Design of Steel Members Subject to Torsion Stresses per AISC360-16

An Online Continuing Education Course for Engineers

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1. Introduction:

Steel structures are used very widely in these days, because of many reasons, like rapid construction, ease of erection, and controlled quality of fabrication.

The processes of structural design can be summarized in the following steps (Figure 01):

1. Determination of applied loads.
2. Selection of economic and proper structural system.
3. Structural analysis of the structural system to get internal actions.
4. Design of structural members to resist internal actions.

By putting the loads on the chosen statical system, we get the straining action in the members of the statical system; by the different analysis methods, these straining actions are several, such as tension, compression, flexure, shear, and torsion.

In this course, we will study the design of steel members subject to torsion stresses, which exist in many steel structures, such as edge beams with eccentric loading and crane beams.

Also, we will study the design of steel members subject to torsion only, such as spandrel beams at building external walls that usually carry eccentric block load that causes torsion in the beam.

This course is the third course of a series related to the design of members; all of these courses are independent and do not require any perquisites. The following is the list of related courses:

1. Design of Steel Tension Members per AISC360-16.
2. Design of Steel Compression Members per AISC360-16.
3. Design of Steel Flexure Members per AISC360-16.
4. Design of Steel Members Subject to Shear per AISC360-16.
5. Design of Steel Members subject to Combined Stresses per AISC360-16.
6. Design of Steel Members subject to Torsion per AISC360-16.

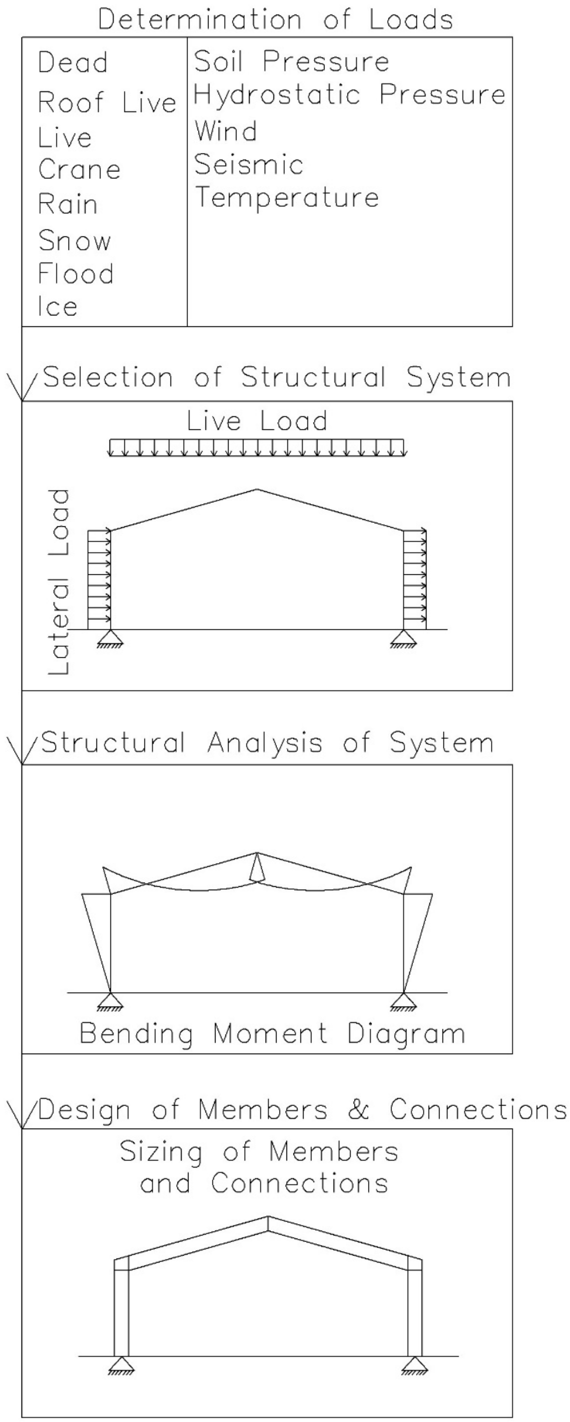


Figure (01). Steps of Structural Design

This course covers the following topics:

1. Fundamentals of Torsion.
2. Torsional shear stresses and shear due to warping.
3. Normal stresses due to warping.
4. Torsional stresses in open cross-sections, single angles, structural tees, closed and sold sections.
5. Design of HSS members subject to torsion.
6. Design of HSS members subject to combined torsion, shear, flexure, and axial force.
7. Design of non-HSS members subject to torsion and combined stresses.

Torsion stresses are not common in typical steel buildings, but in some cases, torsion stresses are significant and shall be considered. Examples of these cases are spandrel beams that exist at the perimeter of the building to carry the façade or exterior block wall of the building, crane beams, and edge beams carrying secondary beams.

For the crane beams, the torsion stress results from the lateral thrust of the crane load at the top of the rail, which is transmitted to the shear center with a torsional moment.

2. Fundamentals of Torsion:

To understand the torsion stress, the reader shall understand the concept of the shear center.

The shear center is the point through which the applied shear loads pass to produce flexure without causing torsion. For doubly symmetric sections, it must pass through the center of gravity, but for singly symmetric sections, it lies on the line of symmetry.

The center of gravity is the point through which the applied axial loads pass to produce pure axial stress without causing a flexure.

Figure (02) shows different shapes and the locations of their shear center and centroids.

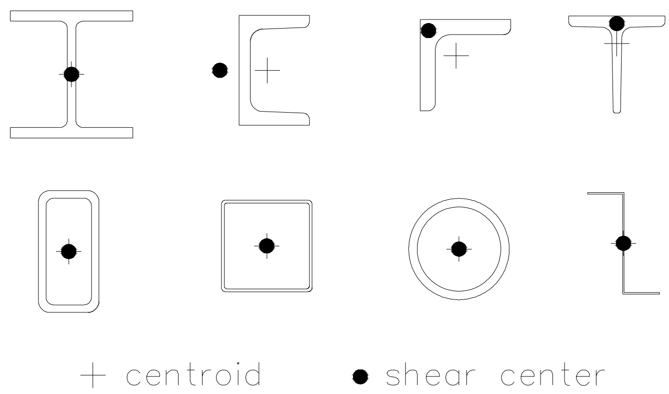


Figure (02). Shear Center and Center of Gravity of Structural Shapes

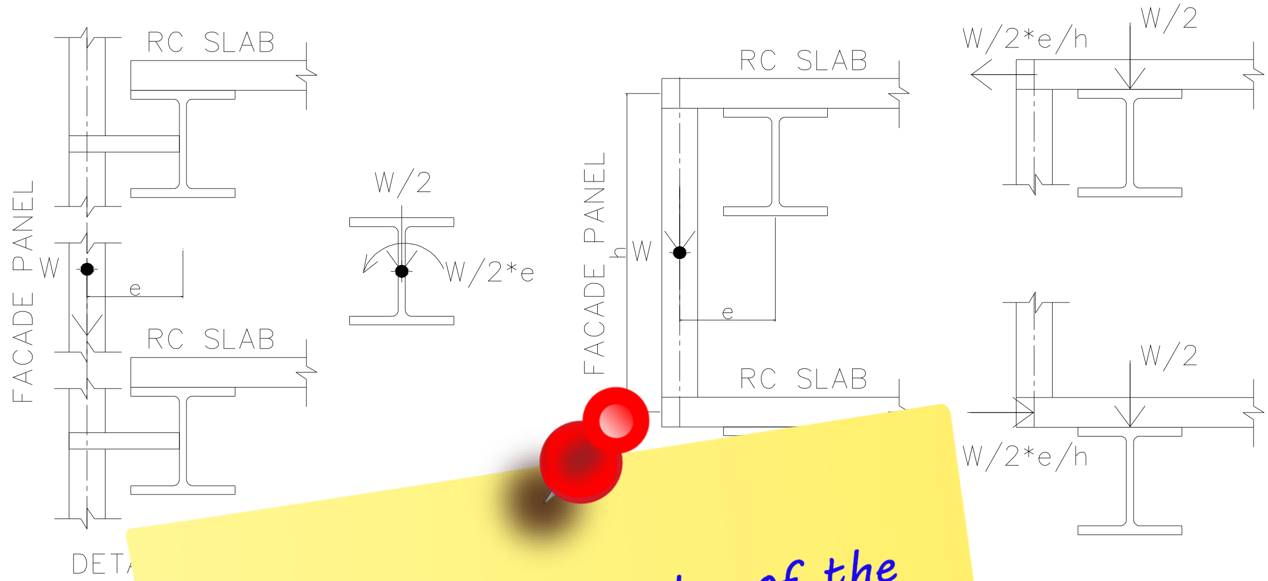
It is prudent to minimize the effect of torsion as much as possible because of the low resistance of W-Shapes to the torsional stresses.

The following discussion demonstrates ways to minimize the torsional stresses.

Figure (03) shows a spandrel beam that carries an external façade panel. By replacing detail No.1 with detail No.2, we can eliminate the effect of torsional stresses.

Detail No. 1 transfers the gravity load of the façade panel to the spandrel beam by moment and torsion.

Detail No. 2 transfers the lateral component of the torsion resulting from the gravity load of the façade panel to the upper and the lower diaphragms. In this case, the spandrel beam carries only the vertical component of the torsion resulting from the gravity load of the façade panel.



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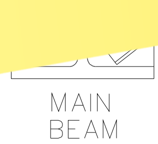

Figure (04). Main Beam subject to Torsion

Torsional restrain may be achieved by providing a kicker between the secondary beam and bottom flange of the main beam or by providing a fully rigid moment connection between the secondary beam and the main beam.