C cross section tension verification using S16-19:

1.1.1 Description

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

The column is subjected to end tension.

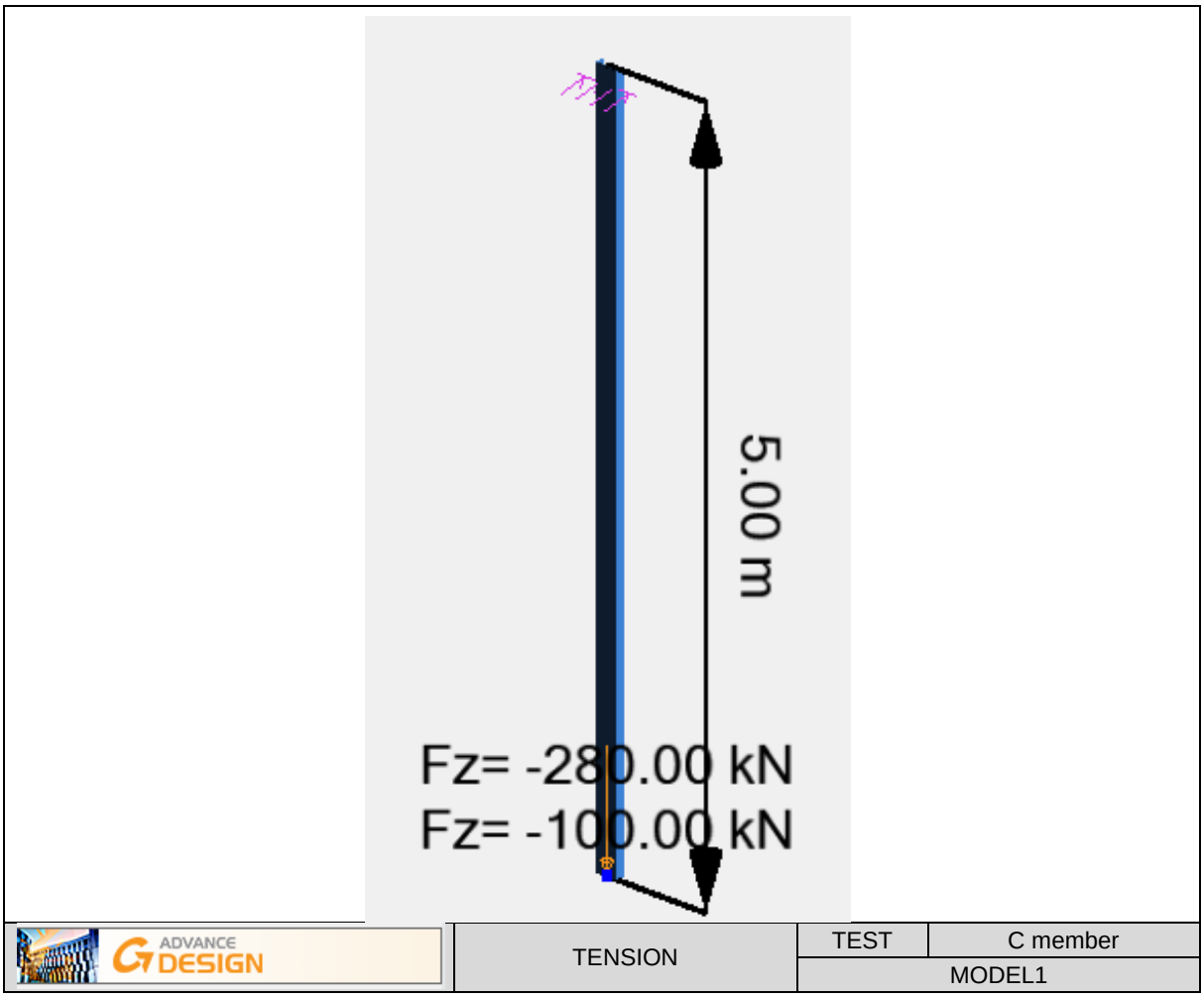
1.1.2 Background

The test verifies the available tension strength of a C180x22 column shown in the figure below. The column is subjected to tension of 100 kN from dead load and 280 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= -100 kN ; F_L= -280 kN

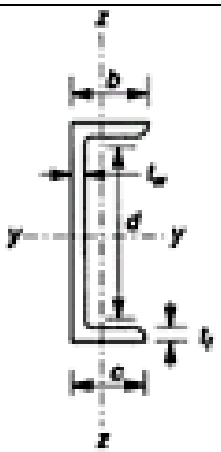


Units

Metric System

Geometry

- Cross section:

Dimensions and surface area		***Properties***	
	***Area***	***Strong Axis (Y-Y)***	
	A ***27.90 cm²***	***I_y*** ***1130 cm⁴***	
	Depth	***S_y*** ***127 cm³***	
	h ***17.78 cm***	***Z_y*** ***163 cm³***	
	Web thickness	***Weak Axis (Z-Z)***	
	t_w ***1.06cm***	***Iz*** ***57 cm⁴***	
	Flange width	***Sz*** ***47.4 cm³***	
	b ***5.80cm***	***Zz*** ***26.7cm³***	
	Flange thickness	***Shear area***	
	t_f ***0.93cm***	***A_y*** ***10.79 cm²***	
	Filet radius	***A_z*** ***18.87 cm²***	
	r ***0.99cm***	***Torsional constant***	
		J ***13.92 cm⁴***	
		Warping constant	
		C_w ***3435.72 cm⁶***	
C180x22			

- 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
$\|Fx\| = 1.25 \times 100 + 1.5 \times 280$ $\|Fx\| = 545\ kN$

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
$\phi = 0.9$ $T_r = \phi \times Ag \times Fy = 0.9 \times 2790 \times 350 = 878.85\ kN$ $T_f = Fx = 545\ kN < T_r = 878.85\ kN$ O.K Work ratio: $r = {T_f}/{T_r} = 62\%$

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	878.85 kN	897.75 kN	0.00%
r	Design ratio	62%	62%	0.00%

	Unfavorable case	Verification	Work ratio
Tension Compression	n°102	Cf ≤ Cr (13.2) 545.00 < 878.85 kN	62%
Combined forces	n°102	Tf/Tr + Mf/Mr ≤ 1 (13.9.1) 0.620 < 1.000	62%

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