HSS circular section in tension verification using S16-19:

1.1.1 Description

The test verifies the tension strength of circular HSS section column.

The column is subjected to end tension.

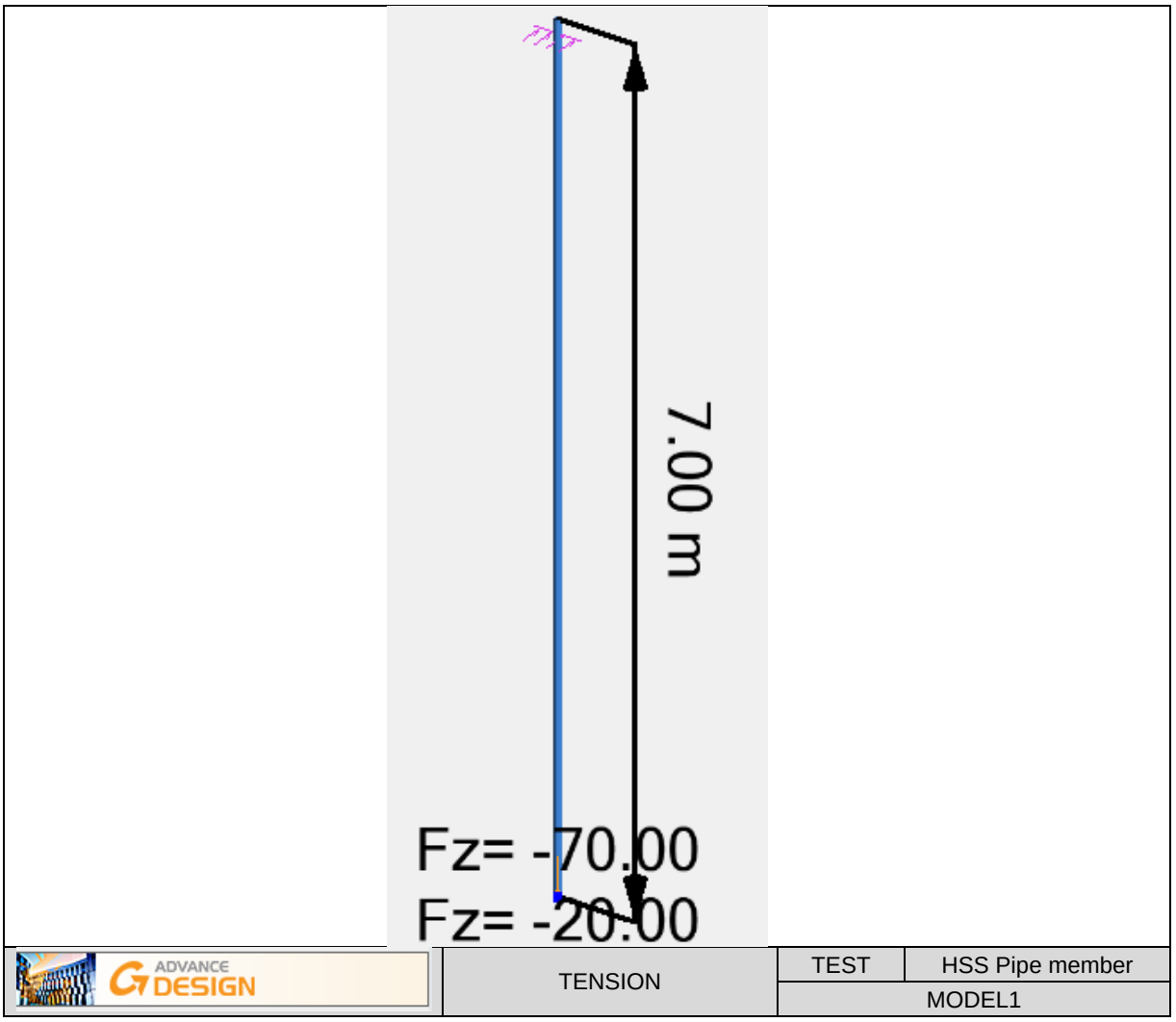
1.1.2 Background

The test verifies the available tension strength of an HSS pipe 76x4 column shown in the figure below. The column is subjected to tension of 20 kN from dead load and 70 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= -20 kN : F_L= -70 kN

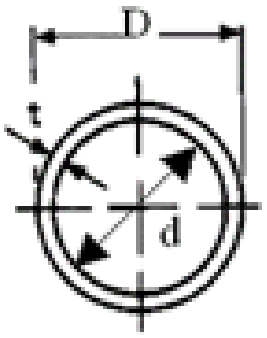


Units

Metric System

Geometry

- Cross section:

Dimensions and surface area		***Properties***	
	***Area***	***Strong Axis (Y-Y)***	
	A ***8.19 cm²***	***I_y***	***54.10 cm⁴***
	Diameter	***S_y***	***15.46 cm³***
	D ***7.62 cm***	***Z_y***	***18.8 cm³***
	Thickness	***Weak Axis (Z-Z)***	
	t ***4 cm***	***Iz***	***54.10 cm⁴***
		Sz	***15.46 cm³***
		Zz	***18.8 cm³***
		Shear area	
		A_y	***1.70 cm²***
		A_z	***1.70 cm²***
		Torsional constant	
		J	***117.82 cm⁴***
		Warping constant	
		C_w	***0.0 cm⁶***
HSS 76x4			

- Beam length: L =700 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 = 700 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
$\|Fx\| = 1.25 \times 20 + 1.5 \times 70$ $\|Fx\| = 130\ kN$

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
$\phi = 0.9$ $T_r = \phi \times Ag \times Fy = 0.9 \times 819 \times 350 = 257.985\ kN$ $T_f = Fx = 130\ kN < T_r = 257.985\ kN$ O.K Work ratio: $r = {T_f}/{T_r} = 50.39\%$

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	257.985 kN	256.72 kN	0.49%
r	Design ratio	50.39%	50.64%	0.49%

	Unfavorable case	Verification	Work ratio
Tension Compression	n°102	Cf ≤ Cr (13.2) 130.00 < 256.72 kN	51%
Combined forces	n°102	Tf/Tr + Mf/Mr ≤ 1 (13.9.1) 0.506 < 1.000	51%

- Section properties:

Gross cross section

start end HSS 76X4

Dimensions(cm)	Outer radius = 3.81 Thickness = 0.40
Cross sections(cm2)	Area = 8.14997 Avy = 1.53552 Avz = 1.53552
Moments of inertia(cm4)	It = 107.734 Iy = 53.8672 Iz = 53.8672
Moments of inertia(cm6)	Iw = 0
Moduli of inertia(cm3)	Welyinf = 14.1384 Welysup = 14.1384 Welzinf = 14.1384 Welzsup = 14.1384 Wply = 18.8565 Wplz = 18.8565

Material and steel grade

Material: G40.21M-350W

Steel grade: = 200000.00 MPa Nu = 0.3

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