W cross section tension verification using S16-19:

1.1.1 Description

The test verifies the tension strength of W shape section column.

The column is subjected to end tension.

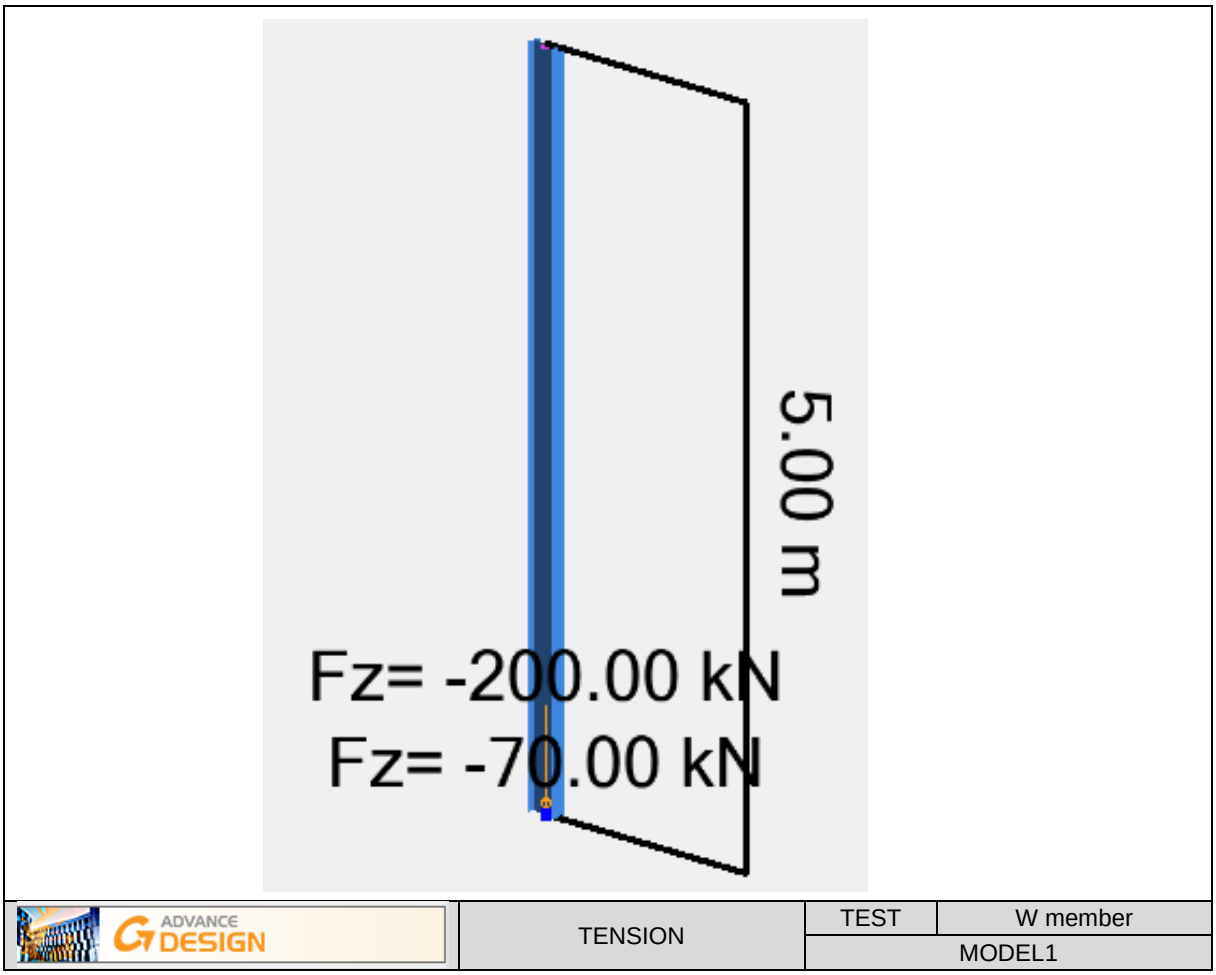
1.1.2 Background

The test verifies the available tension strength of a W250x22 column shown in the figure below. The column is subjected to tension of 70 kN from dead load and 200 kN from live load. Material G40.21M-350W (F_y=350 MPa) steel is selected for this example.

1.1.2.1 Model description

- Analysis type: static linear (plane problem)
- Element type: linear

  The following load case is used:
- Load cases: F_D= -70 kN; F_L= -200 kN

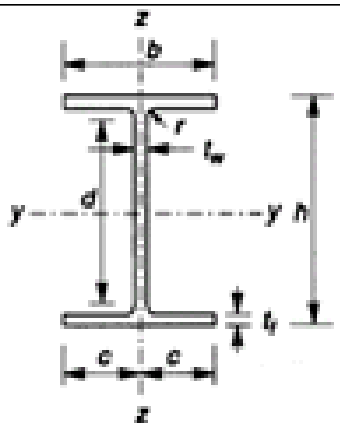


Units

Metric System

Geometry

- Cross section:

Dimensions and surface area			***Properties***	
	***Area***		***Strong Axis (Y-Y)***	
	A	***28.50 cm^2***	***I_y***	***2870 cm^4***
	Depth		***S_y***	***226 cm^3***
	h	***25.4 cm***	***Z_y***	***262 cm^3***
	Web thickness		***Weak Axis (Z-Z)***	
	t_w	***0.58cm***	***I_z***	***120 cm^4***
	Flange width		***S_z***	***23.8 cm^3***
	b	***10.2cm***	***Zy***	***37.7cm^3***
	Flange thickness		***Shear area***	
	t_f	***0.58cm***	***A_y***	***15.17 cm^2***
	Filet radius		***A_z***	***14.73 cm^2***
	r	***1.31cm***	***Torsional constant***	
			J	***6.32 cm^4***
			Warping constant	
			C_w	***18778.2 cm^6***
W250x22				

- Beam length: L =500 cm

Materials properties

Steel G40.21M-350W is used. The following characteristics are used in relation to this material:

- Yield strength f_y=350 MPa
- Longitudinal elastic modulus: E=200000 MPa
- Shear modulus of rigidity: G=76923.1 MPa

Boundary conditions

The boundary conditions are described below:

- Outer:
  - ► Support at X = 500 cm (Restraints: TX, TY, TZ, Rx, Ry, Rz)
- Inner: None.

Loading

The column is subjected to the following load combinations and actions:

- ULS: q = 1.25 x D +1.5 x L
- LSS: q =1 x D + 1 x L

1.1.2.2 Reference results in calculating

Reference solution

From the NBC 2015, the required tension strength for the design is:

ULS
$\|Fx\| = 1.25 \times 70 + 1.5 \times 200$ $\|Fx\| = 387.5\ kN$

The Factored tensile resistance T_r of a member subjected to axial tension is computed from the clause 13.2:

$$T_r = \phi \times Ag \times Fy$$

In order to verify the plasticity of the gross section with the factored load computed at ULS:

ULS
$\phi = 0.9$ $T_r = \phi \times Ag \times Fy = 0.9 \times 2850 \times 350 = 897.75\ kN$ $T_f = Fx = 387.5\ kN < T_r = 897.75\ kN$ O.K Work ratio: $r = {T_f}/{T_r} = 43\%$

Since the member is under tension forces only the verification of bending resistance and combined forces is unnecessary.

Finite elements modeling

- Linear element: S beam,
- 6 nodes,
- 1 linear element.

1.1.2.3 Results comparison

Result name	Result description	Reference value	AD value	Percent Difference
Tr	Factored tensile resistance	897.75 kN	897.75 kN	0.00%
r	Design ratio	43.32%	43%	0.0032%

Cross section | Deflections () | Cross Sections Strength (43%) | Class

	Unfavorable case	Verification	Work ratio
Tension Compression	n°102	Cf ≤ Cr (13.2) 387.50 < 897.75 kN	43%
Combined forces	n°102	Mf/Mr - (Tf*Z)/(Mr*A) ≤ 1 (13.9.2.a) 0.432 < 1.000	43%

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