Axial Load Analysis
2-1/2" and 3" Standard (Schedule 40) Pipe Columns

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Rendered to:

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Scope

Architectural Testing, Inc., an Intertek company, was contracted by INTEX Millwork Solutions to perform an axial compression load analysis for 2-1/2" and 3" Standard Pipe Columns (Schedule 40). This analysis is being performed to determine a maximum load for the two different column diameters at lengths of 8', 10' and 12'.

Referenced standards utilized in this project include:

Steel Construction Manual, Fourteenth Edition. American Institute of Steel Construction, Inc., 2011.

Product Description

Intex Millworks Solutions provided descriptions of the columns. The columns will be either 2-1/2" or 3" standard pipe columns (Schedule 40) at lengths of 8', 10' and 12'. The columns will come with turned PVC shells. The analysis of the compression loads for the columns will include the steel columns only as the PVC shell does not provide a significant increase in axial compression capacity.

Analyses

Maximum Axial Compression Load
Each column diameter and length was analyzed per AISC Chapter E. The loads for the columns are assumed to be concentrically located at the center of the column. Bending of the column was not considered in the analysis. Worst-case end conditions were assumed. At the base, the end condition was assumed to be free rotation with fixed translation. At the top, the end condition was assumed to be fixed rotation and free translation. Pipes are assumed to be ASTM A53 Grade B steel. Maximum loads for axial compression are presented in the following table.

Table 1 Maximum Axial Compression Loads
for Standard (Schedule 40) Steel Pipe Columns

Column Size	Column Length (Feet)		
	8	10	12
2-1/2"	5,949 lb.	3,835 lb.	2,644 lb.
3"	11,554 lb.	7,395 lb.	5,135 lb.

Summary
Maximum axial compression loads for 2-1/2" and 3" diameter steel columns in lengths of 8', 10' and 12' are presented in Table 1. Loads on columns may only be concentric and placed centered at the top of the column. If eccentric loads or other load cases are present, the column must be evaluated by the Engineer of Record for the project.

Calculations

Column Properties

$\Omega = 1.67$
$E = 29,000,000$ psi
$F_y = 35,000$ psi
$K = 2$ (base end condition: free rotation, fixed translation; top end condition fixed rotation, free translation. AISC Table C-A-7.1)

2-1/2" Diameter Standard Column
Diameter (D) = 2.88"
Wall Thickness (t) = 0.189"
Radius of Gyration (r) = 0.952"
Area (A_g) = 1.61 in^2

3" Diameter Standard Column
Diameter (D) = 3.50"
Wall Thickness (t) = 0.201"
Radius of Gyration (r) = 1.17"
Area (A_g) = 2.07 in^2

Determination if Slender or Non-Slender

$\lambda = 0.11(E/F_y) = 0.11(29,000,000/35,000) = 91.14$

2-1/2" Columns: D/t = 2.88"/0.189" = 15.24 < 91.14 Non-slender
3" Columns: D/t = 3.50"/0.201" = 17.41 < 91.14 Non-slender

Use Section E3 in AISC.

$4.71(E/F_y)^{0.5} = 4.71(29,000,000/35,000)^{0.5} = 135.57$

Check KL/r for all columns:
2-1/2" x 8'	(2*(8' x 12))/0.952	= 201.68
2-1/2" x 10'	(2*(10' x 12))/0.952	= 252.10
2-1/2" x 12'	(2*(12' x 12))/0.952	= 302.52
3" x 8'	(2*(8' x 12))/1.17	= 164.10
3" x 10'	(2*(10' x 12))/1.17	= 205.12
3" x 12'	(2*(12' x 12))/1.17	= 246.15

All values greater than 135.57. Use equation E3-3 from AISC

Column Compression

$$P_a = P_n/\Omega = F_{cr}A_g/\Omega \qquad \text{(AISC E3-1)}$$

$$F_{cr} = 0.877F_e \qquad \text{(AISC E3-3)}$$

$$F_e = (3.14^2 E)/(KL/r)^2 \qquad \text{(AISC E3-4)}$$

F_e: 2-1/2" x 8': = $(3.14^2$ x 29,000,000)/(201.7)^2 = 7,036.7 psi
F_e: 2-1/2" x 10': = $(3.14^2$ x 29,000,000)/(252.1)^2 = 4,535.5 psi
F_e: 2-1/2" x 12': = $(3.14^2$ x 29,000,000)/(302.5)^2 = 3,127.4 psi

F_e: 3" x 8': = $(3.14^2$ x 29,000,000)/(164.1)^2 = 10,628.7 psi
F_e: 3" x 10': = $(3.14^2$ x 29,000,000)/(205.1)^2 = 6,802.7 psi
F_e: 3" x 12': = $(3.14^2$ x 29,000,000)/(246.2)^2 = 4,723.9 psi

F_{cr}: 2-1/2" x 8' = 0.877(7,036.7 psi) = 6,171.2 psi
F_{cr}: 2-1/2" x 10' = 0.877(4,535.5 psi) = 3,977.6 psi
F_{cr}: 2-1/2" x 12' = 0.877(3,127.4 psi) = 2,742.7 psi

F_{cr}: 3" x 8' = 0.877(10,628.7 psi) = 9,321.4 psi
F_{cr}: 3" x 10' = 0.877(6,802.7 psi) = 5,966.0 psi
F_{cr}: 3" x 12' = 0.877(4,723.9 psi) = 4,142.8 psi

P_a: 2-1/2" x 8' = (6,171.2 psi x 1. 61 in^2)/1.67 = 5,949 lb.
P_a: 2-1/2" x 10' = (3,977.6 psi x 1. 61 in^2)/1.67 = 3,835 lb.
P_a: 2-1/2" x 12' = (2,742.7 psi x 1. 61 in^2)/1.67 = 2,644 lb.

P_a: 3" x 8' = (9,321.4 psi x 2.07 in^2)/1.67 = 11,554 lb.
P_a: 3" x 10' = (5,966 psi x 2.07 in^2)/1.67 = 7,395 lb.
P_a: 3" x 12' = (4,142.8 psi x 2.07 in^2)/1.67 = 5,135 lb.

Revision Log

Rev. #	Date	Page(s)	Revision(s)
0	06/19/15	N/A	Original report issue