Design of Members Subject to Combined Stresses as Per AISC360-16

An Online Continuing Education Course for Engineers

Course Number: S-2021

Credit: 2 Hours / 2 PDH / 2 CPD

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

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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.

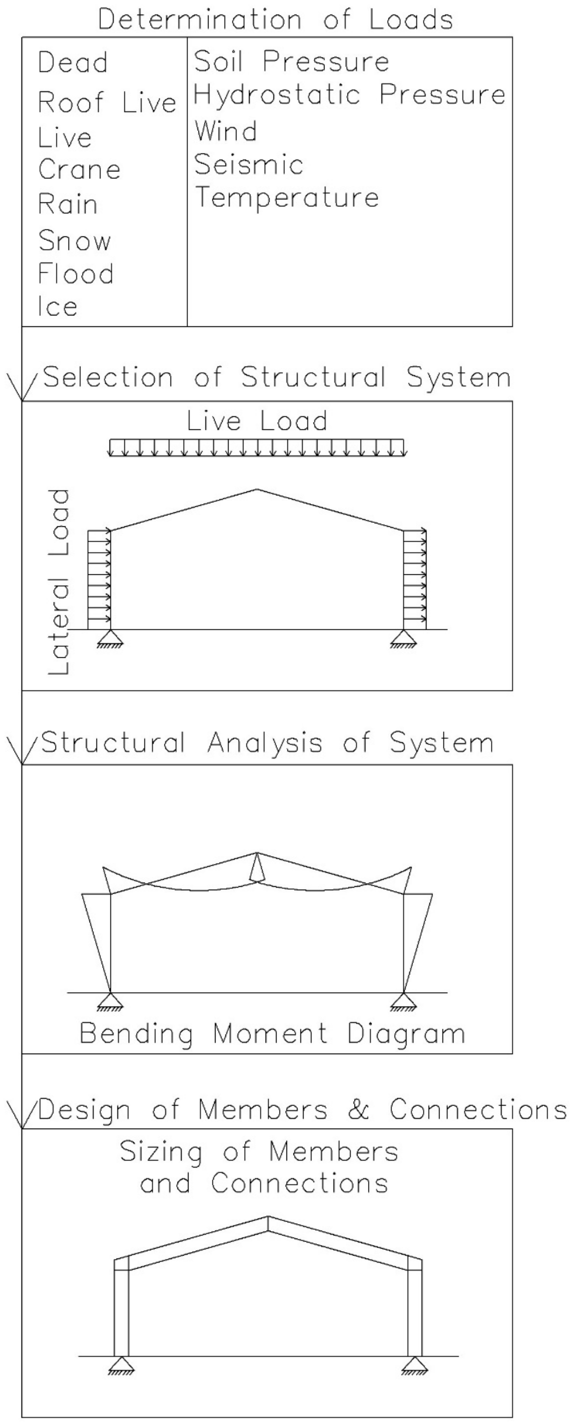
By putting the loads on the chosen statical system, we get the straining action in the members of the statical system; by the different analysis methods, these straining actions are several, such as tension, compression, flexure, shear, and torsion.

In this course, we will study the design of steel members subject to combined stresses (axial + flexure about one or both axes, with or without torsion), which exist in many steel structures, such as frame rafters, frame columns, crane beams, and collector elements.

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.



<u>Figure (01).</u> <u>Steps of Structural Design</u>

This course covers the following topics:

1. Design of members subject to flexure & compression force.
2. Design of members subject to flexure & tension force.
3. Design of members subject to single-axis flexure & compression force.
4. Design of unsymmetrical members subject to flexure & axial force.
5. Design of Round and Rectangular HSS members subject to torsion only.
6. Design of HSS members subject to combined torsion, shear, flexure, and axial force.
7. Design of non-HSS subject to torsion and combined stresses.
8. Rupture of flanges with holes subject to tension.

Figure (02) shows examples of members subject to combined stresses.

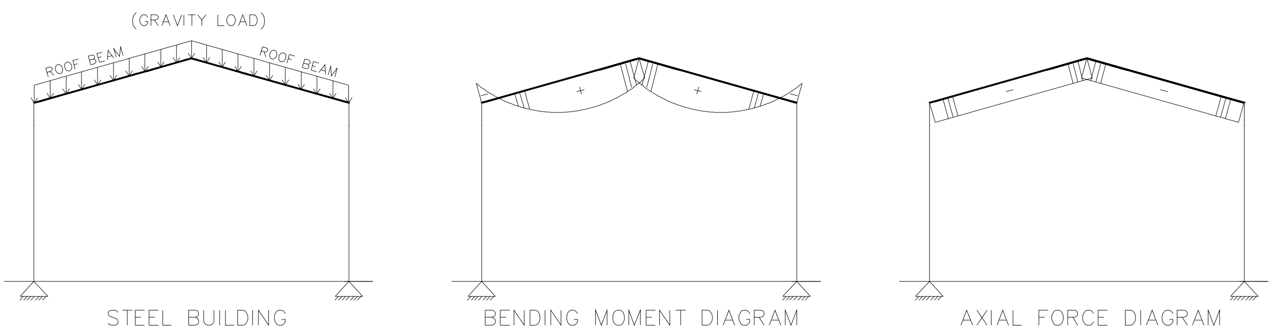


Figure (02). Example of Members Subject to Combined Stresses

2. Design of Members Subject to Flexure and Compression:

This section applies to doubly and symmetric members subject to compression and flexure about major and minor axes, acting simultaneously.

Figure (03) shows examples of singly and doubly symmetric sections.

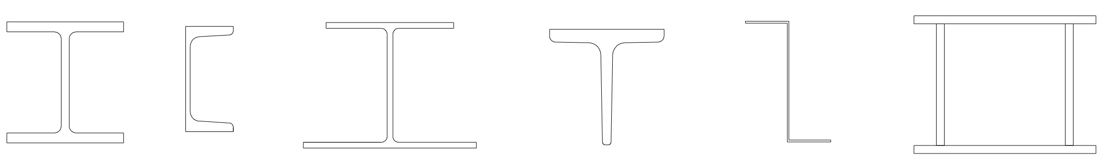


Figure (03). Example of Singly and Double Symmetric Sections

When $P_r/P_c \geq 0.2$:

$$\frac{P_r}{P_c} + \frac{8}{9}\left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}}\right) \leq 1.0 \qquad \text{(H1-1a)}$$

When $P_r/P_c < 0.2$:

$$\frac{P_r}{2P_c} + \left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}}\right) \leq 1.0 \qquad \text{(H1-1b)}$$

Where;

P_r = required compression strength, taking into consideration stability design requirements, using ASD or LRFD methods.

M_{rx} = required flexure strength about axis-x, taking into consideration stability design requirements, using ASD or LRFD methods.

M_{ry} = required flexure strength about axis-y, taking into consideration stability design requirements, using ASD or LRFD methods.

P_c = available compression strength, in accordance with AISC360-16-Chapter-E.

$P_c = \Phi_c P_n$ (LRFD Method), where $\Phi_c = 0.90$

$P_c = P_n/\Omega_c$ (ASD Method), where $\Omega_c = 1.67$

M_{cx} = available flexure strength about the x-axis, in accordance with AISC360-16-Chapter-F.

$M_{cx} = \Phi_c M_{rx}$ (LRFD Method), where $\Phi_b = 0.90$

$M_{cx} = M_{rx}/\Omega_c$ (ASD Method), where $\Omega_b = 1.67$

M_{cy} = available flexure strength about the x-axis, in accordance with AISC360-16-Chapter-F.

$M_{cy} = \Phi_c M_{ry}$ (LRFD Method), where $\Phi_b = 0.90$

$M_{cy} = M_{ry}/\Omega_c$ (ASD Method), where $\Omega_b = 1.67$

Example (EX1):

A simply supported beam with a profile W18x106 is fabricated from ASTM A992 steel. The beam is 18.0 ft in length; the beam is continuously braced at both flanges.

The required strengths in the beam, are as following:

LRFD: M_x = 450 kips.ft, M_y = 150 kips.ft, P_r = … kips.
ASD: M_x = 300 kips.ft, M_y = 100 kips.ft, P_r …

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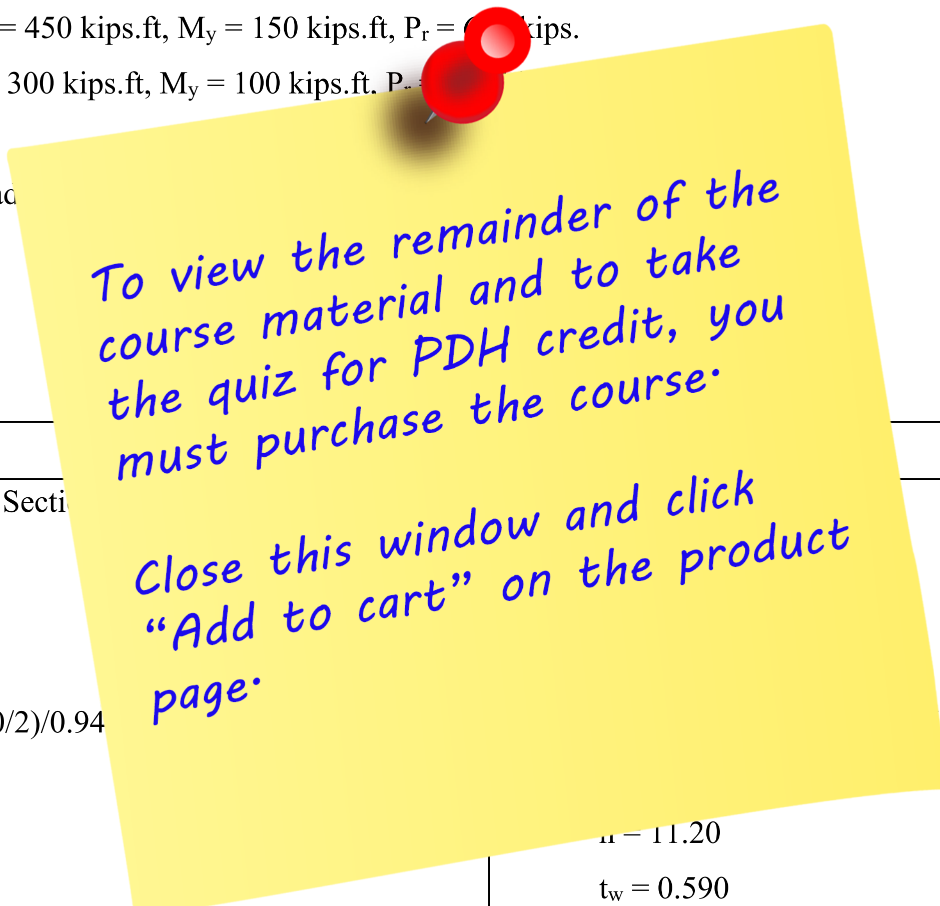

Solution:

• Dimensions of Secti…	
b_f = 11.20 t_f = 0.940 b/t = (11.20/2)/0.94…	
h = 11.20 t_w = 0.590	h = 11.20 t_w = 0.590
h/t_w = 16.048/0.590 = 27.20	h/t_w = 16.048/0.590 = 27.20
A_g = 31.10 in^2 Z_x = 230.0 in^3 Z_y = 60.5 in^3 S_y = 39.4 in^3	A_g = 31.10 in^2 Z_x = 230.0 in^3 Z_y = 60.5 in^3 S_y = 39.4 in^3