AIM 3D Signpost - Pre-Analysis & Start-Up

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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 =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

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