ENGINEERED LIGHTWEIGHT BUILDING MATERIAL

INTRODUCTION

An engineered lightweight building material is a metal or wood structural element, designed and fabricated to replace a more massive structural element. These elements transfer the loads of the building to the ground. These lightweight elements include the following:

- Steel bar joists (open-web steel joist)
- Steel space frames
- Solid sawn wood joists less than 4 in. (100 mm) nominal thickness
- Composite trusses (Bowstring, parallel cord, scissor, Gable trusses)
- Composite joists (wood I-beams)
- Lightweight trusses
- Glulam beams less than 6 in. × 10 in. (150 mm × 250 mm)
- Wood roof systems with less than 2 in. (50 mm) thick wood decking
- Wood columns less than 8 in. × 8 in. (200 mm × 200 mm)

Heavy structural elements include heavy rolled structural steel shapes, such as "I" beams, and wood structural members, such as glulam beams with dimensions greater than those listed under lightweight elements.

This section provides guidance for the use of engineered lightweight building materials.

POSITION

All buildings and structures should be constructed of substantial, noncombustible material. If the use of substantial noncombustible material is impractical, combustible or lightweight material can be used if protection is provided. The type and design of this protection depends on the occupancy and construction material. If the occupancy is considered to have a light fire loading and the building material is noncombustible, then protection may not be necessary.

Protection can be:

- An acceptable installation of automatic sprinklers installed in accordance with NFPA 13 and PRC.12.1.1.0. When wood joist and composite joist construction is encountered, the installation should be in accordance with sections dealing with concealed spaces which includes firestopping installed in the joists to a maximum 160 ft^3 (4.5 m^3) space.
- A minimum 1 h fire-resistance rated, listed floor-ceiling assembly.

- A minimum 1 h fire-resistance rated, listed fireproofing applied to all structural members.

When a fire-resistance rated floor-ceiling assembly is to be attached to the bottom of existing composite trusses and composite joists, conduct a structural analysis of the existing assembly to determine whether or not the existing assembly can support the additional weight. The floor-ceiling assembly should be attached directly to the bottom cord of the composite joists, and firestopping should be installed in the joist space at a maximum 160 ft^3 (4.5 m^3) spacing.

Select the building material compatible with the environment inside the building. For example, do not install steel bar joists and a metal deck over fertilizer storage, battery charging areas, or other corrosive environments, unless there is a protective coating on the steel. Do not install wooden structural elements, such as joists, composite trusses, composite joists, and glulam beams over swimming pools, hot tubs, laundry facilities and other high humidity environments, unless the wooden elements are coated with a sealant.

DISCUSSION

Buildings constructed with wooden, lightweight materials have a higher probability of total roof collapse during a fire when an automatic sprinkler system is impaired. Total roof collapse can also occur in a building constructed of either heavy rolled structural steel shapes or steel bar joists and a combustible roof assembly. Even buildings with multiple sprinkler risers are subject to total collapse.

Buildings constructed of fire resistive material can withstand the destructive forces a fire creates. However, constructing a building from concrete can be very expensive and impractical in some areas. Heavy rolled structural steel shapes and a noncombustible roof can also withstand the destructive forces, but if the temperature of the steel reaches approximately 1000°F (535°C) it starts to elongate. When the temperature reaches approximately 1300°F (700°C), the steel starts to lose structural strength and yield. The greater the mass of a steel shape, the longer the steel will remain in place before yielding.

The use of engineered lightweight building materials is not a new concept in building construction. Solid sawn wood joists have been around for centuries. Houses are the most common buildings constructed of solid sawn joists. The first known use of a fabricated lightweight building material was in 1850 when iron sheets were used to fabricate a joist. The first steel bar joist (open web steel joist) was fabricated in 1923. In 1960 the first wooden composite joist was fabricated.

Engineered lightweight elements have replaced heavy rolled structural steel shapes in many buildings because of the ease of installation, reduced weight, and reduced cost. These elements are less massive than the steel shapes and therefore will lose their structural strength sooner if temperatures exceed 1300°F (700°C). An open web steel bar joist subjected to fire testing in accordance with ASTM E119, ISO 834-1, EN 1363-1, and AS/NZ 1530 failed in 12 min when the roof assembly was loaded to simulate roof loads. A larger steel beam subjected to the same loading and test failed in 30 min.

Structures can be of such substantial mass that a fire will have to be burning for a long time before the building will collapse. One example is a building constructed of at least 2 in. (50 mm) thick wood roofs on at least 6 in. × 10 in. (150 mm × 250 mm) wooden beams or girders. Another example is 4 in. × 6 in. (100 mm × 150 mm) wooden trusses supported by 8 in. × 8 in. (200 mm × 200 mm) wood columns.

Composite trusses, composite joists, wood joists, lightweight trusses, glulams, and plywoods have replaced the heavier, thicker solid sawn timbers, columns, and planks in construction. Two problems with these lighter materials are fire endurance and moisture.

Tests conducted in accordance with ASTM E119, ISO 834-1, EN 1363-1, or AS/NZ 1530 show that a 2 in. × 10 in. (50 mm × 250 mm) solid sawn joist fails in approximately 11 min, while a 7 in. × 21 in. (175 mm × 525 mm) wood beam remains intact for more than 30 min. In another test, the solid sawn joists performed better than composite trusses and composite joists. The solid sawn joists lasted 10 min while the composite elements lasted 5 min.

Numerous tests conducted on joists and glulam beams showed that moisture can affect the structural strength of any untreated or unprotected wood. As the moisture content of the wood increases or decreases, the wood swells and shrinks.

Testing of solid sawn joists and composite joists indicated high humidity (95%) environments cause the joists to lose some structural strength. Collapse could result if this problem is not addressed in the design and fabrication. Also, if a composite truss is fabricated with a high moisture content (12%) and the wood becomes dryer because of a low humidity (65%) environment, the gusset plate can become loose and reduce the ability of the truss to carry the design load.

Moisture also affects glulam beams. A series of tests were conducted to determine the effect moisture has on the strength of glulam beams. The tests used one, two, and three 1½ in. (38 mm) through-bolt connectors on glulam beams with a moisture content of 12% as fabricated and 8% after drying. The results indicated the ability of the beam with through-bolt connectors to carry the load decreased by as much as 73% when the moisture in the beam declined to 8%. Wood joists and trusses coated or treated with a moistureproof material, such as polyurethane, varnish, paint, or exterior or marine grade adhesives, will not lose moisture to, or gain it from the environment.