Skilled labor	220%
Common labor	330%

Although this study by the American Association of School Administration is an average of the entire nation it is quite evident that the State of Michigan is also obtaining economical use of its school appropriations. Between 1955 and 1959 the average cost of construction for complete school buildings in Michigan fell from $15.08 to $13.80 on a square foot basis. At the same time the area per pupil rose from 81.7 square feet in 1955 to 106.0 square feet for 1959.

This trend of obtaining greater usage of school investments may be attributed to functional designs and the proper selection of materials. Constant thought towards economy, enforced and produced by budget restrictions, has presented the tax-paying communities with structures that incorporate improved educational facilities and feasible costs.

Divisions of Initial Cost Material. Materials costs are divided into the initial cost of the material and the subsequent amounts required to install the item. When considering initial cost variations, the cost of the material will measure to some degree the quality of construction and composition as compared to other similar items. Here again, it is necessary to determine how well the item will function and the length of time it will be serviceable; be it a window, roof component or floor covering. Other considerations to take in account when comparing items on a basis of cost are the number of functions the material may accomplish. The total cost of accomplishing two or more functions with two or more materials may substantially exceed a seemingly high priced material which accomplishes a number of requirements.

With the ever increasing cost of labor it is essential to give this item proper consideration when selecting various materials. The cost of installation may be divided into quality and quantity factors. Quality will apply to specialized trades or machinery which will be required for a certain construction phase. These items are proportionally higher in cost and often require careful coordination of activities to insure a continuous flow of construction. Specialization usually indicates a scarcity of such trades and equipment due to supply and demand factors. It is essential to properly plan this work to follow the pattern of activities on a job or else wasted and confused time may occur.

Quantity refers to the amount of labor involved in construction. The merits of pre-assembled materials and easily installed items have developed increased usage during the past years of rising labor costs. Such materials also eliminate poor quality installation by substituting standardized factory procedures. Although factory finished items may carry

a higher initial cost their savings in installation may place them in a more competitive position.

One further consideration regarding labor is the number of various trades necessary for the complete installation of an item. Numerous trades are not only expensive in total but present a problem in coordination of avtivities.

Problems Arising from Cost Analysis. During the course of study necessary to complete this report considerable effort was made to determine actual costs of various building materials. Estimates were secured but not in amounts anticipated. Although the competitive nature of some firms prevented the dissemination of such information, the major reason for this partial void is attributed to the characteristics of the construction business. Architects and contractors stressed that it is extremely difficult to accurately compare material costs by alternate bids due to the individual characteristics found in each building. Such characteristics will not only present variations in cost between different structures but they may also favor or disfavor certain materials. An example would be excessive spans in a building causing increased costs for extra structural support or their prohibiting certain items only available or practical in shorter lengths.

In addition, the quantity ordered will present variations in cost. Discounts and wholesale pricing will present varying costs in the same material ordered in different quantities. Certain manufacturers will also establish various pricing methods to promote a more competitive position. Retail pricing may be a basis for comparison but will not always hold true for volume orders.

Another factor preventing accurate comparison of costs is the cyclic nature of the contracting trade. Competition during ebb periods may reach the extremes of building at cost whereas six months hence the demand may allow lush profits. To compare structures with their included materials built during such extremes or even during various transition periods would produce a maze of inaccuracies.

This is also evident in the materials manufacturing industries. Although for the most part these industries are relatively stable in their supply and demand cycles, some variations will cause the product to rise or fall in cost. More drastic periods are evident during strikes and other shutdowns in production. Costs and supply of materials cannot then be taken as average conditions for comparisons.

Amortization of the Initial Investment. Another important consideration in dealing with initial investments will be the amortization of the loan or other real money paid for interest. Although this factor may be considered as a separate determinate of material selection, for purposes of this report it shall be treated as a product of initial cost. The cost occurred over the period of a loan is directly proportional to the initial investment and produces an extra burden on premium priced materials. It is then necessary, in the actual selection of materials, to have assurances that the amount of service and qualities of a product will justify not only the initial investments but the resulting amortization. At present, the average rate of assessments against Michigan school loans average between 4½ and 5 per cent. Since Michigan school districts usually obtain loans on a twenty to twenty-five year basis the amortization of material investments will only cover this period and not be involved in the entire life of a building.

The cost of loans will also affect the selection of materials on a basis of maintenance. This will be discussed in the next section of this chapter. Primarily it involves the comparison of initial costs in competitive materials and their resulting amortizations with the savings realized in reduced maintenance costs within the school's lifetime.

Maintenance

For purposes of this report maintenance of materials is used to designate the cost of labors expended on materials after installation is completed. This will include such functions as cleaning, refinishing, repairing or replacing and can be considered as a basis for measuring the serviceability of an item throughout the life of the school structure.

An increasing demand for a minimum of maintenance in building materials has placed the importance of this factor on par with initial cost. Actually, these two features are major components of total cost. In the past there was some tendency to disregard maintenance costs and to only stress the initial costs of the structure. This was due to an urgent need for a large quantity of educational space which did not stress the quality features. Dollar and cent values obtain greater significance to the tax payers when presented in a lump sum than do the merits of future savings at a later date. Therefore the school districts presented the public with low initial costs in order to obtain approval and they would thereby disregard the future maintenance expenditures. The "hidden nature" of maintenance costs also allowed this de-emphasis. Maintenance costs are usually paid for from the general operating funds obtained through yearly taxation. Although taxation must also receive the community's approval the tendency to lump all operating costs together considerably reduced the actual importance of maintenance.

However, during more recent years there has been an awareness of rising maintenance costs that are continually being assessed against buildings during their life cycle. To compensate for this, school superintendents and architects now think in terms of the total cost as developed by school buildings.

Even though the personnel affiliated with school planning are realizing the importance of total cost there is still a problem of educating the public. Frequent rejections of bond issues are often the cause of the public's failure to understand the assets of low maintenance construction. Schools that are built are being further critized with comments concerning their "luxury" or "plush appearance". Materials that are initially more expensive in cost and appearance are often those that retain this appearance with a minimum of maintenance.

Continual Maintenance. The procedures included within this term are items such as painting, refinishing, cleaning, waxing, washing, and other continual custodial services. The continual nature of such costs accumulate to a large sum over a period of years. Cost in this case is composed of materials used and the labor expended. In the majority of cases the major cost will be for labor. Materials usually compose only a small fraction of expense. Not only is labor costly but the quality of such services is often at such a low level that school districts try to eliminate all maintenance solely on this basis. Low caliber maintenance presents both poor appearance and a need for frequent repetition.

The extent of these maintenance functions are not always directly related to the type of material but may result from atmospheric conditions, climate, or human occupancy. Rain, dirt, heat, cold, or moisture vapor will exist under normal conditions and many of the maintenance costs are attributed to these items rather than to the materials.

But the elements and occupants will act upon materials with varying results. The ability of a material's composition or surface structure to eliminate maintenance presents a distinct advantage. In some cases maintenance is not only costly but results in the materials wearing at a faster rate.

Repair. Repair is an effort to correct damage resulting from harsh treatment or misuse. Materials are judged both by their ability to withstand such punishment and the ease by which repairs may be made. Items which either resist such treatment or do not readily show the results therefrom will find wide usage in heavily used areas of a school building. Such materials are desired for walls, floor coverings, existing areas, and various types of furniture.

A second consideration should be given to the type of repairs necessary to correct damaged items. Low cost is realized when a minimum of time and variety of trades are expended for such repairs.

Replacement. The final results of excessive damage or continual maintenance may be the replacement of the item. Deterioration by the elements to a stage where inadequate service and appearance result will also require replacement. Seldom is the job confined to a small area and the cost will generally be considerable. Although replacement is usually expensive, it may be more economical in the long run than trying to suffice with a series of small scale repair jobs.

Materials that will outlast others frequently prove to be more economical over their life span than those costing smaller initial amounts. The cost of replacement will also be reduced if the item is stocked locally is of standard dimensions and requires a minimum of labor.

Improper Measurement of Maintenance. Current trends placing greater emphasis on maintenance have also produced over-emphasis of this item and incurred inaccuracies of measurement. Materials that are known to require reapplication of finished coats or certain installation procedures are frequently eliminated without giving consideration to the actual costs involved in such operations or the other qualities which the items may possess. Such over-emphasis of this function is further complicated by comparing improved materials with older materials which did require an excess of maintenance caused by improper designs and manufacturing processes.

Another fallacy associated with the comparison of materials maintenance has been the tendency to accept without

question all claims and guarantees stated by the manufacturers of new products. Such claims are often unfounded or based upon accelerated testing that does not accurately measure the items true resistance to all factors. When applied to the school structure many of these laboratory tested materials will not hold up for required periods under the actual conditions of use.

Both of the above conditions can be remedied during planning. The first condition of over-emphasizing maintenance and inaccurate comparisons could be remedied by the placing of correct information in the hands of persons selecting materials. In other words, the major fault lies with the manufacturer not being truthful about his material. Maintenance may be over-emphasized to such a degree that other advantages common to a material may be completely overlooked during selections. This may be rectified by proper promotion that presents the entire story on the item inclusive of its required maintenance. But in this way certain advantages may also be presented for a more fair consideration. Other inaccuracies will result from improper installation or usage of the material. Frequently materials requiring certain prerequisites for proper installation are put in place by unskilled, careless, or hurried workmen. This may result from neglect on the part of the contractor or inadequate detailing and specification by the architect. The resulting poor service is then blamed fully on materials. Such fallacies are additional competitive advantages favoring the use of preassembled items which partially eliminate the possibility of poor installation.

The second fallacy is due to inaccurate information or poor methods of testing and is best remedied by requiring positive proof of guarantees before incorporating the material within the school structure. Currently, more Michigan school board committees are requiring their architects to present examples of new materials which adequately prove them capable of full service under conditions similar to those found in their areas. Should none exist, the manufacturers will be required to assume all responsibility for the material providing application is correct.

Architectural Requirements

The rapid changes which occurred in our educational systems within the past years and those which will continue on into the future place different requirements upon the school buildings. Such trends are developed by our educators in an attempt to utilize better methods of teaching our increasing population. In turn this transition will require the architect to develop a building that will function properly while adequately housing the student body. Although such prerequisites place certain restraints on design the evaluation of various layouts gradually produce an optimum solution or series of solutions. Since this process of evolution is necessary the architectural field is always behind the

educational field. But through cooperation of efforts the gap between ideas and reality is lessened.

During this transition the requirements of building materials are also continually changing. To some extent older items are replaced by newer materials which may more adequately fit the needs of new structures. In other instances the materials themselves are still sound but require new designs and treatment. Whichever the case may be it is evident that products as well as designs must meet the future requirements or else suffer the fate of replacement.

Flexibility. Rapid transition in the school systems have caused the school administrators to realize that a rigid structure that is not capable of incorporating new ideas will soon be outdated. Since the average life of a school building is estimated at fifty years it is possible to have an antique structure that acts as a detriment to the school district. To reduce this possibility there is now a growing tendency to have the entire interior of a structure composed of movable partitions incorporating a modular layout.

The changes which are of growing concern to educational buildings are the various room arrangements to facilitate different course material and presentation thereof. An increased number of students may require mass lecture systems and proper room space to facilitate such delivery. The extreme of this condition may be supplementing mass lecture with further instruction of much smaller groups on a more personal and informal basis. Various courses are also requiring different sized rooms and space for special equipment. Science courses, speech, the various arts, as well as manual training are developing in importance and require special arrangement of space. The elementary schools are still relatively stable in their method of teaching but the future may even see specialization of courses in these buildings.

With this present movement in systems it is difficult to predict what building, if any, will finally evolve as the major solution. School administrators now stress that their buildings should insure the ability to incorporate any advancements in education. Although such changes may be advisable there is still a tendency by the teaching profession to resist changes and remain with past methods. This in turn presents opposition to new types of buildings.which do not utilize flexible designs. Architects in Michigan have stated that such conditions do exist and present barriers to their ideas. There have also been buildings constructed in this state at additional costs in order to incorporate flexibility but the structures still remain in their original design. The most feasible solution to such problems is to have better dissemination and understanding or educational problems within the school administrative staffs.

The initial cost, installation, and other requirements of design necessary to incorporate movable room partitions pres nt a sizable increase in the cost of a building. For the most part the wall itself represents the greatest cost but since it is of a non-bearing design the roof must incorporate added strength features which also increase the expense. The motive behind this costly design is the resulting changes in layout which will be less expensive with movable panels than with the cost of changing room layout with rigid walls of a bearing nature.

The cost of tearing down a wall, providing adequate roof support for this void, and then rebuilding the new wall will be considerably in excess of a custodial staff rearranging movable walls. In addition, bearing wall alterations are time consuming and disturbing to the teaching process. Although movable partitions are cheaper for alterations it is essential to ascertain whether the school has need of such a flexible nature.

Expandibility. Future increases in school enrollment will require additional space requirements which may be gained by expanding the size of an existing building. In essence expandibility is quite similar to flexibility since both deal with the reorganization of wall sections, the only difference being that the latter deals with interior partitions while the former deals with exterior walls.

Increasing the size of the building with wall panels will still require a new foundation, floor area and roof members to be added to the existing structure. Some materials for these components are also manufactured in a panelized form. But the greatest savings is obtained by disassembling and reconstructing the entire wall area with a minimum of wasted material and labor. Here again, this type of construction is expensive and savings are only realized by utilizing its movable capacity. Other savings may be obtained during initial construction if these panels are of a light weight construction and do not require excess structural support.

The exterior usage of these panel systems presents another problem which is caused by their exposure to the elements. The materials must not only resist exposure but must be combined in such a manner as to provide a tight seal against the elements. Although the wall is a series of panels, once joined they should form a single unit that permits adequate interior conditions for human comfort. The primary consideration of the entire building program is to provide a proper environment for the students. Mechanical advantages are to be desired but should only be included if they harmonize with our basic objective of attaining the proper educational conditions.

Appearance. Perhaps the greatest task and accomplishment which the architectural profession performs is the arranging of various materials in such a manner so as to present not only enclosed space but a structure that is pleasing to the eye and compatable with the educational environment. The great variety of materials available to the architect would seem to simplify his problems unless one considers the restriction placed upon the design by the budgets. It is then necessary for the architect to use a great amount of discretion in his selection of materials.

The success of the architect's goals may be attested to by the public's comments of schools being luxurious, and yet still being within the average cost limits of other Michigan schools. Careful selection of materials presents the public with a service that fully justifies the expense entailed in hiring an architect.

For the most part school building budgets are still restrictive of quality type interior and exterior materials which impart a large portion to the overall appearance. The major item of importance is to present functional space at economical costs. Architectural flavor is only incorporated providing it still meets these primary requirements.

But appearance is receiving greater recognition by school districts in an effort to improve the quality of their buildings and to provide a better educational atmosphere. The bare essentials were necessary during the initial drive for schools but now with better means to meet school demand, a chance to improve the structure's architecture is receiving greater significance. Extra appropriations are available in limited amounts to further this desire of producing schools that develop civic pride.

One method frequently incorporated in Michigan schools is to present the structural members in the building as a decorative item. This process is a combination of functions and presents a more economical unit. In other cases the structural item may still be exposed regardless of appearance due to monetary restriction.

Further efforts on the part of the architect are aimed at the selection of materials and components which eliminate the heavy, uninteresting, massive appearance. Light, graceful materials and designs are sought in an effort to improve appearance and prevent restrained feelings due to spacial limitation. The outside environment is combined with the interior of a building by window areas in such a manner so as to not distract from education but to add to and encourage the process.

The addition of color to school buildings provides a pleasing appearance. In recent years there has been an effort to eliminate the drab stereotyped appearance so common to buildings constructed during the prewar period. The result of this transition was the use of many intense colors in various areas of the building. This produced the other extreme in coloring school buildings and was also rejected. Now, school buildings follow a plan of using one general pastel color theme highlighted by the use of brighter, vivid colors in smaller areas such as a door or chalkboard. This is further developed by harmonizing color with components constructed of natural materials such as stone or wood. The overall selection produces a pleasing atmosphere that is both interesting and not extremely artificial.

This overall architectural effort is summed up by the booklet "Planning Together for Better School Building" which was produced by the Michigan Department of Public Instruction; "Good school buildings are no longer being built as monuments, but rather as being built as a pleasant environment in which children may learn. Emphasis upon informality and non-institutional techniques, variations of shape and mass implied in various educational activities and the creation of atmosphere and delight through the use of color has replaced the use of applied ornamentation and decoration. The result has been a more friendly building, light and airy, in scale with and attractive to the child."[5]

Human Comfort

School administrators realize that in order to develop

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[5] "Planning Together for Better School Buildings", Department of Public Instruction, Lansing Department of Public Instruction, 1956.

educational conditions in a classroom area the students and teaching staff require an atmosphere free of distractions and compatable to the human body. To attain these conditions various mechanical means coupled with proper layout are specified. Once produced for the school structure, it is essential to maintain this environment and prevent other factors from entering which may disturb our educational processes. The maintenance of proper educational surroundings is partially dependent on the selection of building materials which are compatable to these needs.

Insulation from Heat and Cold. Once the heating system in the building has developed an ideal temperature for the school inhabitants it is necessary to provide adequate insulation throughout the building in an effort to prevent fluctuations of this temperature. During the warmer months the problem is reversed to that of preventing excessive heat from entering the school atmosphere. This problem, common to summer months, is somewhat solved by the summer recess of approximately three months. But to meet the constant increase in enrollment school administrators are now devising a system of quarterly vacation periods alternated among four class groups. This would extend the utilization of our schools through the summer months and also present problems of providing air conditioned atmospheres. In either case the construction of the building should prevent the passage of exterior conditions into the classroom areas. This may be accomplished by various construction design and the selection of insulative building materials which shield the entire structure.

Those materials, whether structural or decorative, which eliminate the need of insulating items due to their composition will accomplish two or more functions. This should prove to be an economical selection providing their initial cost is not excessive. In other cases many materials, such as metals, readily conduct heat and cold and require the use of special construction, insulating materials, or a combination of both. The type of construction most common to Michigan employs special insulating materials and the use of dead air spaces throughout walls, roof, and floor sections.

Direct exterior exposure of conducting materials used on the interior surface, such as a door or window unit, presents special problems to school heating. Although this usage may seem contradictory to all basic rules of construction these conducting materials are selected on a basis of the other advantages which school administrators feel are more important. This decision then presents an adverse condition to rectify. In general, the heating costs of a building are increased to compensate for the resulting cold conducted into the class area.

This de-emphasis of heating costs stems from the lack of information concerning this phase of the operating budget.

School buildings will lose a large amount of heat during the day due to the frequent opening of exits and require an even greater amount to adequately heat the interior spaces. In proportion to these expenses the actual amounts required to equalize losses through materials are difficult to determine and given less consideration. Architects realize that losses of heat will occur at areas incorporating highly conductive materials and to compensate for this loss and to prevent radiation of body heat to equalize such cold areas will place heating outlets at such points. These methods will never fully correct the situation due to the heat conductivity of the materials. Generally such methods are accepted by the school administrative and teaching staffs of Michigan and no changes seem imminent.

The "U" factor in this report is a measure of conductivity and refers to the British Thermal Units conducted through a square foot surface area of material per hour per one degree Fahrenheit difference in temperature. Since it is expressed as a decimal equivalent the lower values are more acceptable.

Sound Insulation. The elimination of distracting sounds in the classroom area is a prerequisite for any educational system. Once a room is isolated from the remainder of the building, further thought must be given to the proper transmission of sounds in this unit. Acoustical qualities and sound insulation are obtained by the selection of materials which will absorb excessive vibrations and by utilization of proper design. Design will include the layout of teaching units in such a manner as to isolate distracting regions such as music, shop or athletic areas, and the placement of wall and ceiling surfaces in a style to create proper acoustics.

Various types of sounds will need separate treatments. Air-borne sounds are those which originate within the room and are best controlled by wall, floor, and ceiling finish materials of various textures. The efficiency of a finish to absorb sound is termed its "absorption coefficient" and a high value indicates greater efficiency.

Sound insulators are used to combat air-borne sound which originates outside of a room. The efficiency of a mass to keep out sounds is measured by a "transmission loss" rating. Here again, the higher the rating, the more efficient the material.

The third type of sound is transmitted through the materials of a building and is termed the solid-borne sound. These originate from vibrational sources such as machinery and are reduced by using special insulating mounts at the source. Large slab floor units, due to their extended continuous mass, may also conduct smaller vibrations such as normal student traffic. Expansion joints placed at regular intervals will isolate this type of sound.

Classroom areas should not be "dead rooms" in the sense that all surfaces are completely treated with acoustical material. "Auditory deafness" obtained by this type of treatment is not recommended from a standpoint of economy and the resulting abnormal atmosphere. Students are disturbed by excessive acoustical treatments, and the suggested practice is to incorporate only an acoustical surface on the ceiling. Hallways should be "dead" acoustically so that air-borne noises will be absorbed quickly and not be transmitted to classroom area. Auditoriums present a special problem since long reverberation of sound is best for music whereas short reverberations are ideal for the delivery of a speech. This conflict can be solved by striking a medium with sound absorbing drapes, curtains and ceiling used in a room with flat surface walls. By drawing all drapes and curtains to obtain maximum coverage an adequate sound absorbtive quality is produced.

The isolation and transmission of sound is essential to the educational process and merits considerable weight in the selection of materials. Primary consideration is given to the isolation of class units since this may be obtained by selecting proper structural materials. Special acoustical effects involve added layers of materials and require additional investments which restrict their usage. They will, however, be used in limited amounts where the need is great and

economically feasible.

Fire Restrictions

One of the most important problems confronting the architect during the design of a school building is to provide for the prevention of fire and the safety of inhabitants. Primarily, such measures are necessary to prevent the loss of human lives and check excessive financial losses. The State of Michigan not only encourages such practices but has established various restrictions that the architect must follow.

These restrictions set minimum standards on the type of construction in either single or multi-storied buildings with further ordinances placed on the different types of rooms in each building. In general, the major purpose of these standards is to provide for sufficient evacuation time during a fire and to restrict the spread thereof. As a result of these actions definite limitations are placed on structural and finished materials which are of a combustible nature. To evaluate these restrictions it is necessary to study the source of jurisdiction, the methods of evaluating materials, and the reasons for revising original preventive measures.

Fire Safety Measurements. The two methods of evaluating materials or components of a structure in relation to their performance when subjected to fire are the fire resistance and flame spread ratings. The first was devised by the

American Society for Testing Materials in an attempt to measure the fire endurance of construction assemblies. The test, A. S. T. M. Standard E-199, involves the application of a flame to one side of a structure and the subsequent measurement of time required for the flame to penetrate through to the unexposed side, thereby establishing the fire resistance rating of the assembly. If the assembly is to be used for load bearing purposes a corresponding load is applied during the test, in which case failure under loading will establish the fire resistance rating. In short, this test is a measure of endurance and frequently used for the classification of various wall, ceiling and floor sections.

In the case of doors, an alphabetical classification of fire resistance was devised by the National Board of Fire Underwriters. This listing shows the location for which the assembly is designed and measures the door's fire resistance at various degrees of temperature reached on the unexposed side after thirty minutes exposure to flame. The temperature increases over the thirty minute period used for this broad classification are 250°F, 650°F or no reference to any temperature. Under each of these three categories the doors are designated as follows:

(1) 3 Hour A Door- Fire doors for openings in Fire walls

(2) 1½ Hour B Door- Fire doors for openings in vertical shafts

(3) 1 Hour B Door- " " " " " " "

(4) 3/4 Hour C Door- Corridor and room partition doors

(5) 1½ Hour D Door- Fire doors for openings in Exterior walls

(6) 3/4 Hour E Door- Fire door for opening to Exterior fire escape

The second measurement of materials was devised by the Underwriters' Laboratories in an effort to evaluate the fire hazard of materials exposed on the interior surfaces of a building. The procedure is known as the "Tunnel Test" and was described in the September 1944 Underwriters' Laboratories Bulletin No. 32. The testing apparatus was a horizontal tunnel in which a test specimen twenty inches wide and twenty-five feet in length was installed to serve as a ceiling. A gas flame was placed at one end and distance recorded as the flame moved along the ceiling specimen. The basis of measuring the flame spread was established by rating asbestos board as zero and untreated red oak lumber as 100. All other materials were then related to these base points. These tests were later confirmed by the American Society of Testing Materials, A. S. T. M. E-84 50T and then grouped into an alphabetical classification of finish materials by the National Fire Protection Association. Class A materials were limited from 0-20 in flame spread, Class B from 20-75, Class C from 75-200, Class D from 200-500 and materials over 500 spread are grouped in Class E. With the exception of pitchy pine which is a Class D material, all woods are classified as Class C materials with redwood carrying the lowest flame spread of 75.

Origin of Michigan's Ordinances. Act 306 of the Public Acts of 1937 established the requirement that all plans and specifications for new school buildings and additions to or remodeling of existing buildings needed the approval of the Superintendent of Public Instruction before beginning construction. Bulletin 412 was then devised by this office to act as a basis for evaluating these plans and specifications submitted for approval.

Although the State Fire Marshal's office is not required to approve these school plans it is essential that this department approve the building twice during construction, one inspection to be made of the frame work prior to plastering and the second of the completed structure. In addition, the Department of Public Instruction will frequently confer with the Fire Marshal's office on submitted plans, especially when there are items of questionable fire safety. It is evident that though the Fire Marshal is not directly responsible for plan approvals his jurisdiction will cover this phase in an indirect manner and at a later date his direct approval is necessary.

The Michigan Fire Marshal's office is set up as an agency of the Michigan State Police Administration Force. The duties of the Fire Marshal are assigned to the Commissioner of the State Police. This position is largely a control and approval one with the majority of the duties assigned to the Chief of the Fire Division, who in turn is appointed by the Fire Marshal. All inspections and regulations developed by the central Fire Marshal's office, located in East Lansing, are made under the auspices of the Chief. A staff of four detective sergeants aids the Chief in these matters by developing information on building trends in four different construction areas, one of which is school buildings. At present, Michigan is divided into eight districts, each of which has a regional Fire Marshal office and manned by one to five State Police officers. The actual inspection of school buildings is then made by the district representatives with a report submitted to the main office in East Lansing.

To enable the architect to understand the Fire Marshal's system of approval and to adequately design school structures a number of regulations were sent to architects' offices in the form of "Letters to Architects". Further aid was available in the form of condensed versions of these letters and from material as found in Bulletin 412 as produced by the Department of Public Instruction. Architects were frequently confused and lacked sufficient information on the Fire Marshal's regulations due to the sporadic and dispersed sources of material on this subject. This was further complicated by various inspectors in the state who were not using a standard set of inspection procedures. To correct this situation it was decided in early 1959 to develop a uniform basis for construction approval in relation to fire safety.

This revision was developed by the Fire Marshal's office and the Department of Public Instruction. Material contained within this standard was a coordination of all past regulations developed by the Fire Marshal's office, items contained in the School Building Law or Public Acts of 1937 (as amended), and new restrictions governing the use of interior finishes. This revision was modeled after the Building Exits Code, a standard devised by the National Fire Protection Association to aid in coordinating all fire regulations throughout the nation. The general scope of this standard is: "This code covers the construction, arrangement, and use of exit facilities necessary to provide safe means of egress from structures, together with such features of construction and protection as have bearing on safety of egress."[6] Measurements used in this new revision were flame spread and fire resistance ratings. Although Michigan primarily followed the Building Exits Code, some portions, namely construction methods, were more restrictive than this code.

When the revisions were completed by these two departments a committee was developed to criticize it and to offer suggestions on further refinements. These hearings were composed of three to four members of the Michigan Society of Architects, representatives of the Michigan School Board Association, Michigan parochial school system, and various

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[6] National Fire Protection Association, <u>Building Exits Code</u>, Boston, National Fire Protection Association, 1959.

school board administrators. Suggestions on improvement were discussed by the group and then submitted to the Chief of the Fire Division for his consideration. Although the major purpose of this committee was to insure the development of a practical and workable regulation it did not have any power to enforce its recommendations.

The results of the revision were then printed as a supplement to School Bulletin 412 as originated by the Department of Public Instruction and put into effect October 1, 1959. The fire prevention section is not a law or code passed by the Michigan legislature and only acts as a guide for construction that is approved by the Fire Marshal's department. Since Act 306 requires the Fire Marshal's approval on construction and authorizes him to establish criteria for such, the addition to Bulletin 412 may be considered as an indirect code. Although it is dependent upon the discretion of this department to establish such regulations, there is still a wide degree of flexibility. It is possible to amend or revise this standard without requiring state approval other than that of the Fire Marshal's administrative body.

Fire Prevention Section, School Bulletin 412. The major portions of this bulletin deal with the number, location and size of various types of rooms and their exiting facilities. Material not of great significance to this report includes stair construction, storage facilities, heating and other items restrictive to multi-storied structures.

It is important to note that a full basement is considered as a story. This was a portion of Act 306 and was established to insure adequate exits and retarded flame spread in areas subjected to the danger of fire occurring beneath a floor unit. Should a school building be of a multi-storied design it must be of fire resistant construction, with all steel structural members protected with materials providing a one hour fire resistance. This factor automatically eliminates wood construction products from the majority of uses within this type of building. Since this report is limited to one story structures it is not within it's scope to report on such items. However, the validity of this restriction on materials is questioned and provides an area for further investigation.

There is no direct restriction on the type of materials used for structural components of a one story building providing they are not exposed on the interior surfaces. Should such items be exposed on interior surfaces, the interior finish restrictions will apply whether the item is a finish material or structural in nature.

The major items in this fire prevention section pertinent to this study included the following paragraphs:

Paragraph 7.3 In one story construction, any open combustible attic sections, regardless of depth of area between the ceiling and roof, shall be subdivided into areas not exceeding 3000 square feet, with non combustible partitions.

Paragraph 10.3 All corridor lockers shall be constructed of non combustible material.

Paragraph 11.23 Fire doors and frames equipped with door closers shall be provided as follows:

3. Interior doors to heater and fuel rooms, incinerator rooms, projection booths, transformer rooms, attics, certain storage rooms, shop and industrial art areas, certain fan rooms and in openings to vertical shafts shall be "B" labeled.

4. Openings in fire walls shall be equipped with at least "B" labeled fire doors and frame assemblies.

Paragraph 13.1 Interior Finish -- Ceilings

b. Ceilings in one story buildings shall be Class A or B finish in corridors and exitways and rooms exceeding 200 person capacities.

In all other occupied rooms, ceilings may have Class C finish, which may be applied directly to wood roof deck if desired, and provided that such rooms except doors, of at least a 3/4 hour fire rating separate them from the corridor. Where the ceiling finish is Class A or B with not more than a permissible 10% of the aggregate wall and ceiling area being combustible, or where outside exits are provided from every room in the effected section, such partitions will not be required.

Paragraph 13.2 Interior Finish -- Walls

b. Walls in one story buildings shall be Class A or

B in corridors and exitways, except in lobbies, not over 10% of the aggregate wall and ceiling area may be combustible.

c. In all schools, walls of rooms exceeding 200 person capacity shall be Class A or B finish. In all other occupied rooms, walls may have Class C finish provided such rooms have partition construction, except doors, of at least a 3/4 hour fire rating separating them from corridors. (Partitions are not required as stated in Part B, Paragraph 13.1)

e. Flame spread ratings are those of the basic materials themselves and will not be effected by ordinary varnish or paint, but any highly combustible material application such as lacquer or pyroxylin base materials shall not be used.

Note: This section (13) shall not apply to buildings protected with approved automatic sprinklers.

A Discussion of the Revision

The revision initiated by the Michigan Fire Marshal's office during early 1959 was undoubtedly influenced by the December 1, 1958, fire in Our Lady of the Angels School of Chicago which caused the death of ninety pupils and three nuns. Shortly thereafter, this shocking loss spurred many communities and states to revise their school approval systems in an attempt to prevent such an occurence. In many cases, the haste of such actions prevented an accurate appraisal of materials and construction methods which constitute a fire safe building. These attempts to provide for greater security often resulted in the indiscriminate banning of all combustible materials. Many materials, although capable of supporting fire, are still adequate building items if used in an approved construction method and the restriction of such items only reduces the possibility of economical construction.

If communities would stop and analyze the elements which contributed to this Chicago school disaster a better understanding of the situation would result. This two story, solid brick, masonry wall structure with wood joists was built in 1910 and later converted to a school building. Stairways from the basement to the first and second story levels were not enclosed. Ceilings of classrooms and the hallway were finished with an untreated combustible ceiling tile that develops a flame spread rating of Class D. Exits were inadequate, hallways narrow, and the rooms were overcrowded, housing from forty to sixty-four students in rooms averaging twenty-five feet by thirty-two feet. The fire originated at the bottom of one of the two existing stairways in a pile of old papers and debris. Detection was followed by chaos during which the instructors failed to sound an alarm to warn the entire school and the fire department. Flame, smoke, and hot gases quickly accumulated in the second story level with the tragic result of ninety-three lives being lost.

In its report on the fire, the National Fire Protection Association stated: "The loss of lives in this fire was

primarily due to inadequate exit facilities. It is important to recognize the fact that even if this building had been of fire resistive construction the results of this fire would have been similar because of the combustible material available at the bottom of the stairway, the absence of doors at the top of the stairway, and the combustible interior finish."[7]

Had these factors been properly presented to the public instead of the usual "wood building burns" a better concept of the problem would possibly have resulted. As it stands, wood products are now restricted due to their combustible nature.

In a recent address delivered to the National Fire Protection Association Conference on School Fire Safety, Mr. H. G. Thomas, president of the N. F. P. A. stated:

"The results (of hasty revisions) are obvious -- codes that are unrealistic, impractical, predicated on some fire protection device or measure and generally unsatisfactory all of which leaves the door wide open for criticism from architects, engineers, labor unions, self appointed experts and anyone else who can get on the wagon."[8]

For the most part, the revisions developed by the Michigan Fire Marshal's office are logical steps necessary to promote correct construction and use of materials. But the

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[7] National Fire Protection Association, "The Chicago School Fire", Boston, National Fire Protection Association, 1959.

[8] Thomas, H. G., "Let's Get Our Feet On the Ground", N. F. P. A. Conference on School Fire Safety, New York, Jan. 22, 1960.

tendency to follow past measures which have not been thoroughly proven presents an error in these regulations.

Opinions Obtained Through Interviews. During the course of interviews with architects, school superintendents and consultants, their opinion was asked concerning the recent revision from the Fire Marshal's office. In a surprising number of instances the parties had not heard of this revision or were not familar with the materials within it. This was more evident with superintendents than other groups, probably due to a lack of interest in the building field. Most superintendents in smaller districts rely on the architects to be abreast of such matters.

Architects usually knew of this revision but did not fully understand the extent of such restrictions. A large majority stated flatly that many wood products could not be used in these structures since the Fire Marshal's office did not approve of such items. There also seems to be very little effort on the part of this office to correct such misconceptions. To avoid possible friction with the Fire Marshal, these architects will dutifully design their schools using a predominance of non burning materials, both structural and finish.

Other architects had given little thought to these revisions since they had been designing in non combustible materials for some time and fully realized that they had always complied with the Fire Marshal's regulations. In the majority of such firms it was evident that this process was mandatory rather than by choice.

In the remainder of the architectural interviews, the individuals were well versed on the matter but still hesitated to use some permissible wood products due to the Fire Marshal's tendency to disfavor such items. Their views on wood products were for the most part directly opposite that of the Fire Marshal's office.

It should be pointed out that all wood products restricted by this revision might not be used by architects due to other disadvantages. But the restriction of wood products eliminates any possible considerations an architect might give such items. Any competitive advantages that such a product may possess are quickly destroyed by such regulations.

Architects generally disagreed with the policies arising from the Fire Marshal's office. This may have been due to normal resentments against any regulation or restriction. But the architects' opinions were similar to those of school superintendents and administrators who, although indirectly affected by the Fire Marshal's rulings, are not subjected to direct reversals in their policies. All concerned felt that the recent revision was unrealistic and placed greater restrictions on economy by eliminating useful materials, inclusive of wood products.

A number of those interviewed questioned the organization and goals of the Fire Marshal's department. The placement of construction supervision duties with a law enforcement bureau suggests the possibility of inefficiencies and misconceptions arising from a lack of construction information or experience. An apparent de-emphasis on obtaining economical construction has resulted from stressing the placement of fire resistive materials in school buildings. Although these actions are seemingly made for the betterment of school buildings, their restraint on the district's prime objective of securing economical construction presents a definite problem.

Architects also asserted that the one story structures which they have designed during the past five to ten years have not been unsafe buildings. These buildings did incorporate some wood products but in such a manner as to provide adequate safety from fire. The predominence of one story designs facilitates the use of wood products in a manner compatable with fire safety.

Further comments suggested that the Chief of the Fire Division has a position enabling he and his staff to dictate regulations with no democratic means of curbing such edicts. Although a committee was present for hearings on the initial drafts of the revision there were comments that many suggestions were not included in the final measures. They asserted that the committee was used only to act as a necessary pretext in revamping state regulations. Such comments may be unfounded but the repetition of such remarks from various men in the same and different fields does present some basis for questioning the merits of the revisions.

Material Substantiating these Opinions.

Fire Resistance of Materials. Although unexposed wood structural items are not restricted in one story school structures inadequate information on the part of architects coupled with the suggested tendency of the Fire Marshal's office to disfavor wood products has suppressed the use of these items. The remarks of various national organizations is a sharp contrast to these deletion trends.

The National Citizens Commission for the Public Schools presents this view in its brochure "What Are Our School Building Needs?": "The primary objection to the frame school has been that the material is not fire resistant. This objection has been counteracted by a new attitude toward the entire problem of fire proofing. In the past, fireproofing measures concentrated on saving the building but not necessarily its contents or occupants. Thus, the old fireproof building was the most dangerous of all for the children if they could not get out.

One story frame schools, properly designed with provisions for ground level exits from every classroom to the outdoors, are safer than the best fireproof three story school."[9]

This comment was substantiated by the National Fire Protection Association in their booklet "School Fires": "The one story school, so arranged as to afford direct access to the outside from any part of the building, is the safest design, and when this form of design is used there is little restriction as to the type of construction. In any case the design should be such as to minimize the spread of fire from its point of origin. No highly combustible wallboard or other quick burning interior finish should be used."[10]

The Federal Security Agency stated in its booklet "School Fire Safety": "Buildings of one story may be almost any type of construction provided ample exit facilities are maintained and the danger of flash fires eliminated."[11]

These statements are predicated on the performance of various materials when subjected to fire and a primary concern for the safety of the inhabitants. Materials which will not burn and often misnomered as "fire proof materials" are not immune to fire damage. Unprotected metal building materials are not combustible, but they are subject to collapse in the

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[9] National Citizen's Committee for the Public Schools, "What Are Our School Building Needs?", National Citizen's Committee for the Public Schools, New York, 1955.

[10] National Fire Protection Association, "School Fires", National Fire Protection Association, Boston, 1950.

[11] Federal Security Agency, "School Fire Safety", Bulletin 1951, No. 13, Washington, D. C., Federal Security Agency, 1951.

early stages of a fire. As temperatures rise, steel and aluminum lose their structural strengths rapidly. Steel starts to weaken between 600 and 800°F and aluminum between 200 and 600°F. Not only do these items weaken with heat but expansion will occur at an alarming rate. Such expansion will frequently cause the collapse of a roof, wall, or floor section presenting a definite hazard to fire departments. Concrete is also damages by heat with such defects as cracks or spalls occurring.

A classic example of non combustible material failure is the 1953 General Motors Corporation fire at Livonia, Michigan. This fire resulted in the complete destruction of an automatic transmission plant, a 55 million dollar loss, and the death of three employees. This one story building covered over $1\frac{1}{2}$ million square feet. Its construction was predominately non combustible, consisting of unprotected steel trusses supported by unprotected steel columns and exterior brick apron walls with large areas of plate glass windows in steel frames. The roof consisted of narrow plates of No. 18 gauge steel supporting insulation and a built up roof composed mainly of asphalt and tar. Machinery, materials, and product were also non combustible. But fire did occur in the combustible solutions contained in a dip tank, spread to the oily condensation on the steel roof members, and gradually heated the roof's asphalts and tars which added to the already great heat and smoke. The final result was the collapse of the entire plant due to the steel member's failures.

In contrast to these actions is the performance of structural wood members. Timbers and glued laminated structural elements do burn but retain their shape for some time in a fire. This reaction is caused by the formation of a char on surfaces of wood exposed to a flame. This material acts as an insulator and reduces the progress of destruction within the member. Collapse of a building is far less likely to occur which enables evacuation and subsequent fire fighting operations to continue. The importance of this has reduced the significance of the term "fire proof" in favor of a more meaningful word "fire safe".

Frame buildings of one story design have been improved both from a standpoint of design and construction. Adequate exits properly spaced have permitted complete evacuation of such structures in a matter of thirty-five seconds to one minute. Construction is such as to contain the fire in one area thus permitting early detection, evacuation and extinguishment. The entire building is not only sectioned by fire walls but wall and ceiling units localize fire with frequent fire stops. Heating and wiring have been improved by simplifing installation and then isolating it from other materials. The actual proof of this safety is the lack of a major fire in any one story, permanent frame school building constructed in the past ten years.

One objection to this type of design was found in the Grand Rapids school district. Their Design Standards for Elementary Schools stated that outside exits directly from classrooms were not desirable in this climate because of cold drafts, tracked-in dirt, water and other foreign materials. Preference was for outdoor access through corridors thus localizing the problem at a few points. A lack of direct exiting schools in this state may explain the reason for other districts not realizing these disadvantages. One solution may be incorporating both corridor exiting and classroom exiting systems and maintaining the classroom exits only for emergency use.

Thought must also be given to the contents of a school building. Even if trash is kept at a minimum, such items as furniture, classroom materials, clothing and janitor supplies are available fuel sources to facilitate flame spread. This item is evident in the case of the Livonia fire. This potential source of energy does not need combustible structural items to reach deadly proportions.

Flame Spread. The second phase of restrictions placed on wood products by Bulletin 412's revision is the interior finish application of such items. Corridor lockers are restricted to non combustible materials. Ceilings and walls are restricted to Class A or B materials in such areas as corridors, exitways, lobbies and assembly areas holding over 200 persons. Class C finishes are permitted in classrooms if they are separated from the corridor by a 3/4 hour wall or have exits to the outside. A minimum 3/4 hour wall may be attained with 2 x 4's spaced at sixteen inches with a sheathing of 1/2 inch thick wallboard.[12] Such restrictions are based on the Buildings Exits Code which in turn is based on the flame spread ratings.

The net effect of this section is the elimination of wood hall lockers and a reduced usage of laminated beams, exposed wood deck roofing and interior paneling. Here again, these items are often favored by an architect as a material in school structures. But the combination of direct restrictions, lack of information, and tendencies of the Fire Marshal's office have reduced or ended the utilization of these wood products.

A number of architectural firms had continually used an open type wood locker in their hallway designs. Oak with a natural finish was found to be far superior to any steel constructed lockers. Since an open type locker is frequently used in elementary schools the architects contend that the materials and clothing in such lockers create a far greater fire hazard than the wood construction. And yet, the style of lockers was not restricted.

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[12] "Building Materials List", Underwriters' Laboratories, Inc., National Board of Fire Underwriters', 1960.

The actual flame spread classifications has been questioned by the National Lumber Manufacturers Association. Grouping materials by their flame spread and then selecting only the higher groups for construction purposes does not fully evaluate the remaining classes. Extensive tests were conducted at the Factory Mutual Laboratories for the N. L. M. A. F. M. L. Reports #11760 and #11975.

These tests were conducted in a simulated classroom measuring fourteen feet by twenty feet wide and twelve feet high which included two doors, four windows and six small vents at the ceiling level for adequate ventilation. The room was then completely paneled in various species of wood for each different test and a fuel source was chosen to simulate the equivalent effects of combustible contents common to classrooms. A temperature of 300°F at five foot six inches above the floor was considered as the maximum to which the human body could be exposed without a fatal result.

It is significant to note that the wood paneling stopped burning after the ignition fuel was consumed even though the ignition fuel represented a severe fire exposure. Subsequent tests at the Underwriters' Laboratories demonstrated that the various species used during these tests had an average flame spread below 200. The ignition source alone was sufficient to raise the room temperature to a fatal 300°F at five foot six inches. Persistence of flame spread on smooth wood surfaces of buildings depends principally on the heat from the burning contents. Actual flame spread on wood surfaces requires a wall temperature too high for human life.

A paper delivered by John G. Shope, Chief Engineer of the National Lumber Manufacturers Association discussed these tests at some length and concluded with the comment, "The records of fires fail to disclose any instances where the major reason for loss of life could be attributed to flame spread across the surface of untreated solid wood."[12] This comment was substantiated by the author's review of literature which included such articles as "School Fires" by the National Fire Protection Association and other resumes of fatal school fires occurring since 1907.

Other tests by the Forest Products Laboratory, reported in 1953 under F. P. L. Bulletin No. D. 1941 titled "Experimental Dwelling Room Fires", contained conclusions on the hazard of interior finish materials. They are as follows: "The nature of the walls, whether plaster, fiber insulation board, or plywood, had little effect on the time or temperatures of the critical point and only small effect on the flashover. Regardless of the type of wall material or the rate of temperature rise in the early stages, fire of conflagration proportions eventually developed. The flashover occured in all cases

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[12] Shope, John G., "Control of Flame Spread in Buildings", National Lumber Manufacturers Association, Washington, D. C., 1959.

at a wall temperature too high for human life."[13]

Of perhaps even greater significance is the production of smoke during the early stages of a fire. Such by-products are difficult to contain within one section and will rapidly spread throughout a structure. They not only reduce visibility but have irritating and deadly effects upon the human body. Recent tests on the effects of school fires and methods to combat this occurrence were conducted in Los Angeles, California. A three story structure, condemned for reasons of further school expansion, was used as a test site. A summary of results obtained from starting fires in hallways and classrooms are included in the book "Operation School Burning" and includes: "With the test fires used in these tests and no fuel added to the fire due to construction of the building, smoke (especially as it pertains to visibility and irritant effects) was the principal life safety hazard. Untenable smoke conditions preceded untenable temperature conditions in nearly every test."[14]

From these comments it is quite evident that the hot gases and smoke resulting from a fire produce critical conditions before flame spread will occur on wood surfaces. The importance of adequate exiting measures cannot be overstressed. When

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[13] "Experimental Dwelling Room Fires", Forest Products Laboratory, F. P. L. Bulletin No. D., 1941.

[14] "Operation School Burning", Los Angeles Fire Department, National Fire Protection Association, 1959.

such facilities have been included in the one story school layout, limitations of Class C finishes can be reduced without impairing the safety of these buildings.

Conclusions. Various tests conducted on the effects of fires and material performance during such conditions have resulted in contradictions to the current methods of classfying construction methods and building materials. Failure to realize that preventive measures are only effective after more damaging results have occured indicates the lack of considering the total problem. This not only represents a fallacy in thinking but produces unfair discrimination against some products.

With the Michigan Fire Marshal's office patterning their regulations after such questionable standards, common injustice is then produced within this region. Further tests should be conducted by either state authorities or private associations to stress the inaccuracies of present methods. This material presented by a dedicated group of architects, superintendents and consultants should be adequate pressure for a reappraisal of present measures.

Fire Insurance Ratings

The yearly cost of insuring all the school buildings in a district amounts to a sizable expenditure. Since the size of a premium results from the type of construction and materials involved in the building it is only natural for school officials to favor materials that will reduce this expense. In general, combustible materials are considered as the greater risk and receive a higher premium charge for insurance. School fire insurance does not involve the loss of human life and is only concerned with the property losses resulting from a fire. Statistics have shown that the greater losses will result from fires occurring in combustible construction, assuming contents, area, height and other agents within the building to be equal to those in a non combustible structure.

Michigan insurance firms evaluate the risk of a school building under the Analytic System. Under this system, three categories are established on a basis of construction: (1) Class A, fireproof construction, must have incombustible supporting walls and an incombustible roof. (2) Class B, non combustible construction, must have incombustible walls and may have a combustible roof. (3) Class D, combustible construction, may have both supporting walls and roof of a combustible construction.

Fireproof construction involves the use of non combustible materials and a means to protect them from failures caused by heat. Non combustible construction requires the use of materials that do not support a fire but need not incorporate added protection. Combustible construction utilizes materials that will burn and may continue the spread of flame.

These are only broad classifications of insurance policies and are used as a starting point for the evaluation of risk. Additional measures are then used to determine the structure's standing point within its respective class. Various penalties are assessed against the building for deficiences in its construction. A building may include up to 50% of its construction in another class, but an appropriate penalty will be levied. The base floor construction, interior finish, deficient wall thickness, inferior roof materials, openings between floors and sky lights are a number of the various penalties which increase the cost of a premium. Materials are classified from the published findings of Underwriters' Laboratories.

Next, a system of credits are awarded to the building for various items which may reduce the risk. These include alarm systems, standpipes and fire hoses, automatic sprinklers and other objects which reduce the flame spread and facilitate detection.

After the building has been evaluated an actual monetary charge is assigned according to these results. Insurance companies in this state use a common system of rates established by the Michigan Inspection Bureau. Since all companies use these rates actual variations in policies will only result from deviations in the initial evaluations and services rendered. In general, fire insurance rates do not vary greatly among the competing firms.

The Michigan Inspection Bureau's rates are the basic reason for wide variations occurring in the insurance premiums of various construction methods. Their basis data is obtained from continued studies of fires in this state. An attempt to interview the personnel in this bureau was not acceptable to the staff and further information on their procedures was not obtained. Their conclusions are used to fix the rates for the three types of construction and the subheads within each group created by penalties and credits. At present there is a variation in premiums amounting to roughly 50% between Class A and B construction. The variation between Class D and B construction premiums is considerably greater and amounts to over 150 or 200%. This wide variation between the lower categories has been questioned by various trade associations from the lumber industry. The associations realize that a greater risk is present, but object to the value placed on this risk by the Michigan Inspection Bureau.

In order for wood products to receive a more favorable rating the Michigan Inspection Bureau will need to revise its present standards. There are no indications that such a revision will take place in the near future or, if one is created, that it will give wood products a better position. This bureau should be confronted by the various associations and asked to present the reasons behind current standards. At the same time, sufficient material verifying wood product's stand should be presented. Through a cooperative type meeting some headway may be produced which would give wood products a more competitive status.

CHAPTER IV

MATERIALS USED IN SCHOOL STRUCTURES

Various component parts of a school structure should meet certain functional and economical requirements as discussed in the previous chapter. To accomplish these tasks a critical selection of materials will be required. In most cases, no one material can meet all requirements, but its competitive position will be determined by the number of important functions it will perform.

This chapter will discuss the predominent materials currently used in the various parts of Michigan's one story schools and the reasons for their selections. An evaluation of wood products will be included if these items do not constitute a portion of such construction.

Exterior Walls

Masonry Construction. The predominent type of exterior walls found in Michigan's one story school is solid masonry. More than eighty per cent of the new schools built today probably incorporate this type of construction.

Generally, the wall section is composed of a regular brick veneer, an air space, and a load bearing member constructed of either eight or twelve inch concrete blocks. The block is usually a light weight aggregate type, parged on the exterior surface and painted on the interior surface. Parging of the exterior surface is accomplished by applying one or more coats of Portland cement from the footing to above window height and then placing one coat of bituminous material over the parging. This process provides a damp proofing barrier for the wall section. The presence of an air space, usually two inches in width, between the brick and block areas creates a dead air space which increases the wall's insulating capacity. Brick and block are bonded together with corrosion-resistant steel ties usually spaced thirty-six inches o. c. horizontally and eighteen inches o. c. vertically. In some instances the cavity is filled with a poured or rigid insulating material to better restrict transfer of heat and cold.

Lightweight concrete block is preferred for its ease in laying and handling. This type is more expensive than the heavier, conventional aggregate block, averaging about four cents more in the Lansing area. Composition of these blocks is an expanded clay or slag particle which produces high fire resistive and sound insulating and absorption qualities. With the reduction in weight of these blocks a lighter foundation is feasible.

At present, this type of wall construction has a large number of advantages explaining its preference not only in Michigan but other Lake, Eastern and Midwestern States. Considering the number of functions performed by these masonry products, one finds that it is the most inexpensive type of construction, possibly only surpassed in economy by brick veneer and wood frame construction. Materials are abundant and relatively inexpensive. Labor constitutes the most expensive portion of cost but by requiring only a mason during construction efficient erection and fewer coordination problems will result. Present estimates in the Lansing area place the square foot costs of this finished wall section, using an eight inch light weight block, at $2.00 to $2.15.

Although the cost of brick veneer is high in some areas of Michigan, a preference does exist for this item due to its durable and weather tight finish. Appearance is compatable to any community due to quality type features. Brick veneer is a durable material and usually results in a minimum of maintenance providing proper bonding materials and procedures are used during construction. Variations in color, texture, size and laying patterns provide a degree of flexibility for design.

The homogeneous nature of this wall section provides a continuous wall bearing area. One story designs will not usually require the placement of any additional load supporting members due to the structural qualities of concrete block. This not only facilitates the construction process but enables the architect to simplify his design and detailing.

The interior finish is obtained by a simple procedure of painting the block surface. This creates a textured finished coat that will hide a large majority of blemishes common to classroom use. Application of paint does not require a large degree of skill and repair work may easily be accomplished by the custodial staff. Patterned block work and new block designs will improve the appearance of the room but most schoolrooms use a normal staggered system with tooled joints to reduce the cost of construction.

Major objections to masonry construction stem from the appearance of the interior surface and restrictions placed upon future expansion programs. Limitations by the school building budgets usually force the architect to use the exposed block wall for interiors of classrooms and a few other assembly rooms. Although the resulting finish is durable and requires a minimum of maintenance, the heavy appearance of block construction still leaves something to be desired. Architects have stated that the heavy, monotonous features do not create an adequate atmosphere for these schoolrooms. Instead, a cold, drab effect is created that lacks both quality and interest. Various colors and designs have been attempted but they still produce an institutional appearance. The solution to this problem may lie in an inexpensive, durable overlay that imparts warmth and variety to the surroundings.

Brick veneer-block construction has another disadvantage attributed to its durable nature. Large costs are always involved when the removal of a section is required for expansion or remodeling programs. This construction type is definitely not flexible for any alterations. Such alterations will be expensive since only very small amounts of the wall may be reclaimed while the operations require considerable amounts of time and labor.

Savings in heating costs are questionable when compared to the brick veneer and wood frame construction. Variations in the cavity portion of the wall, size of block, and types of insulation will create different values in every case. In general, the heating costs will not exceed those of wood frame construction by a great amount.

Masonry exterior wall construction should retain its present competitive status for a number of years due to a large number of advantages common to this design. Further increases in labor cost could be a deciding factor in losing its competitive position. Advancements in design by other pre-assembled units could encourage this decline. Fallacies caused by its rigid state may prove detrimental should school expansion policies increase in importance. But for the most part, proper design and placement of flexible materials in critical areas would control this problem and still produce sufficient markets for masonry products.

Curtain Wall Construction. Today the remainder of exterior school wall construction would be dominated by curtain wall materials. For this report, curtain wall or window wall refers to paneled wall systems supported by a structural aluminum member or grid system.

Curtain wall construction is usually divided into three categories; custom curtain wall, standardized curtain wall, and window wall. Both curtain wall types are self-contained structural units that are self-draining and require no caulking during construction. Custom curtain wall is manufactured for a specific design whereas an architect must design the building to fit standardized units. Window wall is simply a system of window units and panels placed in an aluminum grid. Separate mullions are required to support these units and caulking is done during construction to create a weather seal. Window wall units are least expensive of the three types and are predominantly used in structures not exceeding three stories. Standardized curtain wall and window wall are the common types used for school structures but window wall has the greater market.

The most expensive item in these systems is the panel. Increasing window area will reduce the initial cost. The exterior and interior surfaces of the panels are either porcelainized sheet metal, usually sixteen gauge, or a compressed fiber board covered with aluminum and then a porcelain finish. Insulation between the surfaces is accomplished by polystyrene foam, dead air spaces, a honeycombed paper core or other such materials. These panels usually constitute one third of the wall surface with the remainder being metal and glass. Different colored panels are available to provide for variations in building design.

Major advantages of this construction system are its flexibility, reduced costs resulting from installation procedures, and reduced structural supports. The panelized nature of curtain wall will permit future expansion and at a cost savings caused by materials being reclaimed for new layouts. Installation of these panel systems is time and labor saving due to a simplicity of procedures. Since the panels are relatively light, heavy supporting materials and foundations will not be required.

Although these products are increasing in use throughout Michigan's school districts there are a number of objections to this system which need be corrected before greater use is realized. Many architects that have designed buildings incorporating curtain wall construction have expressed a dislike to the overall appearance. They contend that the panels present a commercial appearance to school structures and do not always blend with the surrounding community. Interior surfaces create a monotonous system that is difficult to utilize due to its hard surfaces. In part, some firms have reduced these problems by injecting masonry units within the curtain wall system to create some interest in design.

Other objections result from the actual construction of the system. There have been a number of instances where the weather seal or caulking failed and allowed moisture and water to penetrate into interior surfaces. This is caused by different rates of expansion and contraction produced by the various materials in these panels. Design itself is complicated by the expansion problem of aluminum and creates a problem area prone to failures at a later date.

An abundant use of metals and other heat conducting materials in curtain wall construction presents a definite loss resulting from excessive heating costs. Not only will heat be lost to these units but a reverse problem results during warm seasons. Radiation of body heat to cold surfaces on these units will present an unhealthy condition regardless of the room temperature.

Initial cost of these panels is one of the highest in the school construction field. Fully installed the system will vary from five to twelve dollars per square foot depending on the type of unit and design of the building. This factor alone has banned curtain wall from many school districts. Although savings may be realized from a reduction in materials in the remainder of the building, these units still command the highest initial cost.

A number of architects interviewed stated that one major reason for the material receiving wide acceptance by the architectural field was due to an impressive promotion campaign by the manufacturers and distributors. These gentlemen had used curtain walls in school buildings and other structures but in general were dissatisfied with the results and thought that this material in its present form was only a passing trend in architecture. Architects do have a tendency to design with new materials for no other reason than to maintain a progressive position in their field. It is interesting to note that the American Institute of Architects is now formulating a program to conduct their own intensive tests on new materials and thereby provide its members with accurate and timely data.

The future of curtain wall in one story school construction will depend to a great deal on improvements in the product. A reduction in cost is essential for it to reach a more competitive status. Construction improvements are essential if the architectural field is to make use of the item.

Exterior Walls Utilizing Wood Products

Only small quantities of structural or finished wood products are used in the exterior walls of Michigan's one story school. Although these products are widely used in residential construction there is a tendency to disregard the wood frame wall as a structural unit for larger buildings. Objections to this type of wall are found when discussing this system with architects and superintendents but to some degree wood products may simply be overlooked during material selections.

Cost wise this unit is highly competitive with masonry construction. Lansing estimates of conventional wood frame construction using eight inch wood bungalow siding and a finished interior of plaster are approximately $1.20 to $1.30 per square foot. With the same framing materials, but substituting brick veneer for wood siding the cost is $1.95 to $2.00. These costs were obtained from construction firms and building material dealers. Although architects seldom work with definite building costs, they did estimate this cost as being equal to or below masonry.

Brick veneer was highly favored over wood or aluminum siding due to its reduced maintenance feature. The necessity of painting wood siding every two to four years creates periodical expenses that school districts are trying to eliminate. Aluminum siding is rejected on a basis of questionable performance. Contrary to industrial promotions, architects realize that this siding is not maintenance free and has poor insulating properties. In part, the preference for brick exteriors may also result from a tradition in school buildings design. Regardless of the exterior material, wood frame stud construction possesses excellent insulating properties. The combination of an exterior sheathing, exterior surfacing, dead air spaces and room for added insulating materials produces a temperature barrier long favored in the residential building field.

Materials and labor are in abundant supply which accomodates construction schedules. The need for the mason, carpentry and plastering trades does present a coordination problem but present cost figures still indicate efficient use of these resources.

Comments on the System. One of the major objections to wood frame stud construction is the necessity of including a plastered or dry wall interior. Past maintenance costs in older structures have causes school administrators to favor painted block walls. This objection has not only eliminated wood frame stud construction but also adversely affected the market on metal studs. Plastered walls are subjected to a large amount of scuffs and dirt marks which are only remedied by frequent painting, an added expense. Large chips and cracks requiring extra maintenance may also result. Superintendents and architects were also displeased with the initial appearance of plastered walls. There seems to have been a number of cases in various districts where poor quality workmanship or materials resulted in excessive cracking of such surfaces. Even the application of the gypsum sheets known as drywall has received a large degree of criticism regarding its performance.

A number of architects and superintendents stated that they had not considered wood framing due to the Fire Marshal's office restriction of its use. Although no direct regulation prohibits this type of construction in one story schools, misinformation and attitudes of the Fire Marshal's office do create definite barriers.

Fire insurance premiums are substantially higher for this Class D construction than those incurred by other non combustible construction methods. These excessive rates may be counteracted by savings in initial cost and subsequent amortization of these savings but the small difference in cost between masonry and wood frame reduces the significance of this savings. Continual changes in the construction field create a fluctuation of such cost differentials and outdate many current comparisons. Therefore, the difference in insurance rates is the most widely used method for comparison.

One significant development important to the wood products field has been the growth of one story, residential-type structures used as additions to the primary educational system. These "ranch-type homes turned classrooms" have been used in the Lansing, Detroit and Flint school districts. They have been considered as temporary additions to teaching space necessary to stem the overflow of enrollment in fast growing residential communities. In most cases, the school district erects such structures in clusters of two to four with the fore-thought of eventually converting them back to a small three bedroom home for subsequent sale to the public. Each unit houses one grade and with the exception of eliminating the majority of interior partitions, is identical in appearance to the $15,000 and $20,000 home in the community.

Flint has erected over ninety of these structures and now considers them as a semi-permanent addition to their school system. One teacher supervises each building and his location is so convenient to the source of pupils that parents now praise their idea. These units are only used for kindergarden and the first three primary grades in order to assure that the students are not deprived of upper grade facilities such as an auditorium, cafeteria, gymnasium and library. Teachers are able to give each student more attention and a neighborhood atmosphere prevails. Youngsters first entering school are not subjected to an abrupt transition in these "home like" schools and educational development is very satisfactory.

Perhaps one of the greatest advantages is a reduced cost to the Flint school district on a classroom basis. These buildings average $12,000 exclusive of the site and equipment. In contrast to this an average classroom costs from $25,000 to $35,000. When comparing these costs it should be remembered that the higher price for a conventional classroom in a large school will contain the expenses of added facilities such as cafeterias, gymnasiums and office space. In spite of these items a significant savings would still be realized in the residential units.

The prime reason for this savings is the type of structure. Over the slab foundation a typical wood frame construction is used this includes wood studs, plates, rafters and ceiling joists. Floors are asphalt tile and the interiors are of dry wall construction with the utility room finished in cement plaster. Awning type windows, flush doors and interior trim are also of wood. The exteriors are finished in a variety of ways including wood siding, brick veneer, board and batten and cedar shingles and shakes.

The Chief Engineer of the Flint School District stated that maintenance of these structures was still a questionable item since none of the buildings were older than five years. Excessive maintenance was contemplated in future years but to date such had not been the case. There have been no thoughts of using this structural system in larger schools. This is attributed to such factors as plaster or drywall receiving greater abuse by older children, the possibility of excessive exterior maintenance and the fear of a fire hazard.

Although wood products are being used in these types of school buildings, barriers to further utilization are still present when considering the construction of a regular sized school structure. These buildings are not schools but only a varied use of residential construction. Their general classification as a temporary or substitute school building produces a poor reference for the products used in the structures.

Interior Walls

Concrete Block. Concrete block is the predominant material used for partitions in current school construction. The usual procedure is to lay one course of lightweight block from floor to ceiling height and then paint the exposed surfaces. This type of construction incorporates all the advantages and disadvantages common to a lightweight block as discussed in the previous section.

One major advantage of block construction for interior partitions is a reduced amount of sound transmission attributed to the products mass. A six inch block is preferred but four inch sizes are used in areas not subject to heavy sound transmission of where the budget may restrict the larger size. Sound transmission is a definite problem between adjoining classrooms and was the major reason for selecting concrete block walls.

Certain areas of the classroom interior are finished with a glazed block, a glazing application or a glazed tile overlay. Areas beneath a chalkboard often receive this treatment to reduce wear and subsequent maintenance on this region.

This procedure also improves the room's appearance but cost limits the application. Excessive sound reverberations present one other limitation of this type finish.

Other areas in the building, such as hallways or lobbies, where excessive wear may occur and acceptable appearance is desired will also use a glazed surface. Usual components of this finish are a resinous binder and glass silica sand with pigments or colored granules to supply a variation in color. Bathrooms, locker rooms, and kitchen areas will use these applications to obtain a water resistive and sanitary finish.

Wood Frame Stud Partitions. A limited application of interior wood frame stud walls is still found in Michigan schools. The major use for this wall section is in areas requiring a lightweight partition not subject to an excess of sound transmission. Although sound insulating materials may be incorporated, these products will increase the cost while the wall will still lack sufficient mass to halt transmission. Temporary partitions also incorporate a wood frame stud construction. Insufficient sound insulation and objections to plastered walls generally limit this construction method.

Certain areas in a school will use a wood frame stud wall to facilitate the application of either wood paneling or plywood. Such areas as offices, teacher's rooms or lobbies will use wood overlays to obtain an attractive wall surface.

These materials are prefered by the architect but are restricted by fire regulations, building budgets and insurance penalties.

Flexible Partitions. New trends towards flexible interiors has increased the importance of movable partitions . These partitions are non-bearing and may be readily removed and regrouped by custodial staffs. Ducts, pipe lines, conduits, and so on, are usually run in the corridor or outside wall to reduce the amount of fixed wall space.

These modular systems are produced by both the metal and wood industries but interior surface restrictions limit the use of the wood units. Both systems are only used to a small extent in Michigan's schools due to excessive costs. One estimate of a medium quality, three inch metal partition, system was $27.00 to $30.00 per lineal foot. Wood units were priced at $20.00 per lineal foot. One other disadvantage lies in their hollow core design which does not efficiently hinder sound transmission.

Should flexibility reach the importance predicted by school consultants and designers, the excessive cost of these systems will be balanced by the ability to make changes readily and economically and obsolescence will tend to be held in check.

Floor Construction

Structural Components. Poured concrete slabs now predominate as the basic unit for floor construction. These slabs are poured over a well tamped foundation of cinders or broken stone usually four to six inches deep. A damp course or vapor barrier consisting of a layer of roofing felt or polyethylene sheets, well lapped and cemented and turned down against the exterior wall, is required to prevent the passage of moisture through the slab and into the interior. This layer is placed over the crushed stone foundation prior to pouring the slabs. Insulation should also be provided at the perimeter of the slab at the exterior wall. The concrete slabs, usually four inches thick with steel wire mesh reinforcing are poured in individual units to control expansion-contraction problems and to reduce the transmission of solid borne sounds. After placement of concrete, the surface is screeded to proper elevation and steel troweled to produce a smooth, dense surface required for the application of floor tile adhesives. Lansing construction estimates place the square foot cost of slab construction between thirty-five and forty cents.

Wood joist floor construction is rarely used due to objections arising from the resulting crawl spaces, fire insurance penalties and misinterpretation of the regulations issued by the Fire Marshal's office. Ground level should be at least eighteen inches below the bottom of wood joists to avoid contact with excessive moisture. In addition, adequate drainage, ventilation and termite shields should be provided to protect the wood members from rot and insect attack.

Although these measures offer protection to the joists, the possibility of this crawl space harboring vermin and other health hazards, produces one objection to this type of construction. Fire insurance rates are also increased for combustible floor systems. These objectives coupled with a hesitation on the part of architects to use combustible construction has all but eliminated wood joist floor systems.

Floor Coverings. Proper floor coverings are an important item to any building. This item is not only subject to the scuffling of hundreds of feet and the tracking in of dirt and dust but also receives added wear from constant cleaning and the moving of furniture and equipment. Since a flooring is subject to these forces it is necessary for it to have good wear resistive qualities that maintain a smooth and dust resistive surface.

School floors should also be resilient and quiet. By softening the sound of impact, floors can aid immensely in reducing those distracting noises which arise from necessary and desirable activities. Resilience is necessary to reduce fatigue from constant standing, walking or playing on floor areas. Slipperiness as well as undue resistance to horizontal motion of the foot will also cause fatigue but are not as tiring to the bones and muscles of the human body as a flooring lacking proper resilience.

Areas subject to an excess amount of moisture will require non absorptive floorings. Toilets, shower rooms, and locker room floors require such materials to maintain cleanliness and to prevent odors from developing.

Since extensive floor areas are involved in a school building the initial cost of a flooring is of utmost importance. As with other material, the budget restrictions of school districts will dictate to a large extent the type of flooring.

With the above factors in mind, school districts usually select a rubber based tile for the majority of floor areas. Although initially more expensive than asphalt tile, the wearing and maintenance qualities of rubber tile present a more economical investment over a period of years. The vinyl-type tiles are now increasing in use and may eventually replace the popularity of rubber tiles. This product has an even longer life span and lower maintenance but initial cost is higher than for the rubber tiles.

Areas subject to excessive moisture will use a terrazzo or ceramic floor. Higher initial costs are accepted to insure a non absorptive covering in these areas. Schools are also using these products near main entrances to reduce maintenance and floor repairs and at the same time obtain a more acceptable appearance.

Maple floors have little competition in the gymnasium flooring field. The resilience of this product has not been duplicated successfully by any other floor system and continues to be the preferred surface for athletics. Elementary schools have frequently included wood floors for their multi-purpose rooms. This area is used for athletics, games and other recreational activities common to elementary education. In this case, resilience is not as significant as the warmth of the floor. Students will frequently have to sit on these floors during such activities and the adequate warmth is necessary for human comfort. Wood floors have been largely replaced in other areas of the school by the various tiles. Higher initial costs and reapplication of finishes have made it economically unfeasible to continue the use of wood floors excepting in those areas where warmth and resilience are of utmost importance.

Roof Construction

Contemporary school architecture has repeatedly made use of the flat or relatively flat roof design. To meet the needs of this popular design there have been a host of products developed by various industries. The complex nature of roof systems has caused the school district officials to rely almost completely on the architect for this selection. In turn, the architect chooses those materials with which he has had previous experience and acceptable performance. Competition will try to sway his choice but in general the architect will remain faithful to one system for a number of years.

In order for a system to be compatable to one story flat roof design it must develop sufficient strength and span with a light weight mass. This will enable the wall and foundation components to be lighter which in turn reduce total cost. A complete roof system is usually composed of a structural member, the decking, insulation material, a built-up roof, and a finished ceiling. Some building materials have increased their efficiency by incorporating two or more of these functions thereby eliminating the need for extra products.

One of the more difficult tasks encountered during this study was a determination of cost comparisons between various roof systems. Actual costs were not obtained from any sources due to the large number of variables common to roof structures. Such factors as the complexity of material selection, variations among buildings, construction cycles and business fluctuations constantly change the cost data and compel building concerns to rely on general comparisons. Alternate bids for one job are derived but do not hold true in all cases.

A common item to all roof systems is the exterior layer or the built-up roofing. Built-up roofing may be laid on a wood plank roof, gypsum slabs, laminated structural insulation board, or a concrete plank system. It is composed of three to five layers of rag felt or jute saturated with coal tar, pitch, or asphalt, and with each layer being set in a mopping of hot tar asphalt. The top is usually finished with a layer of crushed slag or clean gravel. When well laid with good materials and workmanship it is an enduring roof which commonly lasts over twenty years.

<u>Structural Members</u>

<u>Steel Bar Joists</u>. Steel bar joists are the most widely used method of supporting roof areas in one story schools. When combined with an economical roof decking and a suspended ceiling it is the most economical of all roof systems. Since it does require other materials for completing, the total cost may fluctuate and reduce its competitive advantage. This joist system may eliminate the finished ceiling but an unfinished appearance and higher insurance rates generally precludes such practices. By exposing the steel members the classification is dropped from fireproof to non combustible and a penalty will develop.

This system is fairly simple to erect due to its construction. The joist consists of an upper and lower steel chord welded together by a web of roundrod. Various depths and lengths are available in four inch modular sizes. Lightweight designing is also possible due to the web arrangement creating a smaller dead load. The depth of a bar joist not only creates an insulating dead air space between planking and ceiling but allows piping and ductwork to lie in this area.

A metal framework is fastened to the lower chord of the joist for the application of a suspended ceiling. Once in place the acoustical tile are snapped into position. This material will be discussed more fully in the ceiling finish section.

Light Steel Beams. A limited use of light steel beams is also found in Michigan's schools. One major reason for its restricted use is the heavier construction of the member which results in an increase of dead loads thereby placing heavier requirements on the wall sections. But their greater load capacity will allow a more liberal spacing than possible with bar joists. Should an exposed structural system be used the wider spacing and solid web will produce a cleaner appearance than that obtained with bar joists.

Prefabricated Concrete Decking. Another limited material in one story school construction is the prefabricated concrete plank. Excessive weight and expense are the chief reasons for preventing wider use. Since the product may span up to thirty-two feet, a system of interior bearing walls will not be required.

One advantage of this unit is the number of functions it can perform. The material not only acts as a structural and decking item but may also function as the finished ceiling. A suspended ceiling is still used in the majority of cases to produce better sound absorption and appearance.

The plank is designed in depths of four, six and eight inches with a modular width of sixteen inches. Specified lengths are prepared at the factory to facilitate erection. Large voids are run throughout the length of each plank to reduce its weight. This area and spaces between each adjoining member permits the installation of pipes and wiring. Both reinforcing and pretensioned steel members strengthen and relieve the stresses within each plank. Either a poured or rigid type insulation is required to produce an efficient thermal barrier. The "U" factor of four inch plank is .16 and with one inch of rigid insulation becomes .11.

Glued Laminated Structural Members. One of the best opportunities for the lumber industry to re-enter the school construction field seems to lie with glued laminated members. This progressive application of wood represents a number of qualities which are desired for school construction. At present, these members are slowly increasing in use throughout Michigan's one story schools.

Glued laminated members are produced by bonding a series ofwood boards or strips, two inches or less in thickness, to a desired thickness, width, and curvature. Individual boards are graded and kiln dried to eliminate the possibility of defects in the final structure. Adhesives range from water resistant interior types to exterior types suitable for use in areas where the average moisture content exceeds sixteen per cent. Casein glues are commonly used for interior members whereas a resorcinal formaldehyde adhesive is used for more rigid specifications. Following the bonding process, the item is sanded, machined for exact dimensions, drilled and tapped for various fittings, and finished with a sealer and natural coating. These units are custom built for each individual job.

These members are more acceptable to Michigan's schools in a post and beam form, a fact attributed to the predominant long span, one story construction. But the more graceful arches, cambered beams, and barrel arches could also be used in other classroom designs. The latter curved members are better adapted to areas requiring large open spacial requirements and a greater ceiling height such as gymnasiums, multi-purpose rooms, auditoriums and cafeterias.

The outstanding advantage of these items is the ability to expose the structural member and yet add beauty, warmth and grace to the surroundings. These members introduce quality to any area. By introducing large open spaces to the interior, a flexible wall plan may be incorporated in the design. Although wood is combustible, a combination of relatively large cross sectional volume and the char capacities of wood during a fire places the safety of these members above that of the non combustible steel construction. Engineered timber construction also has a resilience that preserves strength under shock of wind and seismic impact, often leaving structures sound when other more rigid buildings might have suffered heavy damage. Certain indirect savings are attributed to this construction. These include the elimination of suspended ceiling systems and the ability to use lighter partitions. Since the products are not subject to interior wear, maintneance on these items is also reduced. Factory fabrication will produce further savings by reducing the amount of time and labor spent on erection.

Regardless of these indirect savings, one of the major drawbacks to laminated construction is their excessive initial cost. This is largely attributed to the detailed and custom manufacturing system used by the industry. Steel joist systems are produced and distributed on a mass produced national scale which repeatedly undersells the wood members. School districts with tight budgets restrict the architect from even considering these laminated items.

Despite this fact the lumber industry may successfully counteract by stressing the quality features common to glulam products. School districts have slowly been increasing their building funds to incorporate such quality features in their buildings. It is now evident that various districts are keeping abreast of their school space requirement and do not limit their new structures to bare necessities. Grand Ledge recently completed a new high school building which used glulam beams in the library and cafeteria areas. Jackson, Michigan, has used laminated wood beams in the classrooms of its last seven structures. In both cases, a quality type appearance was the major reason for selecting this structural system.

In the majority of interviews conducted with school officials there were no objections to glulam members. The major reason for not using this product in their schools was attributed to the architects not specifying the material. Many superintendents admired this type of construction as frequently used in their community's churches but had little information on the product, thereby not considering it for their school buildings. Schools and churches were considered as different spacial problems that required different building materials.

When the questioning was directed to architects it became apparent that another reason for their not specifying glulam products was a lack of interest in or inadequate information on the product. In part, this may stem from the architect's schooling which in the majority of cases eliminates a thorough education in timber designing. Despite this fact, one major reason for the architect's indifference is the lack of promotion by manufacturers of glued laminated products. This void should be filled by field representatives who can stimulate the architect, accurately solve his design problems, and personally supplement impersonal printed material. Architects frequently mentioned that such services were offered by competitive industries and to some degree had influenced their material selections. Nearly every architect interviewed expressed a desire to incorporate more natural materials within his school designs and considered wood as a prime means to accomplish this goal. With the presence of such a partiality on the part of the architectural profession, further promotion by the glulam industry sould induce a greater use of these products.

Another reason for glulam products not developing a larger market is the restriction placed on such items by the Fire Marshal's office. Since the exposed glulam products do not perform as Class A or B finishes they are restricted from hallways, lobbies and large assembly areas. As discussed in Chapter III, such restrictions are unfair and need to be revised. Although architects do not agree with these regulations, they have shown no desire to form a body which might influence the Fire Marshal's office revision thereof. Such actions are now the responsibility of the lumber industry and its respective associations.

Glulam products are classified as Class B or non combustible construction for fire insurance ratings. Testing by the Underwriters' Laboratories have shown that these members do not add to the fire loss and as a result are credited by insurance firms.

Decking Materials

Gypsum Products. Gypsum products are used for school construction in one of two forms: a precast plank or poured slabs. The value of gypsum is based on its satisfactory heat insulating qualities, its light weight, a non combustible rating and the fact that it is strong enough for roof slabs which are not heavily loaded.

Gypsum planks are composed of 97% finely ground calcined gypsum and 3% of fibrous materials by weight. These precast roof items are reinforced with a heavy wire mesh and a metal tongue and groove edging. The two inch members are usually available in eight and ten foot lengths. Normal application involves laying these planks perpendicular to the joist members or purlins, adding a layer of rigid insulation and then placing the built-up roof over these layers. Two inch planks carry a "U" factor of .53 and with one inch of rigid insulation the value becomes .20.

Poured gypsum is only used on flat roofs since it will flow on an inclined surface. The foundation for this poured roof consists of formboard panels laid on a system of sub-purlins known as bulb tees. Bulb tees are lightweight, inverted steel T sectioned members, usually an inch deep, which provide a half bearing surface for the perimeters of the formboard. This system is laid perpendicular to the purlins or shorter spaced joist system. Formboard may be an insulating, acoustical or standard sheetrock material and can function as a finished ceiling in exposed steel construction. Once the forming material is in place, reinforcing mesh is overlayed and two inches of gypsum mortar are poured on the roof and allowed to set. This system has an insulating "U" factor of .16 or .11 if an inch or rigid insulation is added.

Plank and poured gypsum are widely used in one story Michigan schools. The system is one of the most economical and has attained satisfactory performance records in the majority of applications. Its use is restricted in areas of high humidity, such as shower rooms and indoor swimming pools, due to its capacity of absorbing water which subsequently weakens its structure.

Composition Roof Decking. One of the newest products in light roof construction is the fiber composition board. These products have increased in popularity during the past few years and now presents a definite challenge to gypsum products. Although Tectum is only a brand name for this product, it predominates construction and is now considered a general term for this product. Major constituents in this board are a uniform mat of wood fibers impregnated with an inorganic binder. This is then compressed to a desired thickness and machined to various lengths and widths. Tectum has a finished surface of wood fibers and a reverse covering of asphalt-saturated roof felt to prevent moisture from penetrating into the material and to also provide for the application of a built-up roofing.

No added insulation is needed since the material has sufficient thermal insulating abilities. "U" values for a two inch board is .20 and .15 for the three inch layer. Other assets include a non combustible rating, acoustical qualities and lightweight construction. Cost is comparable to gypsum decking when the required insulation for gypsum is added.

The material is best adapted to exposed beam construction and is also erected with a system of bulb tee subpurlins. Once the planks are layed on the bulb tees a grout is applied to the resulting gaps which insures a uniform base for the built-up roofing. Here again, this product is not recommended by the manufacturer for application in areas subject to a high humidity.

Steel Decking. Another low cost decking material used in moderate quantities for Michigan's schools are the various steel decking designs. This product is easy to erect and is usually layed perpendicular to the purlins. The sheet metal overlays obtain their rigidity from the longitudinal rib design formed into the material. Usual depth of these formed members average two inches. Once the twenty-five to thirty inch wide sheet is overlapped on the adjoining pieces, the section is spot welded into place, or fastened by self tapping screws.

Initial cost of the roof deck is one of the lowest in the field but its lack of insulating properties requires an added amount of insulation to be incorporated in the roof structure. Architects that were interviewed did not make an extensive use of this system due to problems of insulation and design. Care must be taken to isolate the member from moisture, since it is subject to deterioration from rust. Since this deck system cannot be used as an exposed ceiling due to its overlapped and welded joints, an added layer of blanket insulation may be placed above the required suspended ceiling.

One variation of this metal decking is a structural performed steel decking produced from heavier gauge material and incorporating a "U" form for each individual member. This long span decking eliminates the need for structural support and will span thirty to forty feet depending on the depth and gauge of decking used. Each member is welded to its neighbor to obtain a rigid roof.

Major disadvantages of this system are centered on insulating and expansion problems, inherent in the design. Although the system may be left as an exposed ceilihg, the acoustics and appearance are not desirable. Due to these features the system finds only limited use in school structures.

Wood Roof Decks. Competition among the various roof deck systems is not complete without a discussion on the wood roof deck. This deck system is composed of double tongue and grooved wood members spiked together to form a continuous deck that is a combination of strength, insulating qualities and a finished ceiling. Commonly, this product is used with glued laminated members for various architectural effects but it may also be used with other structural members. The individual planks are grade marked, kiln dried and used in a 3 x 5 or 4 x 5 dimensional size. All pieces are predrilled for a seven inch spike fastener and machine planed and beveled on the edge to produce a grooved surface ready for finishing. Various softwood species are available and their attractive grain textures usually receive a clear finish.

The cellular nature of wood creates a natural insulating property for the member. This feature may omit the need for further insulation but the usual practice is to incorporate one inch or rigid insulation above the decking and then apply a built-up roof. The "U" value for a nominal four inch deck is .17 whereas one inch of insulation lowers this to .11. Adequate strength is produced by this system with construction spans of 16, 14, 12 and 10 feet carrying live loads of 30, 40, 55 and 80 pounds per square foot respectively. Cost is generally classified as competitive with the other systems when the extra material costs incorporated in a finished system are added.

The major advantage of this system is its final appearance. The aesthetic appearance of finished roof decking is not only attractive but versatile due to the number of species available.

No other roof system can produce comparable finishes to those obtained with these wood members.

School buildings can use these architectural assets but certain factors now present a barrier to exposed roof decking. One of the general requirements of the various school districts states a preference for an acoustical ceiling which is of a white or off white color.

Grand Rapids specifies: "Ceiling materials should be as follows: e. Classrooms: Mechanically suspended acoustical tile pasted to sheet lath or acoustical plaster. Room Surface Reflectances (minimum) : Ceilings .... 80%."[15]

The Department of Public Education also recommends: "Ceilings should be finished in a flat white, regardless of material. The material to be used in ceiling finish will depend upon several factors, but often the ceiling surface is designed for sound absorption."[16]

Such comments are the usual practices followed throughout this state. The ceiling is usually finished with a white acoustical tile that gives the teaching area better acoustics and illumination. These measures would reduce the appearance assets of wood roof decks, increase the cost of this roof system and thereby cut its competitive advantages.

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[15] "Revised Design Standards for Elementary Schools", The Collaborating Architects Committee, Grand Rapids, 1954.

[16] "Planning Together for Better School Buildings" Department of Public Instruction, Lansing, Michigan, 1956.

To counteract such measures the industry must strive to change such ideas and stress the importance of obtaining warmth and interest in the interiors of classrooms. A careful selection of lighting fixtures would reduce the need for reflective ceilings, In part, high gloss varnishes will develop reflective surfaces. Acoustics are desired but not always essential. "Planning Together for Better School Buildings" also states: "However, acoustical correction can be accomplished in other ways and many different materials can be used in ceiling finish."[17] Many of the practices within school construction are time honored rituals that may be changed with more aggressive and interesting ideas. Here again, an industrial promotional campaign is essential to introduce these ideas and thereby influence the personnel dealing with material selections and specifications. The entire story of wood deck roofs should be constantly presented to the architects and school administrators in order to correct misconceptions.

The second and largest restriction on this roof system originates from the Fire Marshal's office. Actual restrictions are similar to those placed upon glued laminated members. These restrictions also result in the architect regarding all wood products as being eliminated or unfavorable to the Fire Marshal's office.

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[17] "Planning Together for Better School Buildings", Department of Public Instruction, Lansing, Michigan, 1956.

It is possible to observe these regulations and still use wood products. Such measures as fire retarding paints, fire retarding impregnations, or a sprinkler system will provide adequate protection as prescribed by Bulletin 412. Painting and pressure treatments are expensive and destroy the appearance of natural wood. Sprinkler systems are not only an added initial construction expense, but produce maintenance problems for future years. None of these solutions are economically feasible or compatable to the appearance of wood products. The major solution lies in attacking the problem at its source.

Wood roof decking is also restricted by its fire insurance rating as a combustible roof. This establishes a penalty against the item and was frequently mentioned by school superintendents as a reason for eliminating the item. Reducing this problem will depend on a method to lower the insurance rates.

School Windows

Aluminum now predominates as the material for school windows. This material undoubtedly captures over seventy-five per cent of the window market in school construction. The remainder of the window units are produced from wood and steel, with wood probably having a slight edge over steel.

The one major reason for this selection is a reduction in maintenance costs during the lifetime of a school building.

Architects, superintendents, school consultants, engineers and school board members all stated that one of the prerequisites for window units now centers on its maintenance costs.

Although aluminum requires less maintenance it cannot be classified as a maintenance-free material. Aluminum does react with the elements to form an oxide which acts as a protective coating on the metal. The color of this oxide varies from a whitish grey to almost black, depending upon atmospheric conditions and age. Final results of this natural process are a dull grey surface that neither adds to nor greatly detracts from the exterior's appearance. The oxide coating is not always a guarantee of protection since the layer is relatively porous and in time softens and may erode away. It also is rough and retains certain amounts of dirt.

A second shortcoming of the material is its tendency to actually corrode when exposed to the elements. If excess amounts of acid or alkali are present in the atmosphere this deterioration will be more pronounced. In part, the oxide coat will stop corrosive tendencies but the low stability of these coats cannot be relied on for extended periods of time. Care must be exercised when placing aluminum windows in a masonry wall since a direct contact with masonry will cause the alkali in cement to cause excessive corrosion. Corrosion also exists where aluminum is in contact with steel.

The text, "Saving Dollars in Building Schools", states

"Aluminum reacts readily with the lime found in cement products. This makes aluminum a poor product to use directly against masonry and concrete in any form unless care is taken to separate masonry materials from aluminum in order that excessive corrosion will not occur. Many aluminum store fronts have required replacement in from five to ten years because of the excessive lime bath they receive from water washing over the masonry wall above and over the aluminum."[18]

Due to such tendencies, a number of architects interviewed state that exceptional care must be taken in selecting the aluminum window units. One gentleman stressed that the aluminum industry has played a hoax on the public and its school districts by advertising less expense through the use of a "maintenance free aluminum product". To combat this weakness of aluminum, architects will specify only windows that can resist these actions.

In general, the means to reduce this objectionable occurrence are the actual composition of the metal and special protective coatings. A great number of aluminum alloys can be produced and at present about fifty are currently available. They range from high strength aircraft metals to lower strength items useful for bending and ductibility requirements.

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[18] "Saving Dollars in Building Schools", David A. Pierce, Reinhold Publishing Company, New York, 1959.

Variations also exist in relation to the metals' resistance to corrosion. Alloy 63S is usually selected for extruded shapes such as window frames and sash and has a higher degree of resistance to elements than other cheaper alloys. The second means of protection is offered by subjecting the member to an anodizing process which creates a specified amount of oxidation and a more resistive coating than that occurring through slower, natural processes. A controlled finish is acquired, with a uniform or special color integrally bonded to the base metal.

These measures do offer greater protection to the metal but also increase the cost of the material. Architects that have obtained sufficient knowledge of this metal not only investigate the operating features of a window unit but also its material composition and the degree of coatings. One firm states that to assure their clients of satisfactory results it is essential to order units that have a double anodizing layer. In most cases, the architects and school officials were satisfied with the performance of their aluminum windows and had obtained sizable reductions in maintenance costs. A number of architects stated that although performance was satisfactory some doubt was raised as to the window's lifetime results. The predictions of laboratory testings were questioned due to discrepancies arising from earlier tests on aluminum products.

Regardless of what the future may produce, the present reduction in maintenance has caused aluminum to replace wood and steel units. Maintenance of window units is a major issue with school districts. Not only is it costly and continuous, but the maintenance job may produce low quality results. Many districts were displeased with the quality of workmanship now found in the painting trade, and surmised that while labor costs are increasing the general workmanship has taken a reverse trend. Narrow muntins and bars were not painted neatly, thorough cleaning and paint removal procedures were not applied to all surfaces and crevices, weatherstripping was painted and did not function properly and windows were "painted shut". These and other maintenance failures resulted in the windows not operating correctly, unsightly finishes, and a need for more frequent painting cycles. Should such faults continue over a period of time, these results will be magnified. Even if workmanship was satisfactory the school district is still faced with the need for reapplication of paint every four or five years.

There is also a period between the painting cycle when the window unit will look shabby or have unsightly failures in its paint surface. At times, school appropriations and procedures will create a further lag before the required maintenance can be performed. Such periods will leave the product in an unsatisfactory state and distract from the building's appearance.

Further objections to wood windows resulted from improper installation and inadequate maintenance. Failures, in the form of rotted areas in the window unit, were the result of not properly covering the wood surface, or creating water traps during installation. Should the unit need replacement, the cause of failure was usually placed on the wood materials. Regardless of where the failure does lie, the natural reactions are to eliminate the product.

When the maintenance and installation requirements are improved, the other qualities of a wood window have caused a sizable reduction in the number of aluminum units. Nearly every architect interviewed mentioned that specifications for their residential designs called for wood windows. In this instance the maintenance is usually accomplished by the home owner during the more frequent redecorating periods common to residential dwellings. A personal interest in involved which results in the owner caring for his home or his closer supervision of the hired painters. This attitude does not always exist in the care of public buildings.

The qualities of a wood window which surpass aluminum again lie in the nature of the raw material. Wood is an insulating material and does not conduct heat and cold to other portions of the component. During winter months, aluminum and steel units will have cold interior surfaces and tend to condense the moisture present in the atmosphere.

Condensation results and produces excessive amounts of free water. Contraction of metal framework also causes seams and joints to admit an excessive amount of air. Uncomfortable temperatures will be produced near window areas and be transmitted to other portions of the room. To eliminate client dissatisfaction, the architects specify wood windows.

In part, these objections are controlled in school buildings by placing additional amounts of heat in the classrooms. Humidity conditions within a classroom usually are not as critical as in the home since they do not originate from cooking, laundry or bathing. In areas that do receive excessive amounts of moisture the condition is remedied by using non porous sills and; in extreme cases such as shower rooms, glazed tile surfaces. These measures may alter the results but do not eliminate the cause of the problem.

Cost comparisons between wood, aluminum and steel window units are difficult to make due to the wide number of window models and the quality of manufacture. Construction firms usually consider a wood or steel unit as being equal to the cost of enclosing an equal volume of space with an eight inch Block and Brick veneer wall. Aluminum units are priced from one-fourth to one-third higher than this enclosure expense. These estimates were generally confirmed during other interviews but the variation between aluminum and wood unit costs were not always as great.

Architects have objected to the heavier muntins, bars and mullion strips common to wood window units, however, the changing requirements of school buildings have reduced this criticism. A large number of schools built in the past few years have incorporated large amounts of window area to utilize natural lighting. School districts now realize that such radical departures were not economical or fully functional. These objections were: (1) Natural light varies greatly and schoolrooms must still rely on artificial sources. (2) Natural light may be too intense or cause glare from concrete and snow surfaces. (3) Heat losses and radiation are magnified with larger glazed areas. (4) Curtain and shade expenses are also excessive with large glazed areas.

Due to these objections many school superintendents now want a window coverage not exceeding thiry percent of the wall surface. This may place a restriction on exterior appearance. However, previous schools were not observing functional designs. At the same time, this reduced requirement on window areas may decrease the amount of heavily glazed curtain wall units. To comply with these trends these units would need to increase their amounts of costlier panel members.

Appearance of well kept wood window units also excels over aluminum. The painted surface of wood may vary in color and serves to accent the outward appearance, whereas exposed metal surfaces have an industrial appearance that are not as pleasing to the building's architecture. These conditions will also exist in the classroom interiors.

To summarize the present status of the school window market, it is evident that one major drawback of wood units has resulted in their decreased use. Although they do possess other advantages not found with aluminum or steel, the possibility of unsightly appearances and unsatisfactory functioning has de-emphasized the other selling points. Correction of the problem lies chiefly with a means to reduce this maintenance. Other consideration should also be given in order to emphasize the importance of the other window qualities to architects and school building officials.

Doors

Exterior Doors. Objection to the maintenance of exterior painted or finished surfaces has resulted in aluminum doors being used for main entrances to school buildings. A number of superintendents also objected to the warping and rotting that occurred with various exterior wood doors. The major reason for a properly built door to warp or rot will usually stem from not offering the door sufficient protection from the elements. Excessive time between hanging and finishing or a failure to adequately seal the unit during the initial coat may produce early defects. Failure to replace a worn finish and low quality maintenance offer reason for failures to occur at a later date.

Finishes received excessive wear during winter and spring months from children pushing on the door with wet gloves and clothes. These factors, plus constant exposure to the elements, resulted in short life cycles for the more popular varnish finish. Reapplications by an unskilled custodial staff may often produce further complaints on wood doors.

The usual specifications for schools now call for an aluminum door at main entrances and solid core, flush wood doors for secondary points. Aluminum doors contain a large glazed area and may be combined with glazed side lights. These doors are more expensive than their wood counterparts averaging $200.00 as compared to $60.00 for the wood door. Cheaper units were available but did not stand the constant traffic common to school buildings and developed excess oxidation and corrosion. This expense was cited as one reason for limiting their use to main entrances. Maintenance on aluminum involves a monthly washing with a mild detergent to remove dirt, excess oxidation and smudges by fingers.

Hollow core steel doors are also used on secondary entrances. These units are competing with wood doors for secondary entrances but have not exceeded the popularity of wood. Steel units are often selected in strong colors to accent various areas of the school's exterior. Generally the rusting of exterior steel surfaces and problems on repairing a dented or sprung door are the major objections to steel units.

These factors have given wood doors the competitive edge on this market.

Interior Doors. The major types of interior doors used in Michigan's schools are the solid core, flush wood door and hollow core, flush steel doors. Although competition between these units is keen, the wood doors are receiving slightly higher acceptance.

Wood doors are favored on an appearance standpoint due to their natural features. Natural wood grains are both attractive and complementary to the surroundings in a hallway or classroom. "Planning Together for Better School Buildins" suggests, "Doors should be designed to perform their specific functions -- the provision of quiet, warmth, and privacy -- without themselves becoming obtrusive."[19] A number of architects and superintendents had indirectly made a similar comment on door units and had found that the colored surfaces or metal units did not fulfill this requirement as did the natural wood doors. School districts have used metal units but returned to an exclusive use of wood doors primarily for appearance considerations.

The baked enamel surfaces of interior metal doors were also difficult to repair when damage occurred. Scratches and marring were much more evident than on a natural wood surface and

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[19] "Planning Together for Better School Buildings", Department of Public Instruction, Lansing, Michigan, 1956.

subsequently required frequent maintenance. Most districts had found that the installation of a metal kickplate on the bottom of interior wood doors reduced excessive wear on finished surfaces.

Other maintenance problems occurred with metal doors when the units were unbalanced or had received excessive damage. In most cases, the custodial staff could not handle these metal-working problems and needed extensive shop facilities often resulting in sending the door to a manufacturer's representative.

Solid core wood construction also produces a better sounding door during opening and closing than do the hollow core metal units. This stability reduces sound in the building with less damage from abuse.

Metal doors are generally preferred for their ease of installation and fewer adjustments during operation. A minimum of time and skilled labor is required to install these pre-assembled units. Doors are usually set in the jamb hinges and connected with pins. The initial cost of metal doors is higher but advocates for these units stress the savings occurring through reduced installation and maintenance costs.

Interior wood doors are subject to temperature and humidity changes during the course of a school year. The summer months and holiday seasons create problems for wood doors when the school is closed. Humidity tends to increase during summer months and with the lack of proper circulation in the building may localize these conditions in certain areas. Temperatures may also increase in various rooms and cause excessive drying of wood products. Both conditions, if excessive, will distort the original shape of door units and require added maintenance.

Regardless of the type of door used, metal door jambs and trim are the more common. Wood products have lost a greater share of this market due to the amount of time involved in the installation of the items. With the wide use of interior block walls, steel jambs are now installed by the masonry trade during construction. This reduces the labor costs. Although the material costs of steel jambs are higher, the final analysis prove that expensive labor during wood jamb installation produces a higher total cost figure.

CONCLUSION

For the most part, school construction has evolved to the present status of using materials which will efficiently accomplish the desired requirements of these structures. Wood products have commanded a lower demand due to three general reasons: (1) regulations directly and indirectly prohibit the use of wood products in school buildings, (2) these products do not meet the specific requirements of school buildings as adequately as other materials, and (3) accurate information in sufficient quantities is not directed to the personnel responsible for material selection.

Combustible materials have been widely restricted by the actions of the State Fire Marshal's office. These restrictions not only directly exclude many useful wood products but tend to adversely influence the architects into eliminating all wood products from his designs. Due to the nature of these regulations and their resulting impact it is imperative that their removal be brought about, before any action is taken to re-establish wood products in the school construction field. This restriction is the one major barrier to remove before any promotional or product development actions by the lumber industry would prove effective. At present, the task of removing or altering these regulations lies squarely with the lumber industry and its various lumber associations, since it is their members who are adversely effected. A definite plan of action, backed with valid reasons for changing those regulations, would undoubtedly receive some support from architects and school administrative personnel. This combined force would present a strong potential means of inducing a re-evaluation of present restrictions.

In some areas of school construction wood products do not fulfill the requirements presently established for building materials. As a result, markets have been lost to materials that satisfy those conditions. Solutions to this dilemma include; changing the product itself to more adequately accomplish certain functions, or change the present methods for evaluating building materials. The most feasible solution is a combination of both ideas. Research should be initiated by the various areas in the lumber industry to solve such problems as excessive initial costs, repeated and costly maintenance and dimensional instability. At the same time, progress is needed in developing new products, and more aggressive methods of presenting wood products to the construction industry. Preassembled units, special finishes, new materials to combine with wood products and many more ideas are needed to match the dynamic growth of competitive industries. In some respects, the present status of wood products in the school construction field is the result of a lag in research by the lumber industry while other materials were constantly improved to fit various construction needs.

The second method to counteract these established requirements is related to the third problem of not properly promoting these products. An increased amount of promotion is needed to develop an interest in wood products by school administrators and architects. Advertising and personal sales contacts by manufacturer's representatives should be combined in proper amounts to meet the deficiency in the lumber industry. This promotional campaign should also attempt to have present material standards re-evaluated in an effort to place wood products in a more competitive advantage.

Although these advantages do exist, the groups responsible for material selection are not reminded of these assets in an appropriate manner or in sufficient amounts. Competition has monopolized promotion to the extent that wood products are not recognized or are misnomered. Efforts should be directed to correct these inadequacies and misconceptions by various lumber manufacturing concerns and associations.

These three phases of development are essential for a re-establishment of wood products in school construction. The potential within this field should be a sufficient incentive.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Anonymous, "Primary Units Partial Solution to Flint's Classroom Shortage", Reprint of article in *Michigan Association of School Board Journal*, 1955.

2. American Association of School Administrators, "Stretching the School Building Dollar", Washington, D. C. The American Association of School Administrators, 1957.

3. Collaborating Architects Committee, "Revised Design Standards for Elementary Schools", Grand Rapids, Grand Rapids Board of Education, 1954.

4. Department of Public Instruction, *Planning Together for Better School Buildings*, Lansing Department of Public Instruction, 1956.

5. Department of Public Instruction, "School Construction Data", Department of Public Instruction, Lansing, 1959.

6. Educational Facilities Laboratories, Inc., "Ring the Alarm", New York, Educational Facilities Laboratories, Inc., 1959.

7. Federal Security Agency, "School Fire Safety", Bulletin 1951 No. 13, Washington, D. C., Federal Security Agency, 1951.

8. Hanrahan, F. J., "Heavy Timber Construction for Fire Safety", Washington, D. C., American Institute of Timber Construction, 1955.

9. National Citizen's Committee for the Public Schools, "What Are Our School Building Needs", New York, National Citizen's Committee for the Public Schools, 1955.

10. National Fire Protection Association, *Building Exits Code*, Boston, National Fire Protection Association, 1959.

11. National Fire Protection Association, "General Motors Fire", Boston, National Fire Protection Association, 1953.

12. National Fire Protection Association, *Operation School Burning*, Boston, National Fire Protection Association, 1959.

13. National Fire Protection Association, "School Fires", Boston, National Fire Protection Association, 1958.

14. National Fire Protection Association, "The Chicago School Fire", Boston, National Fire Protection Association, 1959.

15. Parker, H.; Gay, C. M.; MacGuire, J. W., Materials and Methods of Architectural Construction, New York, John Wiley and Sons Inc., 1958.

16. Pierce, David A. Saving Dollars in Building Schools, New York, Reinhold Publishing Corp., 1950.

17. School of Education, Michigan State College, A Survey of the Grand Ledge Community School Area, East Lansing, Michigan State College, 1954.

18. Shope, John G., "Control of Flame Spread in Buildings", Washington, D. C., National Lumber Manufacturers Association, 1959.

19. State Fire Marshal's Office, "Fire Prevention section, School Bulletin 412", East Lansing, State of Michigan, 1959.

20. Thompson, N. S., "The Fire Performance of Timber", Forest Products Journal, Vol. VIII, No. 4, p. 31-34, April, 195[illegible].

21. Underwriters' Laboratories, Inc., "Building Materials List", New York, Underwriters' Laboratories, Inc., 1960.