SSNS 502 - Great displacements of a panel cylindrical élastoplastic simply supported

Summary:

This test represents a calculation of stability of a cylindrical panel simply supported subjected to an effort concentrated in its center.

It makes it possible to validate modeling finite elements COQUE_3D with the meshes TRIA7 and QUAD9 in the geometrical non-linear quasi-static field in the presence of strong instabilities for the elastoplastic behavior.

Displacements and the critical load are compared with a digital reference solution.
1 Problem of reference

1.1 Geometry

![Image 1.1-1. Geometry of the panel]

1.2 Properties of material

Properties of material constituting LE panel in the elastic case are:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young modulus</td>
<td>$E = 3103 \text{ N/mm}^2$</td>
</tr>
<tr>
<td>Poisson's ratio</td>
<td>$\nu = 0.3$</td>
</tr>
</tbody>
</table>

Table 1.2-1. Properties of elastic material

In the elastoplastic case with a linear work hardening, the properties are:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young modulus</td>
<td>$E = 3103 \text{ N/mm}^2$</td>
</tr>
<tr>
<td>Poisson's ratio</td>
<td>$\nu = 0.3$</td>
</tr>
<tr>
<td>Elastic limit</td>
<td>$S_y = 1.0 \text{ N/mm}^2$</td>
</tr>
<tr>
<td>Slope of traction</td>
<td>$E_T = E/2 = 1551.5$</td>
</tr>
</tbody>
</table>

Table 1.2-2. Properties of elastoplastic material with a linear work hardening

In the plastic case perfect, the properties are:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young modulus</td>
<td>$E = 3103 \text{ N/mm}^2$</td>
</tr>
<tr>
<td>Poisson's ratio</td>
<td>$\nu = 0.3$</td>
</tr>
<tr>
<td>Elastic limit</td>
<td>$S_y = 1.0 \text{ N/mm}^2$</td>
</tr>
<tr>
<td>Slope of traction</td>
<td>$E_T = 0$</td>
</tr>
</tbody>
</table>

Table 1.2-3. Properties of plastic material perfect
1.3 Boundary conditions and loadings

- Boundary conditions: panel simply supported on the sides $AD$ and $BC$ (worthless displacements, free rotations)

- One seeks the successive states of balance under a load $F = -1000 \, N$ imposed on the point $P_3$. 
2 Reference solution

2.1 Method of calculating used for the reference solution

The reference solution was obtained with a network 10X10 elementS finishedS of hull T5-IAS4 (Isoparametric Finite Element) with 4 nodes with 5 degrees of freedom per node in isoparametric formulation in the theory of hull "Finite Reissner-Mindlin Rotation" improved. This solution is described in details in [feeding-bottle1].

2.2 Results of reference

2.3 Bibliographical references

3 Modeling A

3.1 Characteristics of modeling

One applies the elastic material properties. A quarter of the panel is modelled (P₁P₂P₃P₄) thanks to geometrical symmetry.

Boundary conditions:
- Side P₁P₂: \( u = v = w = 0 \).

Conditions of symmetry:
- Side P₂P₃: \( w = \theta_x = \theta_y = 0 \).
- Side P₃P₄: \( u = \theta_y = \theta_z = 0 \).

Loading:
- Not P₃: \( F/4 = -250 \ N \)

3.2 Characteristics of the grid

Many nodes: 2481
Number of meshes and type: 800 TRIA7

3.3 Comparison of the results
### 3.4 Remarks

In the elastic case, LE behavior of the panel changes completely and clearly shows points of return in load and displacement “snap-through/snap-back”. Consequently, the strategy of calculation used has breaks up into two stages:

- calculation in loading imposed until $F = 308 \text{ N}$
- calculation in “imposed displacement”: then, one imposes a displacement imposed by using the technique length of arc imposed on all the structure (option `LONG_ARC` in `STAT_NON_LINE`).

For, only the one curve reference solution of the factor of loading (`ETA`) according to absolute displacement in P3 is available. Values of reference being to extract on a graph, the precise comparisons are made difficult. Consequently, one checks only the values of not-regression at a few moments.
4  Modeling B

4.1  Characteristics of modeling

One applies the elastic material properties.

One models a quarter of the panel thanks to geometrical symmetry. The loading, the boundary conditions and of symmetry are the same ones like modeling A.

4.2  Characteristics of the grid

Many nodes: 1681
Number of meshs and type: 400 QUAD9

4.3  Comparison of the results

![Diagram of the quarter of the panel simulated in modeling](image)

Image 4.1-1. Diagram of the quarter of the panel simulated in modeling

One applies the elastic material properties.

One models a quarter of the panel thanks to geometrical symmetry. The loading, the boundary conditions and of symmetry are the same ones like modeling A.

4.4  Remarks

In the elastic case, LE behavior of the panel changes completely and clearly shows points of return in load and displacement "snap-through/snap-back". Consequently, Lstrategy of calculation used has breaks up into two stages:
- calculation in loading imposed until $F = 308 \, N$
- calculation in “imposed displacement”: then, one imposes a displacement imposed by using the technique length of arc imposed on all the structure (option LONG_ARC in STAT_NON_LINE).

For, only the one curve reference solution of the factor of loading ($\eta$) according to absolute displacement in P3 is available. Values of reference being to extract on a graph, the precise comparisons are made difficult. Consequently, one checks only the values of not-regression at a few moments.
5 Modeling C

5.1 Characteristics of modeling

One applies the elastoplastic material properties with a linear work hardening.

One models a quarter of the panel thanks to geometrical symmetry. The loading, the boundary conditions and of symmetry are the same ones like Modeling A.

5.2 Characteristics of the grid

Many nodes: 2481
Number of meshs and type: 800 TRIA7

5.3 Comparison of the results

In the case élastOplas ic, the behavior of the panel shows points of return in load but clearly a growth in displacement. That allows a calculation in "imposed displacement": one imposes simply a displacement imposed by using the technique of piloting on the point P3 (option DDL_IMPO in STAT_NON_LINE ).
For, only the one curve reference solution of the factor of loading (ETA) according to absolute displacement in P3 is available. Values of reference being to extract on a graph, the precise comparisons are made difficult. Consequently, one checks only the values of not-regression at a few moments.
6  Modeling D

6.1  Characteristics of modeling

One applies the elastoplastic material properties with a linear work hardening.

One models a quarter of the panel thanks to geometrical symmetry. The loading, the boundary conditions and of symmetry are the same ones like Modeling A.

6.2  Characteristics of the grid

Many nodes: 1681
Number of meshes and type: 400 QUAD9

6.3  Comparison of the results

Image 6.3-1. Loading according to the DZ in P3: Comparison enters the reference and the results of Code_Aster for the elastoplastic case with the meshes of QUAD9

6.4  Remarks

In the case élastoplastic, the behavior of the panel shows points of return in load but clearly a growth in displacement. That allows a calculation in "imposed displacement": one imposes simply a displacement imposed by using the technique of piloting on the point P3 (option DDL_IMPO in STAT_NON_LINE ).
For, only the one curve reference solution of the factor of loading (\( \text{ETA} \)) according to absolute displacement in P3 is available. Values of reference being to extract on a graph, the precise comparisons are made difficult. Consequently, one checks only the values of not-regression at a few moments.
7 Modeling E

7.1 Characteristics of modeling

One applies the material properties with perfect plasticity.

One models a quarter of the panel thanks to geometrical symmetry. The loading, the boundary conditions and of symmetry are the same ones like modelisation A.

7.2 Characteristics of the grid

Many nodes: 2481
Number of meshes and type: 800 TRIA7

7.3 Comparison of the results

Image 7.3-1. Loading according to the DZ in P3: Comparison enters the reference and the results of Code_Aster for the plastic case perfect with the meshes of TRIA7

7.4 Remarks

In the case élastoplastic, the behavior of the panel shows points of return in load but clearly a growth in displacement. That allows a calculation in “imposed displacement”: one imposes simply a displacement imposed by using the technique of piloting on the point P3 (option DDL_IMPO in STAT_NON_LINE).

Warning: The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

Copyright 2020 EDF R&D - Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)
For, only the one curve reference solution of the factor of loading ($\eta$) according to absolute displacement in P3 is available. Values of reference being to extract on a graph, the precise comparisons are made difficult. Consequently, one checks only the values of no-regression at a few moments.
8 Modeling F

8.1 Characteristics of modeling

![Diagram of the quarter of the panel simulated in modeling](image)

Image 8.1-1. Diagram of the quarter of the panel simulated in modeling

One applies the material properties with perfect plasticity.

One models a quarter of the panel thanks to geometrical symmetry. The loading, the boundary conditions and of symmetry are the same ones like Modeling A.

8.2 Characteristics of the grid

Many nodes: 1681
Number of meshes and type: 400 QUAD9

8.3 Comparison of the results

![Comparison of the results](image)

Image 8.3-1. Loading according to the DZ in P3: Comparison enters the reference and the results of Code_Aster for the plastic case perfect with the meshes of QUAD9

8.4 Remarks

In the case élastoplasic, the behavior of the panel shows points of return in load but clearly a growth in displacement. That allows a calculation in "imposed displacement": one imposes simply a displacement imposed by using the technique of piloting on the point P3 (option DDL_IMPO in STAT_NON_LINE).

Warning: The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

Copyright 2020 EDF R&D - Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)
For, only the one curve reference solution of the factor of loading (ETA) according to absolute displacement in P3 is available. Values of reference being to extract on a graph, the precise comparisons are made difficult. Consequently, one checks only the values of not-regression at a few moments.
9 Summary of the results

While comparing with the digital reference solution, one finds a coherence of the behavior of the panel subjected to an effort concentrated in his center in the elastoplastic field in spite of small differences.

Whatever the law of behavior (linear elasticity, élastoplasticity with a linear work hardening or perfect plasticity), one obtains results identical for the two various types of mesh (TRIA7 and QUAD9).