LE1: Plane stress elements—elliptic membrane

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This problem provides evidence that Abaqus can reproduce the result from the benchmark defined by NAFEMS and cited as the reference solution.

This page discusses:

ProductsAbaqus/StandardAbaqus/Explicit

Elements tested

CPS3

CPS4

CPS4I

CPS4R

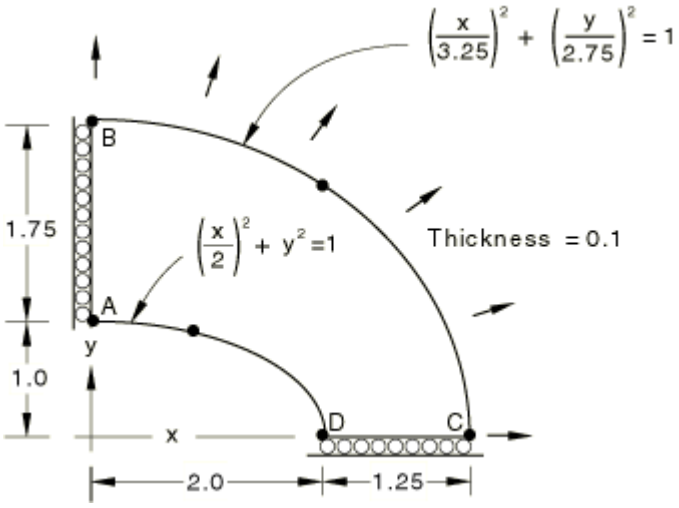
CPS6

CPS6M

CPS8

CPS8R

Problem description



Model:

Plane stress problem with shape defined by ABCD. Functions defining the curves BC and AD are given above.

Mesh:

A coarse and a fine mesh are tested for each element. In addition, a very fine mesh is tested for each element in the explicit dynamic analysis.

Material:

Linear elastic, Young's modulus = 210 GPa, Poisson's ratio = 0.3, density = 7800 kg/m^3.

Boundary conditions:

ux=0 along edge AB, uy=0 along edge CD.

Loading:

Uniform outward pressure of 10 MPa at outer edge BC. In the explicit dynamic analysis the loading is applied such that a quasi-static solution is obtained.

Reference solution

This is a test recommended by the National Agency for Finite Element Methods and Standards (U.K.): Test LE1 from NAFEMS publication TNSB, Rev. 3, “The Standard NAFEMS Benchmarks,” October 1990.

Target solution: Tangential edge stress (σyy) at D is 92.7 MPa.

Results and discussion

The results are shown in Table 1 and Table 2. The values enclosed in parentheses are percentage differences with respect to the reference solution.

Table 1. Abaqus/Standard analysis.

Element	Coarse Mesh	Fine Mesh
CPS3	51.04 MPa (−45%)	71.26 MPa (−23%)
CPS4	66.73 MPa (−28%)	84.54 MPa (−9%)
CPS4I	58.82 MPa (−37%)	78.21 MPa (−16%)
CPS4R*	40.48 MPa (−56%)	56.18 MPa (−39%)
CPS6	89.10 MPa (−4%)	94.01 MPa (1%)
CPS6M	85.88 MPa (−7%)	93.71 MPa (1%)
CPS8	84.54 MPa (−9%)	92.81 MPa (0.12%)
CPS8R	85.80 MPa (−7%)	90.07 MPa (−3%)

*A comparison of the results for reduced-integration and full-integration lower-order elements indicates that the full-integration elements perform significantly better for problems with stress concentrations of this type.

Table 2. Abaqus/Explicit analysis.

Element	Coarse Mesh	Fine Mesh	Very Fine Mesh
CPS3	51.2 MPa (−45%)	71.5 MPa (−23%)	85.7 MPa (−8%)
CPS4R	39.6 MPa (−57%)	55.7 MPa (−40%)	87.3 MPa (−6%)
CPS6M	86.12 MPa (−7%)	92.93 MPa (−0.2%)	—

Input files

Abaqus/Standard input files

Coarse mesh tests:

nle1xf3c.inp

CPS3 elements.

nle1xf4c.inp

CPS4 elements.

nle1xi4c.inp

CPS4I elements.

nle1xr4c.inp

CPS4R elements.

nle1xf6c.inp

CPS6 elements.

nle1xm6c.inp

CPS6M elements.

nle1xf8c.inp

CPS8 elements.

nle1xr8c.inp

CPS8R elements.

Fine mesh tests:

nle1xf3f.inp

CPS3 elements.

nle1xf4f.inp

CPS4 elements.

nle1xi4f.inp

CPS4I elements.

nle1xr4f.inp

CPS4R elements.

nle1xf6f.inp

CPS6 elements.

nle1xm6f.inp

CPS6M elements.

nle1xf8f.inp

CPS8 elements.

nle1xr8f.inp

CPS8R elements.

Abaqus/Explicit input files

Coarse mesh tests:

le1_cps3_c.inp

CPS3 elements.

le1_cps4r_c.inp

CPS4R elements.

le1_cps6m_c.inp

CPS6M elements.

Fine mesh tests:

le1_cps3_f.inp

CPS3 elements.

le1_cps4r_f.inp

CPS4R elements.

le1_cps6m_f.inp

CPS6M elements.

Very fine mesh tests:

le1_cps3_vf.inp

CPS3 elements.

le1_cps4r_vf.inp

CPS4R elements.