Engineering Notes

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UL Assemblies - Minimum Beam Size

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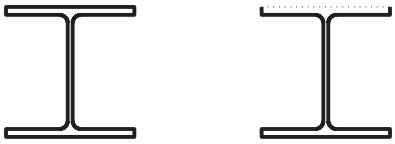
Steel floor and roof systems are usually part of an UL Fire Resistance Assembly. These assemblies specify a minimum beam or joist size. For example, Design #G515 requires a W8x15 minimum.

Would a W10x12 be an acceptable shape for UL G515? For fire resistance purposes, the beam size is expressed in terms of the weight per foot divided by the exposed perimeter. This is the W/D ratio. By this method, the W10x12 is not larger than the W8x15.



Full Perimeter

Top Surface Excluded

The perimeter is defined as the interface between the beam and the protection material. Thus, a beam directly under a concrete slab would not have its top surface "exposed." However, a beam supported a corrugated steel deck would have portions of the top surface exposed.

This leads to two common variations of the W/D ratio: one using the full perimeter, and one excluding the top flange surface. In practice, I typically calculate both values and exclude any shapes that do not meet the criteria for either case.

Minimum Joist Sizes

UL assemblies also specify minimum bar joist sizes. Occasionally, older H-series joists are designated. For floor/ceiling assemblies, alternate joists can be used as long as their weight per foot and their depth meet or exceed the specified joist. Note that both these requirements must be met. For roof/ceiling assemblies, there is the additional requirement that joists be 10" deep minimum.

In my opinion, the minimum depth requirement means that joist substitutes (VS series) should not be used; although they are clearly more compact. Perhaps one could justify these shapes in terms of their W/D ratios.

Restrained versus Unrestrained

A related topic concerning UL assemblies is the restrained versus unrestrained designation. Restrained assemblies are ones in which the surrounded structure prevents thermal expansion of the assembly.

This is accomplished in the UL laboratory by building a very stiff frame into which the test structure is enclosed. The frame remains outside the fire area. It is acceptable to use the restrained designation when the actual structure provides surrounding stiffness in excess of the test parameters.

The reason restrained ratings are usually higher than unrestrained is because of secondary stresses created by the restraint. In other words, when the heated beams expand, they squeeze against the surrounding structure. But the surrounding structure does not budge. The resulting compressive stresses in the assembly offset bending stresses and "strengthen" the beam.

In real structures, it is very difficult to justify a restrained assembly. Basically it requires a confining structure to surround the assembly,

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which does not undergo thermal expansion. If this confining structure were to expand, then it would offer reduced, or no, resistance to the assembly's expansion. An assembly that goes from exterior wall to exterior wall is free to expand everywhere.

Therefore, I recommend using unrestrained assemblies. Exceptions could be small areas surrounded by concrete walls or perhaps an isolated, new floor section in an existing concrete structure. For these special cases, the stiffness can be calculated and compared to the test frame stiffness.

The architect should communicate the UL assembly designations to the structural engineer before they begin design. It is a simple matter to program analysis software to automatically exclude beams that do not meet the W/D requirements.

Online Caculator

There is an online calculator in the library of our website: www.wsengineer.com. If you select a beam shape from the drop-down list, the program will return a list of all the wide-flange shapes that **cannot** be used, i.e. those shapes whose W/D ratios are less than the specified shape.

We also have a list of H-series joists and their weight-per-foot. This information is not always easy to find since these joists are no longer being produced.

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