SBC ASSOCIATION

Research Report

Sprinkler Systems and Wood Trusses

SRR No. 1509-04

Structural Building Components Association (SBCA)

October 23, 2015

SBCA is an APPROVED SOURCE

This research report is based on practical scientific research (literature review, testing, analysis, etc.), with the goal of supporting strategic needs for code and standards development and market expansion. This research report complies with the following sections of the building code:

- *IBC* Section 104.11.1 and Section 1703.4.2 – "**Research reports.** Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this code, shall consist of valid research reports from *approved sources*."
- *IBC* Section 202 – "**APPROVED SOURCE.** An independent person, firm or corporation, *approved* by the *building official*, who is competent and experienced in the application of engineering principles to materials, methods or systems analyses."

Structural Building Components Association (SBCA) | 6300 Enterprise Lane, Madison, WI 53719 | 608-274-4849 | sbcindustry.com

Table of Contents

Introduction:

The following information is intended primarily for construction design professionals that design with light wood framing. The goal of this document is to assist in designing safe buildings economically, especially when sprinkler systems are required or desired in the design.

The Structural Building Component Association (SBCA) supports making a positive effort to promote universal building installation of sprinklers for all types of construction and structural elements, provided they are cost effective and do not create a competitive advantage for one structural element over another. Installed and functioning sprinkler systems can save lives and reduce property damage. This is a win for everyone: the owner/occupant, firefighters, insurers, and the community in general.

Due to the development of residential sprinkler system standards and components specifically designed to meet residential requirements, a residential sprinkler system can be installed affordably. The inclusion of a sprinkler system can pay for itself through lowered insurance costs, reduced corridor widths, less expensive wall and door assemblies/finishes, the reduction or elimination of exit requirements, and enhanced resale value.

Authoring numerous codes and standards related to fire safety, the National Fire Protection Association (NFPA) is an international non-profit organization advocating fire prevention and safety. The NFPA publishes three separate standards dealing with the installation of sprinklers in buildings. The purpose of the NFPA sprinkler system standards is to fairly evaluate construction practices and materials and define methods to best protect the occupants, the contents, and the structure in the event of fire. NFPA 13 is the over-arching standard for sprinkler system protection. However, in evaluating the methods promoted by this standard, the implementation of these methods in residential construction was seen as cost-prohibitive. The 13D and 13R standards were created to cover very specific classes of residential construction: one- and two-family up to four-story multi-family residential buildings.

The NFPA standards are designed with two specific but not always equal considerations:

- Life protection.
- Property protection (contents and/or structure).

Protection of life is the primary consideration in residential sprinkler system design. Preservation of property is generally dominant in non-residential design.

The information in this document is applicable to the 2010 or 2013 editions of the NFPA standards. It is intended to provide general guidance and does not represent the full complexity of the NFPA standards.

- the *IBC*-06 references NFPA 13, 13D, & 134R, 2002 editions – *IRC*-06 references NFPA 13, 2002 edition
- the *IBC*-09 references NFPA 13, 13D, & 134R, 2007 editions – *IRC*-09 references NFPA 13 & 13D, 2007 editions
- the *IBC*-12 references NFPA 13, 13D, & 134R, 2010 editions – *IRC*-12 references NFPA 13 & 13D, 2010 editions
- the *IBC*-15 references NFPA 13, 13D, & 134R, 2013 editions – *IRC*-15 references NFPA 13 & 13D, 2013 editions

Key Definitions:

WOOD TRUSS: Individual metal plate connected wood component manufactured for the construction of the building.

TRUSS PANEL: The chord segment defined by two successive panel points.

TRUSS PANEL LENGTH: The centerline distance between panel points measured along the chords

TRUSS PANEL POINT: Location on a truss where the web members and top or bottom chords intersect and are connected by metal connector plates.

TRUSS WEBS: Members that join the top and bottom chords to form the triangular patterns typical of trusses. These members typically carry axial forces.

From NFPA 13-2013

OBSTRUCTED CONSTRUCTION: Panel construction and other construction where beams, trusses, or other members impede heat flow or water distribution in a manner that materially affects the ability of sprinklers to control or suppress a fire.

UNOBSTRUCTED CONSTRUCTION: Construction where beams, trusses, or other members do not impede heat flow or water distribution in a manner that materially affects the ability of sprinklers to control or suppress a fire. Unobstructed construction has horizontal structural members that are not solid, where the openings are at least 70 percent of the cross-

section area and the depth of the member does not exceed the least dimension of the openings, or all construction types where the spacing of structural members exceeds 71/2 ft. (2.3 m) on center.

NONCOMBUSTIBLE MATERIAL: A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Materials that are reported as passing ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, shall be considered noncombustible materials.

LIMITED-COMBUSTIBLE MATERIAL: Refers to a building construction material not complying with the definition of noncombustible material that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu per lb. (8141 kJ/kg) (see NFPA 259, and includes either of the following: (1) materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of 1/8 in. (3.2 mm) that has a flame spread index not greater than 50; or (2) materials, in the form and thickness used having neither a flame spread index greater than 25 nor evidence of continued progressive combustion and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread index greater than 25 nor evidence of continued progressive combustion when tested with ASTM E 84, *Standard Test Method of Surface Burning Characteristic of Building Materials*, or ANSI/UL 723, *Standard Test Method of Surface Burning Characteristic of Building Materials*.

Background:

Fire Sprinkler Systems may be used as an effective method of providing fire protection. When Fire Sprinkler Systems are used with truss systems, it is essential to design the trusses to carry the additional dead load and required live loads imposed by the Fire Sprinkler System. This *SBCA Research Report* provides information to aid in the design of buildings with wood floor and/or roof trusses that are required to support Fire Sprinkler Systems.

The use of automatic Fire Sprinkler Systems in commercial, multifamily, and residential construction is intended to provide improved protection to a building and its contents from damage due to fire. It is also intended to provide improved protection from injury of the building's occupants. As metal plate connected wood truss usage has become more prevalent in all construction types, it is essential for the Building Designer to consider the loads imposed on the truss system and provide the Truss Designer with this information. This allows the Truss Designer to make provisions in the truss design for the structural effects of the Fire Sprinkler Systems.

The open webbing of truss construction makes it highly compatible with other building trades. Water lines for sprinkler systems can be run through the open webbing making maximum use of the available space and eliminating costs associated with drilling or the loss of headroom. Occasionally, a building's use or its contents demand a Fire Sprinkler System with special layout requirements and heavy main waterlines that cannot be compromised. Truss construction can easily be manipulated with adjustments to panel lengths and web configurations to accommodate most special requirements.

Application:

NFPA 13D - One- and Two-Family & Manufactured Homes (as defined by NFPA 13D-2010/13, Section A1.1) (see also *IRC* Section 2904)

If sprinklers are specified or required by the building code . . .

LOCATION OF SPRINKLERS:

Sprinklers shall be installed in all locations per the 13D requirements **except** the following locations (13D-2010, Sections 8.6.2 – 8.6.7 & 13D-2013, Sections 8.3.2 – 8.3.8) (see also *IRC* Section 2904.1.1):

- Bathrooms 55 ft^2 and less.
- Closets 24 ft^2 and less.
- Garages, open attached porches, carports and similar structures.
- Attics, floor/ceiling spaces, crawl spaces, and other concealed spaces that are not used or intended for living purposes.
- Covered unheated projections at entrances that are not the only means of egress.
- Ceiling pockets where the following conditions are met:

  - Total volume of all unprotected ceiling pockets in a compartment does not exceed 100 ft^2.
  - The entire floor under the unprotected pocket is protected by the sprinklers at the lower ceiling level.
  - The interior finish of the unprotected pocket is noncombustible or limited-combustible material.
  - Skylights not exceeding 32 ft^2 shall be permitted to have a plastic cover.
- Closets in garages and exterior closets where there is no unprotected penetration into the dwelling unit.

NOTE: Although basements are not excluded, a basement may be sprinklered as if the ceiling were finished (13D-2010/13, Section 8.2.4).

SPRINKLER HANGER REQUIREMENTS:

NFPA 13D has its own specific sprinkler hanger requirements. Since most residential sprinkler systems use the domestic water system, little or no extra design loading is required for roof or floor systems.

NFPA 13R - Multi-Family 4 stories or Less (2013 adds not exceeding 60 ft above grade plane)

This category includes (as defined by NFPA 13R-2010, Sections 1.1 & 3.3.7 & 13R-2013, Sections 1.1 & 3.3.9):

- Apartment buildings and condominiums.
- Lodging and rooming houses.
- Board and care facilities (slow evacuation type with 16 or fewer occupants and prompt evacuation type).
- Hotels, motels, and dormitories.

NOTE: some building code editions allow a 2 hour separation wall to divide larger multi-family buildings into one- and two-family dwellings allowing them then to be sprinklered per NFPA 13D requirements.

If sprinklers are specified or required by the building code . . .

LOCATION OF SPRINKLERS:

All areas are to be sprinklered **except** the following (13R-2010/2013, Section 6.6):

- Bathrooms 55 ft^2 and less.
- Closets or pantries within dwelling unit 24 ft^2 and less, least dimension does not exceed 3 ft, walls & ceiling covered with noncombustible or limited-combustible materials.
  - Except for closets within dwelling unit used for heating and air-conditioning equipment (2013 adds washers, dryers or water heaters).
- Porches, balconies, corridors, and stairs that are open and attached (2013 adds porte cocheres).
  - 2013 adds: sprinklers are required for roofed exterior balconies or decks and ground floor patios in buildings of Type V Construction.
  - 2013 adds: requirements for sidewall sprinkler installation
- Attics, penthouse equipment rooms, elevator machine rooms, concealed spaces containing only dwelling unit ventilation equipment, crawl spaces, floor/ceiling spaces, noncombustible elevator shafts, and other concealed spaces that are not intended for living purposes or storage and do not contain fuel-fired equipment.
  - If fuel-fired equipment is present, at least one quick-response intermediate temperature sprinkler is required.
- Closets on exterior balconies and exterior breezeways/corridors as long as there are no penetrations into dwelling unit.
- 2013 adds: requirements for interior stairwells and spaces below them.

SPRINKLER HANGER REQUIREMENTS:

Sprinkler hangers follow NFPA 13 standard requirements. Roof and floor design loads must be adjusted for sprinkler system weights (see Design Load Considerations).

NOTE: where good design allows, there can be an economic advantage to designing a building to fit within the requirements of NFPA 13R rather than NFPA 13. However, some code jurisdictions require NFPA 13 protection for buildings in this category.

NFPA 13 - Everything Not Covered by NFPA 13D or 13R Follows NFPA 13 Standard

A Roof/Ceiling or Floor/Ceiling construction can be constructed either in an open space environment or be constructed with ceilings that enclose the structural members and create concealed spaces within the floor or roof assemblies. There are two categories of construction type defined to determine the spacing and positioning rules for sprinklers - **OBSTRUCTED** or **UNOBSTRUCTED CONSTRUCTION**.

Examples of **OBSTRUCTED CONSTRUCTION** (13-2010/13, Sections 3.7.1, A3.7.1 & 8.6.4.1.2) include:

- Beam and Girder – spaced 3' to 7.5' on center and 4" or greater in depth.
- Composite Wood Joists (I-Joist) requiring fire-stopping so channels do not exceed 300 ft^2
- Panel where spacing of structural members creates panels of less than 300 ft^2.
- Semi-Mill (modified standard mill) with greater column spacing and beams resting on girders.
- Wood Joists (2x or 4x wide max and 14" deep max) regardless of spacing. 2013 adds: wood joists may exceed 14" depth.
- Bar joists that are 30% obstructed
- Steel Purlin construction
- 2013 adds: Truss Construction (wood or steel) parallel or pitched chord members constructed by open web members with top and bottom members greater than 4" in depth* (see 70% rule)
- 2013 adds: Bar Joist Construction (wood or steel) with top and bottom chords greater than 4" in depth.

Examples of **UNOBSTRUCTED CONSTRUCTION** (13-2010/13, Sections 3.7.2, A3.7.2 & 8.6.4.1.1) include:

- Any construction where supporting members are spaced 7.5' on center
- Where spacing is less than 7.5' on center, any structural member that is not solid and where openings are at least 70% of cross section and the depth does not exceed the least dimension of the openings.
- Bar Joists (steel or wood) with top and bottom chords not exceeding 4" in depth
- Open Grid Ceilings
- Smooth Ceilings (as detailed)
- Standard Mill – heavy timber construction
- Truss Construction (wood or steel) parallel or pitched chord with bottom chords not exceeding 4" in depth* (see 70% rule.)

If the assembly is constructed as a floor/ceiling or roof/ceiling arrangement and is partially or wholly enclosed by combustible construction, the concealed space may be required to be protected by sprinklers.

CONCEALED COMBUSTIBLE SPACES, exceptions to the requirement for sprinklers in combustible floor/ceiling or roof/ceiling concealed spaces are allowed (13-2010/13, Section 8.15.1.2) where the space is:

- Formed by studs or joists with less than 6" between edges.
- Formed by bar joists with less than 6" between roof/floor and ceiling.
- Formed by ceilings attached to or within 6" of wood joists.
- Formed by ceilings directly attached to composite wood joists provided joist channel is fire-stopped into volumes not exceeding 160 ft^3 with material equal to that of the webs.
- Entirely filled with non-combustible insulation*. 2013 adds: a maximum 2" air gap at top of space is permitted.
- Within wood or composite joist construction with insulation filling space from ceiling to bottom of joist and in composite wood construction fire stopped into volumes not exceeding 160 ft^3 with material equal to that of the webs.
- Over isolated small rooms not exceeding 55 ft^2 in area
- Created with rigid materials with any exposed surface having a flame spread rating of 25 or less.*
- Constructed entirely of fire-retardant treated wood as defined by NFPA 703.*
- Noncombustible construction having exposed combustible insulation where the heat content of the facing and substrate does not exceed 1000 BTU/ft^2.
- Created by insulation laid directly on top of or within the ceiling joists in an otherwise sprinklered attic.
- A pipe chase under 12 ft^2 formed by studs or wood joists, provided they are fire stopped at each floor and contain no sources of ignition.
- Exterior columns under 10 ft^2 in area formed by studs or wood joist, supporting exterior canopies that are fully protected with a sprinkler system.
- Noncombustible or limited-combustible suspended ceilings suspended from wood joists or composite wood joists, wood bar joists or wood trusses having insulation, where the heat content of the facing and substrate does not exceed 1000 BTU/ft^2, filling the gap between the structural members and which have sprinklers above the insulation*.

- Noncombustible or limited-combustible suspended ceilings suspended from wood joists or composite wood joists where the space between the members is filled with noncombustible batt insulation with a maximum 2" air space between the insulation and the roof decking.
- Soffits, eaves, overhangs & decorative frame elements made of combustible material not exceeding 4 ft in width or volume not exceeding 160 ft^3 and which are separated from the interior of the building by noncombustible or limited-combustible material and which contain no unprotected penetrations to the interior of the building.

NOTE - * applies to truss systems

70% RULE

(Unobstructed Construction 13 2010/13, Section 3.7.2)

In these examples a single panel is being calculated. If a truss is not completely uniform, the entire truss will have to be included in the calculation. This rule can only be applied to a specifically designed truss.

The truss members in Figure 1 are 2x4's oriented horizontally (4x2):

Area of the panel = 24" x 30" = 720 in^2

Chords = 2 x (30" x 1.5") = 90 in^2

Webs = 2 x (25.816" x 1.5") = 77 in^2

Total area = 90 + 77 = 167 in^2

Area of panel divided by obstructed area = 167/720 = 0.233 or 23%

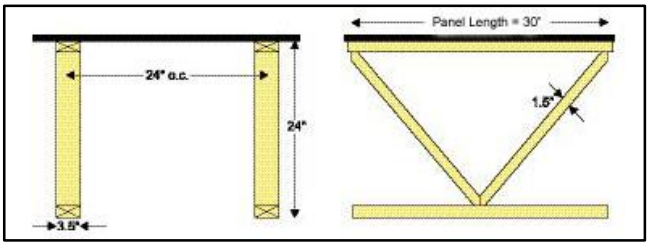

Figure 1 - 4x2 Example

The panel is 77% open, therefore this configuration would be considered **'Unobstructed Construction**.'

The truss members in the Figure 2 are 2x4's oriented vertically (2x4):

Area of the panel = 24" x 30" = 720 in^2

Chords = 2 x (30" x 3.5") = 210 in^2

Webs = 2 x (25.81" x 3.5") = 181 in^2

Total area = 210 + 181 = 391 in^2

Area of panel divided by obstructed area = 391/720 = 0.543 or 54%

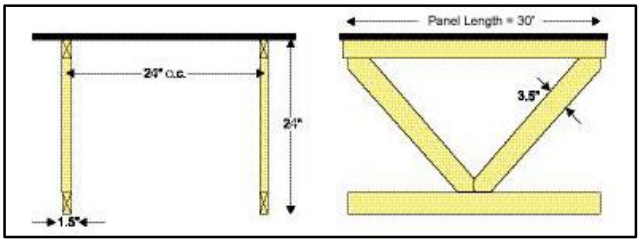

Figure 2 - 2x4 Example

The panel is 46% open, therefore this configuration would be considered **'Obstructed Construction**.'

Design Load Considerations

The Building Designer must include adequate dead load information (i.e., magnitude and exact location) to account for the additional weight of the sprinkler system (generally expressed in pounds per square foot). Not only must the dead load of the sprinkler system be provided but also the specific locations of the load attachments for the truss design process. In addition to the weight of the water-filled pipe, a 250 pound load per attachment must be applied at each point of hanging to accommodate installation personnel per NFPA 13 2010/13: Section 9.2.1.3.1. This is a short term load neither applied simultaneously to all support points nor simultaneous with other short duration loads.

It is generally best to support the sprinkler system from the top chord of the truss. When conditions require that attachment be made to truss bottom chords, special provisions must be made by the Truss Manufacturer. Trusses can support significantly higher loads at panel points (i.e., where the chords and web members meet) than in the spaces between panel points. The location of the pipe support relative to the panel points of the truss is critical for the design. Once the support connection types and points have been determined, it is critical that they are followed during the installation process.

Smaller point loads are generally designed to be carried by each truss. However, the larger point loads created by large diameter sprinkler lines, significant risers and lines running parallel to trusses may require very specific attachment points or additional members. Refer to NFPA 13, Chapter 9 and the Metal Plate Connected Wood Truss Handbook for further support information.

Conditions of Use:

Because of the variation in the adoption of the NFPA standards into national, regional, state, and local building codes, the design professional is responsible for understanding and designing to the governing local code.

Regardless of whether a sprinkler system is installed or not, smoke detectors, draft and firestop construction, and rated assemblies must be included as required by the governing building code.

Although exceptions to sprinklering certain areas are allowed, the level of safety is not equivalent to that if the area were sprinklered. However, the building is still considered sprinklered throughout as required by the model codes.

Special sprinklers have been developed for specific applications in concealed roof/ceiling or floor/ceiling cases where trusses are used. They address protection for flat concealed spaces as well as pitched roof attic spaces, including hipped roofs.

Building Designer Responsibility:

Unless the AHJ allows otherwise, the Construction Documents shall be prepared by a Building Designer (e.g., Owner, Registered Design Professional, etc.) for the Building and shall be in accordance with *IRC* Section R106 and *IBC* Section 107.

The Construction Documents shall be accurate and reliable and shall provide the location, direction and magnitude of all applied loads and shall be in accordance with *IRC* Section 301 and *IBC* Section 1603.

Construction Documents shall be submitted to the Building Official for approval and shall contain the plans, specifications and details needed for the Building Official to approve such documents.

Responsibilities:

- The information contained herein is a product, engineering or building code compliance research report prepared in accordance with the referenced building codes, testing and/or analysis using accepted engineering procedures, experience and good technical judgment.
- Product, design and code compliance quality control are the responsibility of the referenced company. Consult the referenced company for the proper detailing and application for the intended purpose. Consult your local jurisdiction or design professional to assure compliance with the local building code.
- SBCA research reports provide an assessment of only those attributes specifically addressed within a given report.
- The engineering evaluation was performed on the dates provided in this report, within SBCA's scope of work.

This research report is subject to periodic review and revision. For the most recent version of this report, visit sbcindustry.com. For information on the current status of this report, contact SBCA.

References:

ANSI/AWC National Design Specification® (NDS®) for Wood Construction, 2012, by the American Wood Council

ANSI/TPI 1 National Design Standard for Metal Plate Connected Wood Truss Construction, 2007, by Truss Plate Institute

ASCE/SEI 7, Minimum Design Loads for Buildings and Other Structures, 2010, by the American Society of Civil Engineers and the Structural Engineering Institute

International Building Code, 2012 & 2015, by the International Code Council

International Residential Code, 2012 & 2015, by the International Code Council

NFPA 13, Standard for the Installation of Sprinkler Systems, 2010 and 2013, by the National Fire Protection Association

NFPA 13R, Standard for the Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height, 2010 and 2013, by the National Fire Protection Association

NFPA 13D, Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes, 2010 and 2013, by the National Fire Protection Association
NOTE: NFPA Standards may be viewed for free at the NFPA Free Access site by signing in.

Metal Plate Connected Wood Truss Handbook, Third Edition, 2002, Chapter 17 Part 1 & Part 2, by the Structural Building Component Association, 6300 Enterprise Lane, Madison, WI 53719.