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SSNP123 - Plate notched in elastoplasticity

Summary:

This test in plane deformations quasi-static makes it possible to illustrate the relative questions with the incompressibility during the use of an elastoplastic law of behavior: when the rate of plasticity becomes important, of the nonphysical oscillations of constraints can appear. It is shown that the use of elements QUAD4 and HEXA8 under integrated can make it possible to mitigate this problem.

It is about a notched rectangular plate made up of an elastoplastic material with isotropic work hardening which is subjected to a traction at its ends. One is interested in the elastoplastic solution in load.

Modeling A corresponds to the use of elements QUAD4 under integrated stabilized by the method “assumed strain”.

Modeling B corresponds to the use of the incompressible elements QUAD8 which make it possible to obtain a reference solution for modeling A.

Modeling C corresponds to the use of elements HEXA8 under integrated stabilized by the method “assumed strain”.

Modeling D corresponds to the use of the incompressible elements HEXA20 which make it possible to obtain a reference solution for modeling C.

In addition, modelings E with J check the elements HHO and their robustness in extreme cases incompressible.

1 Problem of reference

1.1 Geometry

This calculation is based on the modeling of a notched sample requested by an imposed displacement.

1.2 Material properties

Elastoplastic behaviour with isotropic work hardening:

$E = 200\,GPa$
$\nu = 0.4999$

$\sigma_y = 200\,MPa$
$E_T = 1000\,MPa$

1.3 Boundary conditions and loadings

On BD : $DY = 0.$
On DF : $DX = 0.$
On FG : $DY = 0.1$

2 Reference solution

The reference solution of modeling A (respectively modeling C) is given by modeling B (respectively modeling D) carried out with incompressible elements quasi -.

3 Modeling A

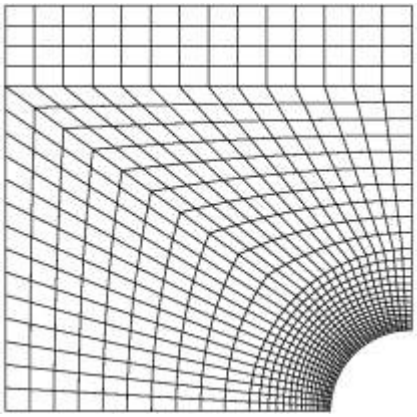
3.1 Characteristics of modeling

Modeling C_PLAN with elements QUAD4 under integrated stabilized by the method assumed strain.

3.2 Characteristics of the grid

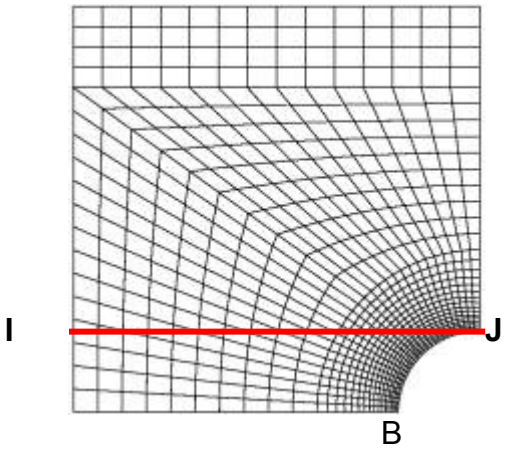
Many nodes: 527

Many meshs: 582
SEG2 : 102
QUAD4 : 480



3.3 Sizes tested and results

The coordinate is tested $SIYY$ tensor of the constraints in various points of the way IJ



One tests compared to modeling B (AUTRE_ASTER):

Curvilinear X-coordinate	Reference	Precision	Test
0.0	234,174	4×10^{-3}	AUTRE_ASTER
1.0	241,964	8×10^{-3}	AUTRE_ASTER
3.0	298,027	4×10^{-3}	AUTRE_ASTER

In addition, one tests (in not-regression):
- ERME_ELEM and ERME_ELNO (error in residue)
- The constraint SIXX and SIYY with the node B

4 Modeling B

4.1 Characteristics of modeling

One takes again the preceding grid which one passes in quadratic elements with an aim of using modeling D_PLAN_INCO_UPG (elements adapted to the incompressible problems).

4.2 Characteristics of the grid

Many nodes: 1533

Many meshs: 582
SEG3 : 102
QUAD8 : 480

4.3 Sizes tested and results

The coordinate is tested $SIYY$ tensor of the constraints in various points of the way IJ in nonregression.

Curvilinear X-coordinate	Reference
0.0	234,174
1.0	241,964
3.0	298,027

In addition, one tests (in not-regression):
- ERME_ELEM and ERME_ELNO (error in residue)
- The constraint SIXX and SIYY with the node B

5 Modeling C

5.1 Characteristics of modeling

A modeling is used 3D_SI with elements HEXA8 under integrated stabilized by the method assumed strain. The grid used is an extrusion of the grid of modeling A on a height of $0,1\,m$ with only one element in the thickness. All the degrees of freedom are blocked according to Z in order to approach the assumption of the plane deformations used in modelings A and B.

5.2 Characteristics of the grid

Many nodes: 1054

Many meshs: 1731
QUAD4 : 1052
HEXA8 : 480

5.3 Sizes tested and results

The coordinate is tested $SIYY$ tensor of the constraints in various points of the way IJ compared to modeling D (AUTRE_ASTER):

Curvilinear X-coordinate	Reference	Precision	Test
0.0	234,122	1×10^{-2}	AUTRE_ASTER
1.53224	256,988	1×10^{-2}	AUTRE_ASTER
3.26890	300,287	1×10^{-2}	AUTRE_ASTER
3.80797	267,555	1×10^{-2}	AUTRE_ASTER
4.40378	183,498	1×10^{-2}	AUTRE_ASTER

In addition, one tests (in not-regression):
- ERME_ELEM and ERME_ELNO (error in residue)
- The constraint SIXX and SIYY with the node B

6 Modeling D

6.1 Characteristics of modeling

One takes again the preceding grid which one passes in quadratic elements with an aim of using modeling 3D_INCO_UPG (elements adapted to the incompressible problems).

6.2 Characteristics of the grid

Many nodes: 1054

Many meshs: 1731
SEG3 : 199
QUAD8 : 1052
HEXA20 : 480

6.3 Sizes tested and results

The coordinate is tested $SIYY$ tensor of the constraints in various points of the way IJ in nonregression.

Curvilinear X-coordinate	Reference	Test
0.0	234,122	NON_REGRESSION
1.53224	256,988	NON_REGRESSION
3.26890	300,287	NON_REGRESSION
3.80797	267,555	NON_REGRESSION
4.40378	183,498	NON_REGRESSION

In addition, one tests (in not-regression):
- ERME_ELEM and ERME_ELNO (error in residue)
- The constraint SIXX and SIYY with the node B

7 Modeling E

7.1 Characteristics of modeling

One takes again the preceding grid which one passes in quadratic elements with an aim of using modeling D_PLAN_HHO_121 and D_PLAN_HHO_222 (elements adapted to the incompressible problems).

7.2 Characteristics of the grid

Many nodes: 1533

Many meshs: 582
SEG3 : 102
QUAD8 : 480

7.3 Sizes tested and results

One tests compared to modeling B (AUTRE_ASTER):

Curvilinear X-coordinate	Reference	Precision	Test
0.0	234,174	4×10^{-3}	AUTRE_ASTER
1.0	241,964	7×10^{-3}	AUTRE_ASTER
3.0	298,027	4×10^{-3}	AUTRE_ASTER

In addition, one tests (in not-regression):
- The constraint SIXX and SIYY with the node B

8 Modeling F

8.1 Characteristics of modeling

A modeling is used 3D_HHO_121 with elements HEXA27. The grid used is an extrusion of the grid of modeling A on a height of $0,1\,m$ with only one element in the thickness. All the degrees of freedom are blocked according to Z in order to approach the assumption of the plane deformations used in modelings A and B.

8.2 Characteristics of the grid

Many meshs: 1731
QUAD9 : 1052
HEXA27 : 480

8.3 Sizes tested and results

The coordinate is tested $SIYY$ tensor of the constraints in various points of the way IJ compared to modeling B.

Curvilinear X-coordinate	Reference	Precision	Test
0.0	234,122	3×10^{-2}	AUTRE_ASTER
1.53224	256,988	2×10^{-2}	AUTRE_ASTER
3.26890	300,287	1×10^{-2}	AUTRE_ASTER
3.80797	267,555	1×10^{-2}	AUTRE_ASTER
4.40378	183,498	0,33	AUTRE_ASTER

In addition, one tests (in not-regression):
- The constraint SIXX and SIYY with the node B

9 Modeling G

9.1 Characteristics of modeling

One takes again the preceding grid which one passes in quadratic elements with an aim of using modeling D_PLAN_HHO_121 and D_PLAN_HHO_222 (elements adapted to the incompressible problems). The behavior is GDEF_LOG.

9.2 Characteristics of the grid

Many nodes: 1533
Many meshs: 582
SEG3 : 102
QUAD8 : 480

9.3 Sizes tested and results

One tests compared to modeling B (AUTRE_ASTER):

Curvilinear X-coordinate	Reference	Precision	Test
0.0	234,174	0,022	AUTRE_ASTER
1.0	241,964	0,02	AUTRE_ASTER
3.0	298,027	0,01	AUTRE_ASTER

In addition, one tests (in not-regression):

- The constraint SIXX and SIYY with the node B

10 Modeling H

10.1 Characteristics of modeling

A modeling is used 3D_HHO_121 and 3D_HHO_222 with elements HEXA27. The grid used is an extrusion of the grid of modeling A on a height of $0,1\,m$ with only one element in the thickness. All the degrees of freedom are blocked according to Z in order to approach the assumption of the plane deformations used in modelings A and B. The behavior is GDEF_LOG.

10.2 Characteristics of the grid

Many meshs: 1731
QUAD9 : 1052
HEXA27 : 480

10.3 Sizes tested and results

The coordinate is tested $SIYY$ tensor of the constraints in various points of the way IJ. One tests compared to modeling B (AUTRE_ASTER).

Curvilinear X-coordinate	Reference	Precision	Test
0.0	234,122	3×10^{-2}	AUTRE_ASTER
1.53224	256,988	2×10^{-2}	AUTRE_ASTER
3.26890	300,287	2×10^{-2}	AUTRE_ASTER
3.80797	267,555	1×10^{-2}	AUTRE_ASTER
4.40378	183,498	1×10^{-1}	AUTRE_ASTER

In addition, one tests (in not-regression):
- The constraint SIXX and SIYY with the node B

11 Modeling I

11.1 Characteristics of modeling

One takes again the preceding grid which one passes in quadratic elements with an aim of using modeling D_PLAN_HHO_121 and D_PLAN_HHO_222 (elements adapted to the incompressible problems). The behavior is GDEF_LOG.

11.2 Characteristics of the grid

Many meshs: 690 TRIA6

11.3 Sizes tested and results

The coordinate is tested $SIYY$ tensor of the constraints in various points of the way IJ in nonregression. One tests compared to modeling B (AUTRE_ASTER):

Curvilinear X-coordinate	Reference	Precision	Test
0.0	234,174	0,004	AUTRE_ASTER
1.0	241,964	0,004	AUTRE_ASTER
3.0	298,027	0,004	AUTRE_ASTER

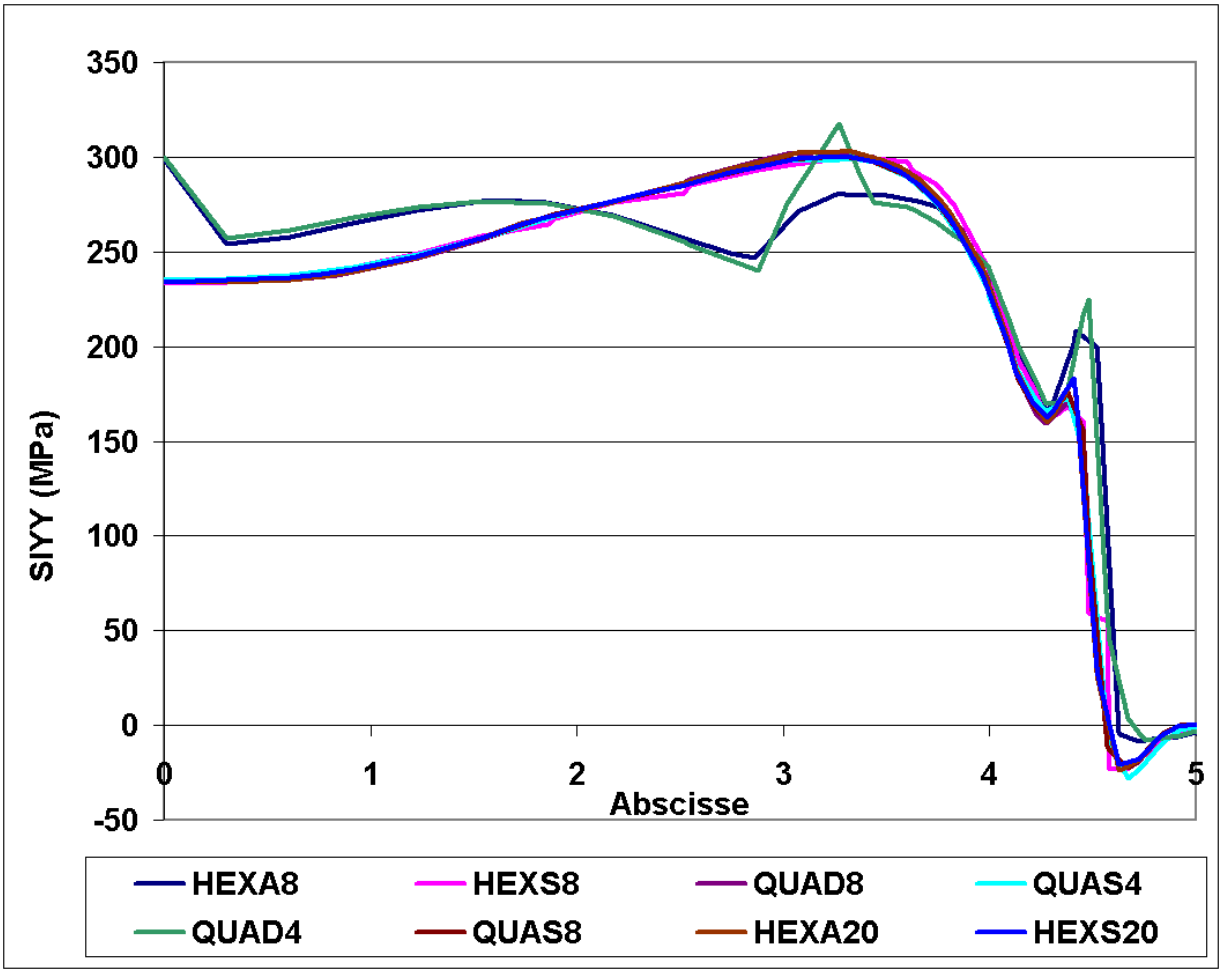
In addition, one tests (in not-regression):
The constraint SIXX and SIYY with the node B

12 Summary of the results

The results got using the various elements under integrated stabilized by the method “assumed strain” are very close to the results provided by the incompressible quadratic elements, as one can note it on the graph below. This graph gathers the results for various elements:

HEXA8	elements HEXA8 classics
QUAD4	elements QUAD4 classics
HEXA20	elements HEXA20 quadratic
HEXS20	elements HEXA20 quadratic incompressible
HEXS8	elements HEXA8 under integrated
QUAD8	elements QUAD8 quadratic
QUAS8	elements QUAD8 quadratic incompressible
QUAS4	elements QUAD4 under integrated

One thus notes the good quality of the solution given by the elements under integrated and the disappearance of the oscillations of constraints given by the linear classical elements.



In addition, modelings HHO give excellent results, without any locking