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BUILDING CODES AND THEIR APPLICATION[1]

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ABSTRACT

The application of building codes regarding building construction and associated wood products is discussed with emphasis on fire protection. Buildings regulated by both occupancy and construction materials appear as either fire or nonfire rated. The Uniform Building Code provides for 3 classifications of wood constuction: Types III, IV, and V. The major fire problem in the United States is loss of life in dwelling fires with smoke detectors being utilized as a primary weapon in fire safety. A methodology is under development that would establish techniques for predicting fire performance of structures. Numerous changes to the UBC have been proposed affecting use of wood construction.

Keywords: Uniform Building Code, building codes, model codes, fire ratings, occupancy, wood construction, life loss.

INTRODUCTION

This paper explores trends in the regulation of building construction and related wood products with emphasis on fire protection regarding wood products. To give an adequate background, a brief overview of the building code picture in the United States, basic information on model code influence, and the manner in which model codes function are provided.

An authoritative study of building code use in the United States is found in a paper by Milton Applefield (1973). This study examined the code status in over 2,000 municipal jurisdictions. The survey determined the method by which fire zones or fire districts were reached. A fundamental question in the survey was the type of code used, the code basis, and whether it was a local or model code. Of particular interest was the fact that all cities in the United States with a population of at least 10,000 were contacted, and there was nearly 100 percent response. Although this study produced interesting data, one significant conclusion was that building code adoption and application throughout the United States was almost universal. Only a small percentage of the country, principally rural or unincorporated areas, was without regulations. Significantly, model codes were utilized as the code basis in over 75% of the areas surveyed. The extent of model code adoption has broadened since the time of this survey so it would probably be reasonable to assume that approximately 85% of the population of the United States is under one of the four model codes or a code derived from one of the model codes.

Three of the model codes were developed and are maintained by government-sponsored organizations. The fourth, the National Building Code, is sponsored by the insurance industry. All of the model codes are similar in their scope and purpose, but there are substantial differences in format, composition, and treatment of the problems associated with life, fire, health, and structural safety.

To illustrate model code operations, the International Conference of Building Officials and the Uniform Building Code will be utilized as an example. ICBO is a nonprofit California corporation owned and controlled by governmental jurisdictions that comprise its voting interests. These jurisdictions are required to designate a representative who will act for them in

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exercising their voting interest. This is generally the individual who bears the title of Building Official. The activities of the ICBO are under the purview of a Board of Directors elected at an annual meeting as is the case with other corporations. The director's terms are staggered to maintain continuity within the Board.

The Board appoints the key staff and all standing committees. Standing Committees for ICBO are Code Changes, Education, and Research. The Code Changes Committee is responsible for the receipt, processing, and evaluation of changes to the Uniform Building Code and its associated codes. They are required to develop recommendations regarding disposition of proposed changes. These recommendations are then voted on at the annual meeting. Changes thus approved are subsequently reflected in a new code edition.

The Education Committee is responsible for development of educational programs, curricula, textbooks, course syllabii, and related materials. They are also responsible for implementation of an inspector and plan reviewer certification program.

The Research Committee charge is the evaluation of new building products and systems, maintenance of a quality control program embracing testing and inspection agencies engaged in quality control, and listing of agencies involved in prefabrication. Their work revolves around the Uniform Building Code and its related documents.

The Code Changes Committee has several standing subcommittees, each responsible for the evaluation of changes within their areas. These include General Design, Seismology, Mechanical, Fire and Life Safety, Administrative, and Architectural Barriers. The Fire and Life Safety Subcommittee and the Research Committee are the most involved with trends occurring in fire protection.

The former is the key subcommittee for evaluation of changes relating to the fire and life safety aspects of building construction. An important aspect of Research Committee involvement is verification of compliant products and systems to the fire protection standards of the Code. The committee is also heavily involved in evaluating new products for which no specific standards apply. An example of Research Committee involvement would be evaluation of fire protection assembly, which has been tested in accordance with standards set forth in the Code. The Research Committee serves the very important function of serving as a clearinghouse for verifying that the tests were conducted properly, which eliminates the need for the manufacturer of a product or system to obtain the approval of each agency in which the product might be utilized. Both the manufacturer and the enforcing jurisdiction can rely on the evaluation accomplished by the Research Committee.

CURRENT CODE FRAMEWORK

Buildings are regulated on the basis of the occupancy housed therein and the construction materials of the building. The occupancy and construction materials dictate the allowable area and building height. These two parameters, height and area, reflect the amount of combustible material that may be contained within the building volume. Included as additional regulatory factors are location of the building on the property, its accessibility from more than one side, and exiting. The Uniform Building Code has three distinct building classification types where wood framing is predominant. The most common type of construction is Type V, in which the materials of construction of walls, floors, ceilings, and roofs may be wood. Actually, they can be any material. However, the code provides that the building be classified as its least fire-resistance category, so if there is a mixture of wood and masonry materials, for example, the building classification would be Type V. Wood is also the primary material in Type IV buildings of heavy-timber construction. This building is characterized by heavy-timber framing for the floor, roofs, and perhaps interior walls with exterior walls composed of noncombustible materials. It is a traditional type of construction that is frequently called "ordinary." A similar type of construction, or at least without heavy-timber interior framing, is the Type III building, which typically consists of masonry exterior walls and interior walls, roofs, and ceilings of combustible materials.

With the exception of Type IV heavy-timber buildings that have unique characteristics, Type V and Type III buildings are classified as either nonfire-rated or one-hour fire-rated. The one-hour rating implies one-hour fire-resistive construction for walls and floor-ceiling and roof-ceiling combinations. The basic allowable floor area in the Uniform Building Code for Type V buildings sets the basis for floor areas permitted in all types of construction. They are derived from early studies on fire loading and the fire experience record of buildings over the years. If the building has a one-hour fire-resistive envelope throughout, it enjoys a greater area. For example, the areas permitted for Type V, nonfire-rated construction are increased 75% if the building is rated one-hour throughout in its component parts. In Type III construction, a 50% greater area is permitted than the area for nonrated Type III construction when the interior components are protected with one-hour construction. Type IV heavy-timber construction is assigned the same basic floor area as a Type III one-hour building. Thus, equivalence is established between heavy-timber and one-hour construction. This equivalence is not based upon exact performance under the ASTM E-119 standard fire endurance test but rather performance on the experience record.

To summarize, buildings housing various occupancies and constructed principally with wood framing appear in codes, such as the Uniform Building Code, in two basic configurations: nonfire-rated and fire-rated, as well as the classical heavy-timber framing. This breakdown is further differentiated for exterior walls of wood framing or masonry. In the latter case, a greater floor area and an advantage in height accrues.

TRENDS IN STRUCTURAL FIRE PROTECTION

When component parts of buildings are required to be of fire-resistive construction, the details of construction to achieve this fire rating can be found in various fire rating tables contained in the Uniform Building Code. Table No. 43-A contains ratings for the main structural framing of buildings, but wood framing does not appear in this table. Accordingly, main structural elements of wood obtain their fire protection from envelope or membrane protection consisting of a roof-ceiling or a floor-ceiling combination. Heavy-timber constructions have been subjected to the standard ASTM E-119 fire-endurance test; however, no specific ratings are assigned in the Code nor have they been pursued. Table Nos. 43-B and 43-C in the Code deal, respectively, with ratings assigned to both bearing and nonbearing walls and ratings assigned to floor-ceiling and roof-ceiling combinations. The standard fire-endurance test requires that load-bearing assemblies be tested under loads that will reflect the in-service conditions. Since most structural elements will be fully loaded in some designs, it is the practice to load members of fire test specimens so as to fully stress structural elements. This is the case in roof and floor-ceiling construction systems. For walls, there are provisions for both load-bearing and nonload-bearing ratings.

The test standard actually permits application of loads that are reflective of field construction. Thus, one could essentially fire test a custom design in which members, for example, are loaded at half stress or whatever the design parameter would be for the construction. This procedure has not been optimized primarily because the suppliers of membrane protection are the principles involved in testing for fire ratings rather than the end users.

TRENDS IN CUSTOMIZED TESTING

There are many sections of the building code in which wood construction is required to exhibit some fire-endurance distinct from the areas discussed thus far. For example, separations between different occupancies within the same building are required to be of fire-resistive construction since these occupancies may not be compatible in terms of the fire hazards they contain or the hazards they present to the occupants. There is a growing trend in the Uniform Building Code to afford particular protection to the individual tenants of multiple-residential buildings. The thesis is that a family in a multiple dwelling unit should have some degree of protection from the acts of families in adjacent units corresponding to the protection that is inherent in separate single family dwellings. Currently, the Uniform Building Code requires one-hour fire-resistive construction for multiple-residential buildings with more that three thousand square feet of floor area above the first story. An alternate exempts each dwelling unit separated from its neighbor by a one-hour fire-resistive envelope. This alternate will probably evolve as a standard in future years on the basis that fire safety of the family in multiple-residential building should not be less than those in single family dwelling units. Admittedly, the question is complex since there are a variety of ways to deal with the fire problem other than through structural fire protection. Nevertheless, structural fire protection has unique qualities.

One of the perplexing problems facing building officials is associated with condominium construction in residential neighborhoods. By definition, a condominium is a form of ownership where individuals essentially own air space within the unit and through a legal instrument collectively with others own the structure and remainder of the property. Condominiums assume many forms ranging from duplexes, or two-family condominiums, to garden-type and high-rise buildings. A similar type of construction in terms of occupancy hazard would be an apartment building where individual units are rented. A variation would be row housing, or so-called townhouses, consisting of one- or two-family units divided by area separation or fire walls. From the building code standpoint, the hazard posed by a condominium is not different from comparable dwelling or apartment house construction. Some code clarification of this is needed and will undoubtedly be developed in the near future. The confusion lies primarily with the row-house or town-house where property lines are developed between adjacent units, and yet there is a desire to share common walls. History has shown that common wall construction does not permit easy maintenance in the event of fire or structural damage unless legal instruments are drawn up to provide for the continued maintenance of these common elements. Thus, the trend is toward separately constructed property line walls for each abutting property.

Table No. 43-C of the Uniform Building Code provides for fire ratings for wood joist systems but does not specify a joist size, although minimum joist sizes are necessary in order to show successful performance in the standard fire-endurance test. The table also does not provide a sound basis for determining fire-resistive ratings for typical carpenter-framed trussed construction. Truss tests do not fit the furnace design. Many of the fire-rated assemblies that are given in the code were based upon tests conducted at the National Bureau of Standards many years ago. At that time, it was customary to stress joists so the maximum stress in flexure was a thousand pounds per square inch. Today, tests are conducted to develop flexural stresses at considerably higher levels. Stress tests involving wood members are naturally difficult because of the wide variations that can occur within grades, so it may be possible that some of the older tests would not be repeated today.

There is a growing inequity in that many newer wood component systems have been challenged from a fire-endurance standpoint because of the obvious lack of net section in key structural elements. Prefabricated trusses with pins drilled through many of the bottom chords are a good example. Fire tests conducted on these elements show a demand for much greater membrane protection than for a standard joist system. Thus, the lack of a minimum joist depth is not defensible. During the fire-endurance test, the wood-frame member becomes ignited at some point in time into the test, and fire-endurance of assemblies is dictated by composite endurance derived from the protective membrane as well as the endurance intrinsic to the framing deteriorating under fire. Since the test is an ultimate load test, as in the case of floor-ceiling assemblies, the construction can be at the point of incipient failure at the time the rating-point is reached. Therefore, the amount of material within the framing member is extremely important in achieving performance. This dichotomy probably will be corrected in the code over the next few years to eliminate what currently amounts to a double standard.

There is a noticeable lack of information available on the fire endurance of exterior walls of wood frame construction. For one-hour construction, the Uniform Building Code contains two wall assemblies for exterior use, one with an exterior treatment of cement plaster and the other with an exterior treatment of dropsiding or plywood over gypsum sheathing. The interior is finished with materials that have achieved ratings for interior construction. It would be both useful and realistic to examine some other construction systems that would provide the necessary rating. It can be expected that this will be done in the near future since the increased use of insulation in walls and ceilings will undoubtedly present assemblies that have an improved fire-endurance capability. The ICBO office receives frequent requests for determination of fire-resistive ratings for exterior walls of other than dropsiding or plywood. Fiberboard, particleboard, hardboard, and brick veneer are cases in point. It would be proper for those having the interest to come forward with appropriate data.

Studies such as those stated in the report of the President's Commission on Fire have fairly well pinpointed that the major fire problem in the United States concerning loss of life is dwelling fires. Dwellings have traditionally had no inherent fire endurance or fire resistance, but have wide-ranging distributions of combustible materials and vastly different levels of housekeeping. The challenge to reduce or mitigate these life losses is a real one and yet must be addressed while facing spiraling costs in housing construction. The decision of the ICBO was to utilize the smoke detector as a primary weapon. From a cost-benefit point of view, it is obviously a suitable course of action promising the greatest rewards for the least cost. Detector requirements first were approved in the 1973 Edition of the Uniform Building Code, and most codes throughout the United States have followed this lead. Little effect will be shown in the fire record until similar steps are taken with respect to existing housing. Attempts to interest people to install fire detectors on a voluntary basis are moderately successful, but not to the extent that they will show a significant trend in residential fire losses without some additional incentive. There is a proposed code change to require detectors in existing dwelling units if work valued at more than $1,000 is contemplated or if adding or creating bedrooms.

TRENDS IN FINISHES

All occupancies in the Uniform Building Code with the exception of private garages are required to observe certain limitations with respect to the surface flammability of interior finishes. These are derived from the ASTM E-84 Tunnel Test, and flame-spread numerical ratings are assigned to various use areas of buildings. In residential buildings, for example, Class III or a numerical rating of 76–200 is applied throughout the structure. In contrast, institutional buildings must observe Class I flame-spread ratings (0–25) for finishes in vertical exit ways and Class II elsewhere. Wood protection when serving as an interior finish, such as wood paneling or exposed wood framing, generally exhibits Class III ratings. An exception would be very thin materials applied without backing.

When regulations governing flammability of interior finish were added to the Uniform Building Code in the early 1950's, the smoke and toxicity characteristics were also addressed. Both smoke and toxicity were based on comparing finished wood to the burning of untreated wood. Later, the smoke limit of 450 per the tunnel test was developed. These regulations have proven to be increasingly burdensome to the regulating agency, particularly in the absence of controls on the building contents. Toxicity will be dropped in the 1979 Code. Smoke per the E-84 tunnel lacks response to different conditions of burning.

TRENDS IN FIRE ZONING

The Uniform Building Code established three fire districts: Fire Zones 1, 2, and 3. Fire Zones 1 and 2 are the most restrictive; Fire Zone 1 excludes buildings with wood frame walls. Fire Zone 3, the least restrictive zone, permits a 33⅓% floor area increase for all occupancies. Currently there is a proposal to eliminate Fire Zones as criteria in the Uniform Building Code. The rationale for this lies in the fact that the Uniform Building Code regulates structures assuming a maximum hazard based on occupancy within the building and assuming the building faces a maximum exposure condition on the adjacent property. If Fire Zones are deleted from the Uniform Building Code, provisions must be added to deal with exterior wall protection requirements based upon the proximity of the structure to a property line or to adjacent buildings. Buildings on the same property are assumed to have a property line between them unless their collective size is no greater than the area for a single building.

Since the building code currently permits an area increase for Fire Zone No. 3, the question might logically arise as to what will happen to this variant, not only for wood construction types, but for all buildings. The Fire Zone 3 basis area should become the common denominator since there are no data that would show that buildings in Fire Zone 3 have not recorded the same fire record as those in other fire zones. Fire zones were originally developed as an approach to fire problems in densely occupied areas of the city. However, alignment of fire defenses, rather than building construction details, has proven to be the better concept. For example, the concentration of fire department apparatus, fire flow, faster response, and greater fire department staffing are more logical ways to deal with fire problems presented in congested areas. The fact that fire defenses have grown in this matter shows the way communities address the problem. As a matter of fact, one can now take the view that the safest area for the construction of a nonfire-resistive building would be a congested area where fire defenses are the greatest. In any event, fire zones are becoming obsolete.

NEW ANALYTICAL TECHNIQUES

A methodology is being developed to establish techniques for predicting fire performance of various structures. In the case of prestressed concrete and conventionally reinforced concrete, accumulated data are being reduced analytically so as to permit the designing engineer or architect an opportunity to calculate fire endurance for specific designs rather than incur the expense of testing. Techniques thus far developed provide for better utilization of materials and also address situations where the standard fire endurance test does not apply because of limitations of the test furnace or component interaction. Similar techniques are being developed for steel structures, and attention is also being directed to the need to recognize different exposure conditions, such as building exterior exposures with a fire source in the building interior. Mathematical modeling is also being developed to match fire loads and building configurations based upon occupancy characteristics and exposure hazards. It is apparent that economics alone will validate the need for these analytical approaches.

Fire-resistive construction has been suggested as a panacea for residential fire loss, but benefit to life safety would be marginal since fire-resistive envelopes frequently tend to conceal the presence of fire. Structural fire protection, however, would serve to lower property losses to some degree. The cost-benefit relationship, however, does not seem valid in view of today's spiraling cost of construction. Perhaps property protection could be achieved more simply by insurance and improved fire department response.

FIRE FLOW

There are a number of proposed changes to the Uniform Building Code that might have a significant effect on use of wood construction. For example, ICBO is currently processing a proposal that would limit the size of buildings based upon available water supply for fire or fire flow. Proponents of the change have based their approach upon the fire flow schedule developed by the Insurance Service Organization. This fire flow schedule was not developed for the purpose of regulating building area. However, proponents of the change contend that lack of available water is an obvious problem. There is no question that water supply is fundamental to fire extinguishment. The assumption that a building is totally involved is not valid, nor is it valid to assume that water flow alone is the only parameter. Response time, for example, is a valid element. Most urban communities have developed minimum fire flow requirements. Many rural areas, however, have limited water supplies. The proposal obviously must be viewed within the entire context of all modes of fire protection as well as fire prevention. As it stands, the proposal is unrealistic.

CONCLUSIONS

Protecting buildings from the consequences of fire depends heavily upon an adequate enforcement program. For new building construction, this involves careful evaluation of plans prior to construction to be sure that the completed structure will conform to laws designed to protect fire and life safety. Building inspection is based upon the plans being followed. Hence, if the plans are improperly drawn or reviewed, incompetent inspection can very well ensure that a dangerous structure may be built.

Once a structure is completed, it is necessary that jurisdictions have an organized building maintenance program that will ensure the proper use and maintenance of fire protection features of structures. The failure of communities to do this can be a major contributor toward life loss.

There are many attempts to increase the level of fire safety through additional regulations, and there is developing resistance in view of excessive costs and infringement on freedom. Additional regulations must be cost-effective and reasonably drawn. Those which unduly infringe upon personal freedoms may very well be rejected by people who prefer less safety and more freedom.

REFERENCE

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