

Fire Protection Alternatives for Metal Buildings

Spray-applied Fire Resistive Materials and Intumescent Coatings Can Be Specified for Columns and Frames

When fire protection of metal building frames is required by the building code, the assemblies have historically been gypsum board enclosures, such as UL Design No. X524. However, a recent study, sponsored by the Metal Building Manufacturers Association (MBMA), determined that it is also feasible to use other common materials such as spray-applied fire resistive materials (SFRM) or intumescent coatings.

Nestor Iwankiw, PE, SE, Ph.D. of Jensen Hughes studied 180 single-story metal building designs that varied in span length, roof slope, and location in the continental United States. The weight-to-heated-perimeter ratio (W/D) values of the rigid frame members were determined for the metal building designs.

The results support the use of spray-applied products and intumescent/mastic coatings on metal building frames with a W/D of at least 0.30 lb/ft/in., the value for a W8x10 steel member. Several column assemblies, such as UL Design Nos. X632, X649, X772 and X829, have a minimum W/D of approximately 0.30 lb/ft/in.

If you have specific questions, contact the MBMA Engineering Department at 216.241.7333 or mbma@mbma.com.

By investigating W/D values of metal building frames, we demonstrated that alternative fire protection materials and products can be specified to accommodate various architectural schemes.



Fire protection using SFRM and intumescent coatings can be considered where a finished interior appearance with gypsum board is not necessary, such as industrial and warehouse buildings.



The minimum W/D should be specified for alternative fire protection assemblies, in addition to the structural criteria.



EXECUTIVE SUMMARY

W/D Study of Non-prismatic (built-up) I-shaped Framing Members in Metal Buildings

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Project 1NRI00074.000

March 8, 2019

The weight to heated perimeter ratio (W/D in lb/ft/in. US customary units) of I-shaped steel members is an important parameter for the fire resistance rated design of steel structures. Larger W/D values (for heavier shapes) indicate the presence of greater thermal inertia which enables better fire resistance, and vice-versa. Fire resistance rated assemblies are based on the tested specimen size(s) and their design applications are limited to members with W/D equal to or greater than the minimum W/D. Thus, a given fire resistance rated assembly cannot be directly used for comparatively lighter members with a smaller W/D than the minimum value listed in an assembly.

Metal building systems commonly use non-standard built-up steel shapes that are also typically non-prismatic (meaning cross-section area varies along the member length). Because of these unique and optimized frame configurations for the required design loads, the current design range of the rigid frame members is unknown. Therefore, there was a need to develop a representative design database for the industry for the purpose of identifying the members with lower W/D values which may be at risk of not being directly allowable within the existing inventory of fire resistance rated assemblies or future MBMA project developments.

The MBMA Fire & Insurance Committee decided in 2018 to address this need through a representative series of single-story metal building designs generated by Metal Building Software, Inc. (MBS), a MBMA Associate Member, in lieu of a membership survey. The postulated design variables were three frame spans and two roof slopes intended for the building code and load requirements in 30 cities within the continental United States. The resulting database of 180 designs provided by MBS was processed to compute the W/D values for the cross-sections of the rigid frame members.

While this comprehensive database of 180 frame designs also remains available for other analyses and/or information retrieval as may be deemed necessary, the main results of this work to date relative to the industry W/D range are the following:

- minimum W/D was 0.24 lb/ft/in. for columns of the shorter 50-ft frame spans in locations with little or no snow accumulation.
- maximum member W/D in this database was approximately 1.0 lb/ft/in., which occurred for the columns and rafters of the longer 150-ft frame spans in the cities with the greatest snow design loads.

A review of several existing rated UL column assemblies for gypsum board enclosures and other types of contour-applied protection revealed a general W/D lower bound of approximately 0.30 lb/ft/in., the value for a W8x10. Thus, there is only small difference in the lowest W/D of 0.24 lb/ft/in. for I-shaped members in rigid frames compared to a common minimum W/D limit of 0.30 lb/ft/in. and minimum limit in UL Design No. X524 of 0.27 lb/ft/in. Furthermore, these results indicate that a viable opportunity already exists for increasing applications of spray-applied products and intumescent/mastic coatings in metal buildings for structural framing members with a W/D of at least approximately 0.30 lb/ft/in. in column assemblies, such as UL X632, X649, X772, and X829. Consideration is encouraged for alternative potential uses of spray-on protection in industrial or warehouse metal buildings, and the like, wherein a finished interior appearance with gypsum board is not necessary.

I-shaped rigid frame members with W/D less than approximately 0.30 lb/ft/in. can occur in metal building construction. If fire protection is required, it is recommended that the framing members be checked for the minimum W/D limit during design in addition to the structural criteria.