

WOOD I-JOIST FLOORS, FIREFIGHTERS AND FIRE

Prefabricated wood I-joists are used in approximately 50 percent of new wood-frame construction. When compared to sawn lumber, wood I-joists are stronger, stiffer, and lighter in weight. They are typically the preferred design choice in the larger rooms and the open designs favored by many homebuyers and designers. They are also environmentally friendly by making optimum use of a renewable forest resource and are manufactured to exacting industry quality standards.

1. Code Requirements

Life safety of the occupants has traditionally been the focus of building codes, both for structural safety and fire safety. Occupants of single-family homes nearly always have numerous paths of escape (doors and windows) from fire available to them. In addition, the requirement for smoke detectors in all new homes was introduced into the codes as fires typically emit smoke prior to bursting into flame and it has been estimated that smoke detectors give most occupants three to five minutes to escape from a burning home before smoke and flame become life threatening. Since the introduction of smoke detectors into homes, fire deaths have been reduced by nearly 50 percent. They are considered the homeowners' primary means of defense against injury or death from fire.

Section 907.2.10.1.2 of the 2006 International Building Code (IBC), Section R313.2 of the 2006 International Residential Code (IRC) and Sections 3.2.4.20 and 3.10.19 of the 2005 National Building Code of Canada (NBC) require single-family homes to have smoke detectors. Neither code, however, requires single-family homes to be sprinklered or built of fire-resistant construction although some designers, builders and home owners are now considering the use of sprinkler systems as an active home fire protection system. Homes are, therefore, constructed using all types of materials such as wood, concrete, steel, masonry, plastic and even straw in many architectural styles.

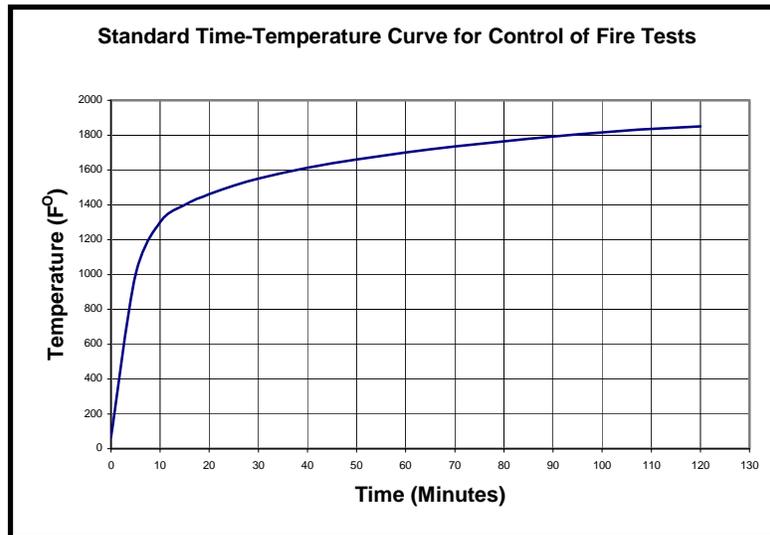
Because of the above factors, there is no building code requirement for fire endurance of materials or assemblies in single-family homes, resulting in very few standard fire endurance tests performed on unprotected (joists fully exposed to fire beneath) floor systems. Nearly all standard fire tests have been performed on floor/ceiling assemblies intended for multi-family residential or commercial structures, where exits may be remote from the occupants and the windows too high or break-resistant (security considerations) for quick escape. In these occupancies, there are code-mandated minimum standards for fire endurance under standard, fire-test conditions.

Code recognition of a need for firefighter safety has only recently been introduced into the building codes. Section 101.3 of the 2006 IBC states that one of the intents of the building code is "to provide safety to firefighters."

2. Fire Tests

The standard fire tests used to evaluate floor/ceiling assembly performance are ASTM E 119 or NFPA 251 or CAN/ULC-S101 (in Canada). In the full-sized version of these tests, a constructed floor assembly, that is approximately 14 x 17 feet, is placed on a

furnace cavity fired by natural gas. The underside of the assembly is directly exposed to flame and supported only by the edges of the furnace walls. The rate of temperature rise is carefully controlled to follow the standard's time-temperature curve. The value of the standard test fire is that it is repeatable from test to test and lab to lab. This permits a direct, consistent way of comparing the fire endurance of one assembly to another.



ASTM E 119 Standard Time-Temperature Curve

Contracted by APA, an ASTM E 119 fire test was conducted at the National Gypsum Association's fire laboratory on a fully loaded wood I-joist floor system consisting of 9-1/2-inch deep joists spaced 24 inches o.c. The flanges of the I-joists were 1-1/2-inch wide by 1-5/16-inch thick laminated veneer lumber (LVL) and the webs were 3/8-inch thick oriented strand board (OSB). The clear span of the joists was 13 feet 1 inch. The floor sheathing was 23/32-inch thick tongue-and-groove OSB and the bottom of the joists was protected by a single layer of 5/8-inch thick Type X gypsum wallboard. Joints were taped and sealed with joint compound.

The result of the test was that the assembly failed after 32 minutes 58 seconds. This compares to 8 to 12 minutes for an exposed sawn lumber floor system and represents approximately a 300% increase in time to failure under fire load.

3. Floor Behavior During Fires

It is widely recognized that real structure fires, unlike the standard ASTM, NFPA or CAN/ULC test fires, are highly variable in their size, rate of growth and intensity. Responding firefighters are unlikely to know when a given fire started, how hot it has been prior to arrival, how long it has been at any given temperature, the design capacity and actual loads on the floors over the fire or the amount of actual damage that the fire may have done to the joists. All of these factors make it impossible to predict the remaining capacity of a floor by even the most knowledgeable, professional fire experts.



Removing Full-Size I-Joisted Floor Assembly
from the furnace after the ASTM E 119 Test



Fire Protected I-joisted Floor under ASTM E-119 Test
Note Water Containers Leaning Inward Due to Floor Sag

Firefighters should be aware that while floor sag may be a widely accepted warning of an impending structural failure, floor sag is not always present or visible prior to catastrophic collapse in a fire, regardless of the joist type, due to the fire's intensity, the combination of joist spans and loads present, the location of serious structural fire damage or simply because it is too dark and/or smoky to see a sag in the floor. This is true for all types of structural joists, including combustible such as sawn lumber, wood I-joists, and open web wood trusses and noncombustible members such as lightweight steel joists.

When unprotected, any lightweight residential floor/ceiling assembly, either combustible or noncombustible, may fail within just a few minutes of the fire's ignition. When subjected to a standard ASTM E 119 fire test, for instance, unprotected, fully loaded sawn-lumber floor joists typically fail in eight to twelve minutes. When fully loaded and

subjected to the same fire-test conditions, unprotected wood I-joint floors typically fail in four to eight minutes, depending on flange size and web thickness. The few minutes of difference in endurance times among the different types of joists is of no practical use to the firefighter for predicting the safety of the floor. It makes sense, therefore, that when there is a serious fire beneath a floor, there is no "safe" amount of time that anyone can remain on that floor. Any floor system protected or not, can fail unpredictably when exposed to a substantial fire beneath.

4. Gypsum Wallboard Provides Additional Floor Protection

Millions of homes have been built and are still being built with exposed wood floor joists - typically over some type of habitable basement area. The lack of a code-mandated fire-resistance requirement, such as a requirement for a one-hour fire-rated floor, means that the floor framing may not be protected on the underside.

A simple, inexpensive yet significant increase in fire resistance can be achieved in any type of joist or truss system by simply adding a single layer of gypsum wallboard to the underside of the floor joists. The use of 1/2-inch thick ordinary, unrated gypsum wallboard will very likely more than double the fire-endurance time for all commonly used wood floor joist systems, including sawn-lumber, open web wood trusses and I-joists.

Based on this, APA recommends the use of a single layer of 1/2-inch thick gypsum on the underside of all I-joists used in floor/ceiling assemblies over habitable spaces.

5. Summary

It is important for everyone, (home owner, building official, firefighter and others) to remain aware that no amount of additional protection will make any floor "safe" for any predictable minimum length of time when the underside of that floor is exposed to an intense fire. All floor/ceiling assemblies, however, will endure a severe fire longer if protected by gypsum wallboard, regardless of the type of floor framing.

Thus, firefighter and occupant safety can be addressed by early evacuation of occupants through the use of smoke detectors, by adding passive or active fire suppression such as by the use of gypsum wall board and equally important by firefighter education and pre-planning. The wood industry has been actively involved with the USFA in providing educational materials for the fire service and this effort is continuing.

Technical Services Division

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