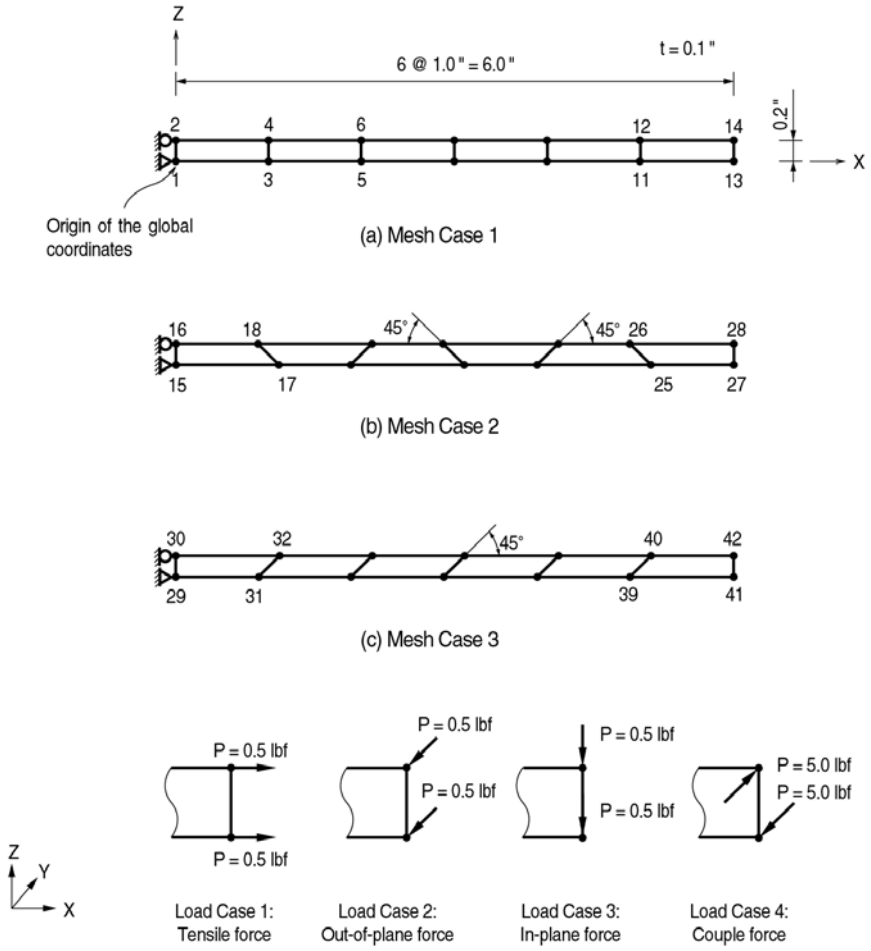
Static-16

Title

Cantilever beam subjected to various static loads

Description

A cantilever beam is subjected to unit forces at the free end. Three orthogonal direction unit forces and a unit torsion are applied individually.
The beam is modeled with different mesh geometries.



Structural geometry and analysis model

Model

Analysis Type

3-D static analysis

Unit System

in, lbf

Dimension

Length 6.0 in Depth 0.2 in Thickness 0.1 in

Element

Plate element (Thick type)

Material

Modulus of elasticity $E = 1.0 \times 10^7$ psi

Poisson's ratio $\nu = 0.3$

Element Property

Mesh ; Case 1 (Regular Mesh) a × b = 1.0 in × 0.2 in

Case 2 (Trapezoidal Mesh) angle = 45°

Case 3 (Parallelogrammic Mesh) angle = 45°

Boundary Condition

Nodes 1, 15 and 29 ; Constrain Dx, Dy, Dz, Rx and Rz (Hinge supports)

Nodes 2, 16 and 30 ; Constrain Dx, Dy, Rx and Rz. (Roller supports)

Load Case

Refer to the figures shown above.

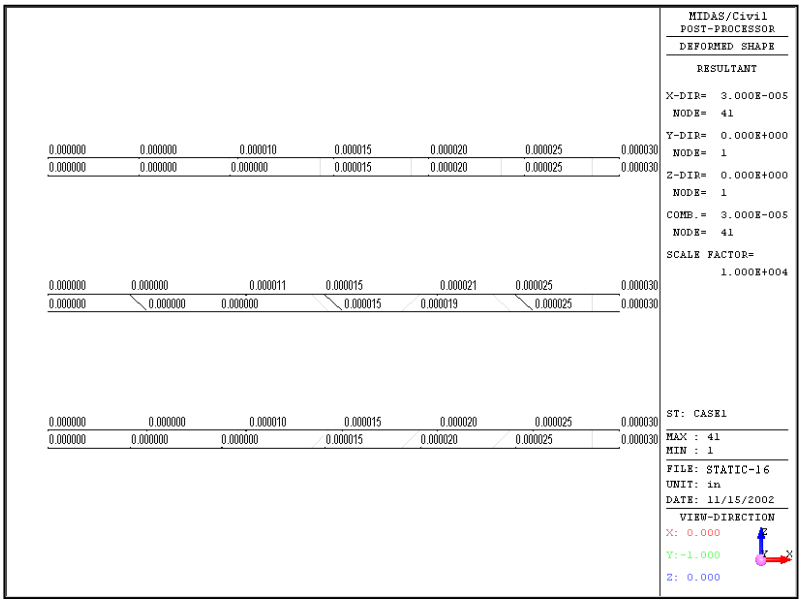
Load Case 1 ; Tensile forces are applied to the free end in the X direction.
2 @ P = 2 @ 0.5 lbf

Load Case 2 ; Out-of-plane forces are applied to the free end in the -Y direction .
2 @ P = 2 @ 0.5 lbf

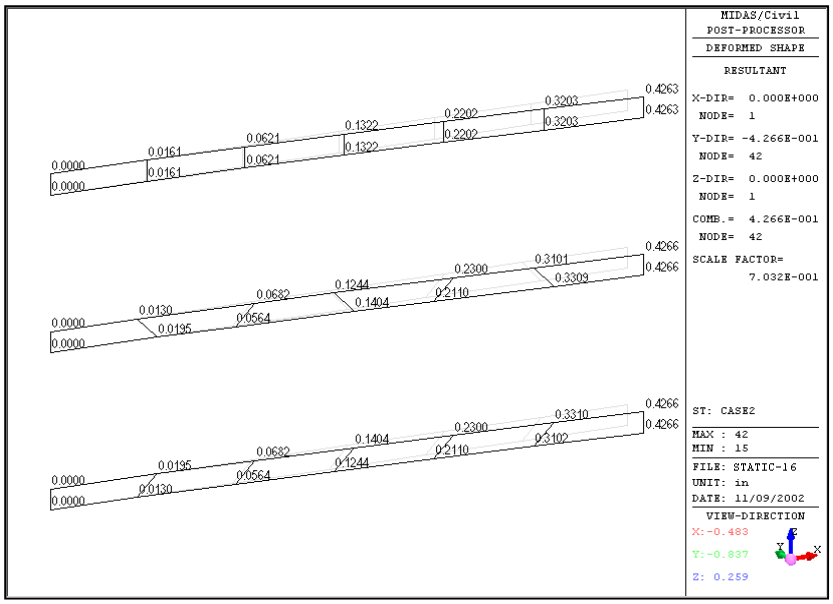
Load Case 3 ; In-plane forces are applied to the free end in the -Z direction.
2 @ P = 2 @ 0.5 lbf

Load Case 4 ; Torsion is applied to the free end about the -X direction.
T = Depth × P = 0.2 in × 5 lbf

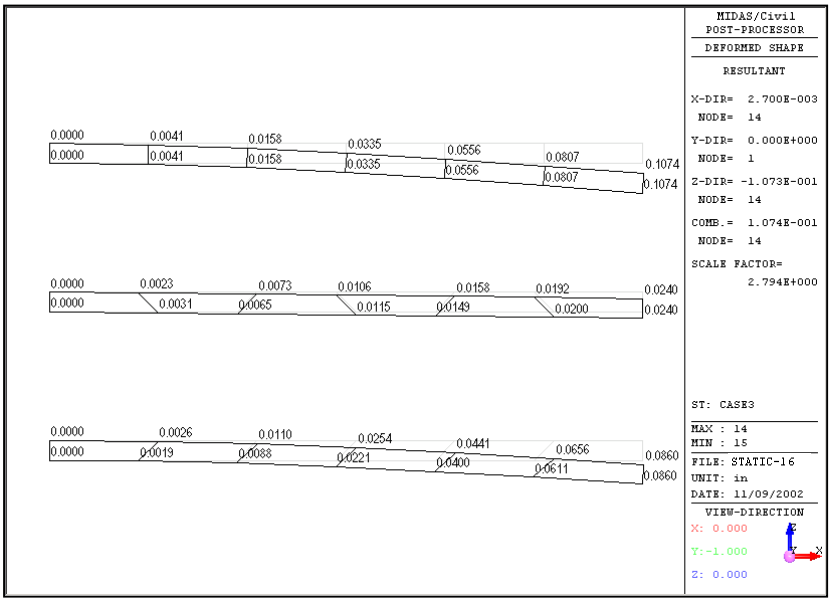
Results



Deformed shape of the structure : Load Case 1



Deformed shape of the structure : Load Case 2



Deformed shape of the structure : Load Case 3

Displacements (Load case 4)

	Node	Load	DX (in)	DY (in)	DZ (in)	RX ([rad])	RY ([rad])	RZ ([rad])
▶	13	CASE4	0,0000	-0,0024	0,0000	-0,0236	0,0000	-0,0002
	14	CASE4	0,0000	0,0024	0,0000	-0,0236	0,0000	0,0002
	27	CASE4	0,0000	-0,0024	0,0000	-0,0236	0,0000	-0,0002
	28	CASE4	0,0000	0,0023	0,0000	-0,0236	0,0000	0,0002
	41	CASE4	0,0000	-0,0023	0,0000	-0,0235	0,0000	-0,0002
	42	CASE4	0,0000	0,0024	0,0000	-0,0235	0,0000	0,0002

Comparison of Results

Unit : in

Load Case	Load Type	Mesh Case	Displacement		
			Theoretical	SAP 2000	MIDAS/Civil
1	Tension (δ_X)	1	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
		2	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
		3	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
2	Out-of-plane force (δ_Y)	1	0.4321	0.4263	0.4264
		2	0.4321	0.4266	0.4266
		3	0.4321	0.4266	0.4266
3	In-plane force (δ_Z)	1	0.1081	0.1072	0.1073
		2	0.1081	0.0228	0.0240
		3	0.1081	0.0803	0.0860
4	Torsion (δ_X)	1	0.0321	0.0233	0.0236
		2	0.0321	0.0233	0.0236
		3	0.0321	0.0233	0.0235

References

MacNeal R. H. and Harder, R. C., "*Proposed Standard Set of Problems to Test Finite Element Accuracy*", Finite Elements in Analysis and Design 1(1985), pp. 3-20, North Holland.

"SAP90, A Series of Computer Programs for the Finite Element Analysis of Structures, Structural Analysis Verification Manual", Computer and Structures, Inc., 1992, Example 10.