4.10.1 3DNLG-1: Elastic large deflection response of a Z-shaped cantilever under an end load

Product: Abaqus/Standard

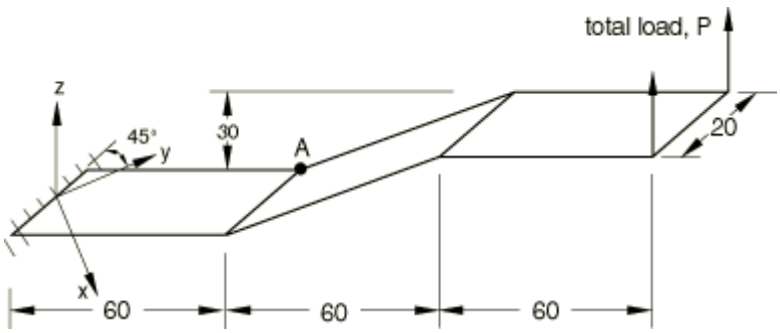
Elements tested

B31 B31H B32 B32H B33 B33H

S4 S4R

SC6R SC8R

Problem description



Model:

Uniform thickness (t = 1.7).

Material:

Linear elastic, Young's modulus = 2.05 $\times$ 10^5, Poisson's ratio = 0.3.

Boundary conditions:

All degrees of freedom restrained at built-in end.

Loading:

Concentrated end load (P = 4000).

Reference solution

This is a test recommended by the National Agency for Finite Element Methods and Standards (U.K.): Test 3DNLG-1 from NAFEMS Publication R0024 “A Review of Benchmark Problems for Geometric Non-linear Behaviour of 3D Beams and Shells (SUMMARY).”

The published results for this problem were obtained with Abaqus. Thus, a comparison of Abaqus and NAFEMS results is not an independent verification of Abaqus. The NAFEMS study includes results from other sources for comparison that may provide a basis for verification of this problem.

Results and discussion

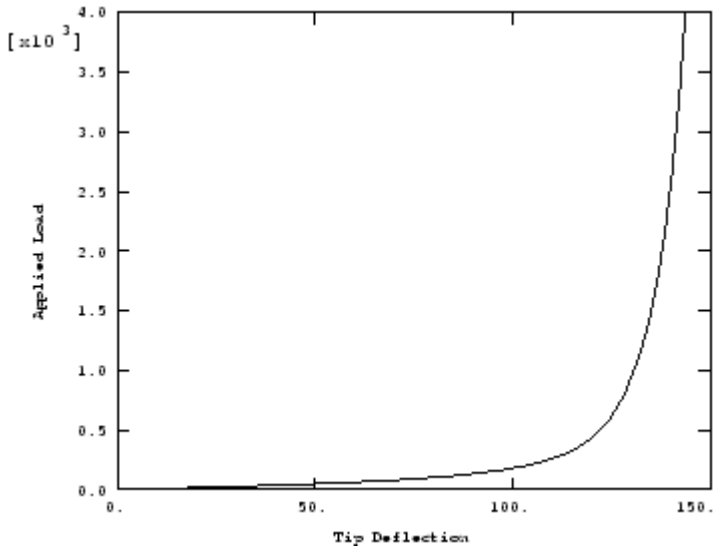
Displacements converge faster than stresses. Even though the displacements seem to have converged, the lower-order elements need more refined meshes (compared to the higher-order elements) before the stresses are observed to converge. Stresses are most accurate at the integration points within the element. When stress values are extrapolated from the integration points to the nodes and then averaged, the stress values calculated may not capture the peak values if a stress gradient is present. Since the higher-order elements (B32, B32H, B33, and B33H) use linear extrapolation within an element, a stress gradient in an element may be captured

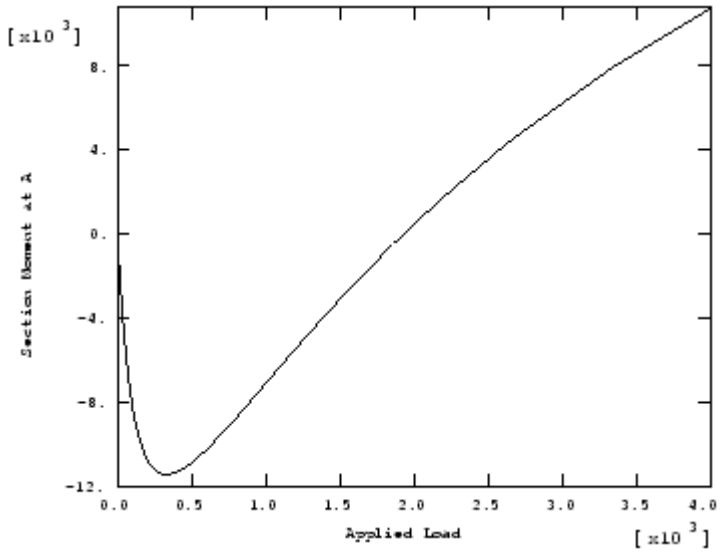
adequately when extrapolating stresses to the nodes. However, constant extrapolation is used for linear elements (B31, B31H, S4, S4R, and SC8R), which results in slow convergence of nodal stress values. Higher mesh refinement near stress gradients is needed for such elements.

Tip Displacement				
Element Type	Number of Elements	Applied Load		
		104.5	1263.0	4000.0
B31	72	80.42	133.1	143.5
B31H	72	80.42	133.1	143.5
B32	9	80.42	133.1	143.4
B32H	9	80.42	133.1	143.4
B33	9	80.42	133.1	143.4
B33H	9	80.42	133.1	143.4
S4	1 ◆ 72	80.42	133.1	143.5
S4R	1 ◆ 72	80.42	133.1	143.5
SC6R	2 ◆ 72 ◆ 1	80.56	133.1	143.5
SC8R	1 ◆ 72 ◆ 1	79.28	133.1	143.5

Moment at A				
Element Type	Number of Elements	Applied Load		
		104.5	1263.0	4000.0
B31	72	◆8333	◆5510	9921
B31H	72	◆8333	◆5509	9922
B32	9	◆8308	◆4963	10742
B32H	9	◆8308	◆4962	10743
B33	9	◆8316	◆4982	10659
B33H	9	◆8317	◆4983	10661
S4	1 ◆ 72	◆8334	◆5510	9934
S4R	1 ◆ 72	◆8334	◆5510	9934
SC6R	2 ◆ 72 ◆ 1	–8315	–5481	9831
SC8R	1 ◆ 72 ◆ 1	–8333	–5507	9939

Response predicted by Abaqus (element B32)





Input files

n3g1x33x_b31.inp

B31 elements.

n3g1x33x_b31h.inp

B31H elements.

n3g1x33x_b32.inp

B32 elements.

n3g1x33x_b32h.inp

B32H elements.

n3g1x33x_b33.inp

B33 elements.

n3g1x33x_b33h.inp

B33H elements.

n3g1x33x_s4.inp

S4 elements.

n3g1x33x_s4r.inp

S4R elements.

nlg1_std_sc6r.inp

SC6R elements.

nlg1_std_sc8r.inp

SC8R elements.