3D Signpost - Pre-Analysis & Start-Up

Authors: Rajesh Bhaskaran and Vincent Prantil

Pre-Analysis & Start-Up

Pre-Analysis

This problem requires a relatively straightforward application of linearly superposed solutions from individual loadings. A simple spreadsheet can be prepared to give the results for the stresses associated with the separate loadings experienced by the signpost. An example is given here for the case of a solid post with a diameter of 1.12 feet:

F25   fx =H19*(E21+C21)

Project 3: Designing a steel sign post

Definitions

- P = Axial load
- V = Lateral load
- M = Bending moment
- T = Torsion
- do = External diameter
- di = Internal diameter
- A = Area
- I = Moment of Inertia about the neutral axis
- J = Polar Moment of Inertia
- c = Centroid referenced from the extreme compression fiber (equal to outer radius)
- σ_{max} = Normal stress produced by the combined effects of axial load and bending moment
- τ_{max} = Shear stress produced by the lateral load

$$\sigma_{axial} = \frac{P}{A}$$

$$\sigma_{max\ bending} = \frac{Mc}{I}$$

$$\sigma_{max} = \sigma_1 + \sigma_2 = \frac{P}{A} + \frac{Mc}{I}$$

$$\tau_{max\ lateral} = \frac{2V}{A}$$

$$\tau_{max\ torsion} = \frac{Tc}{J}$$

						wind x	wind y	weight sign	
Data	**x1**	**z1**	**b2**	**h1**	**h2**	**Wx2**	**Fy1**	**Wz1**	**Unit Wt Steel**
Units	**ft**	**ft**	**ft**	**ft**	**ft**	**k/ft**	**k**	**k/ft**	**k/ft^3**
Value	**6**	**4**	**13**	**28**	**8**	**0.70**	**8.00**	**0.90**	**0.49**
Units	in	in	in	in	in	k/in	n/a	k/in	k/in^3
Value	72	48	156	336	96	0.0583	n/a	0.0750	0.000284

Reactions	Vx = Ax	Vy = Ay	Vresult	P = Az	Mx	My	Mresult	T = Mz
Units	kip	kip	kip	kip	kip*in	kip*in	kip*in	kip*in
Value	-12.6	-8.00	14.93	29.08	3072	-4502	5450	-576

Property	d_o	d_i	wall thick	A	Ix	J	c	Wt Post
Units	in.	in.	in.	$in.^2$	$in.^4$	$in.^4$	in.	kip
Value	**13.44**	**0.00**	**6.720**	141.87	1601.6	3203.3	6.720	**17.38**

Stress	σ_{axial}	$\sigma_{bending}$	max σ_z	$\tau_{lateral}$	$\tau_{torsion}$	max τ
Units	ksi	ksi	**ksi**	ksi	ksi	**ksi**
Value	0.20	22.87	**23.07**	0.21	1.21	**1.42**
Allowable Stress			25.00			16.00

Note that the formula for the moment about the x-axis is highlighted and shown in the formula bar above the spreadsheet. Not surprisingly, the stresses are quite low as solid posts are almost never used in practice. You may wish to begin with this case of an over-designed signpost. The tutorial contains geometry files for both solid and hollow poles. Then you will want to consider hollow poles and compare results as you attempt to optimize the post's load-carrying capacity:

35							
36	**RESULTS SUMMARY**						
37							
38		Record your results (numbers, not formulae) below.					
39		d_o	d_i	t	max σ_z	max τ	Weight of Post
40		in.	in.	in.	ksi	ksi	kip
41	Option 1						
42	Option 2						
43	Option 3						
44	Option 4						
45	Option 5 (Solid)	13.44	0.00	6.72	23.07	1.42	17.38

You will want to continue and re-design lighter hollow posts which sustain higher stresses, but remain in the elastic regime.

Start-Up

Launch ANSYS Workbench and start a "Static Structural" analysis in the project page as shown in the video below.

Go to Step 2: Geometry

Go to all ANSYS Learning Modules