



JENSEN HUGHES

Advancing the Science of Safety

EXECUTIVE SUMMARY

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

Prepared for:

Metal Building Manufacturers Association
1300 Sumner Avenue
Cleveland, OH 44115

By:

Nestor Iwankiw
Jensen Hughes
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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.