SSNP302 - Element charged in thermics - Appearance of the secondary stresses

Summary:

This test of linear quasi-static mechanics 2D consists in charging in thermics an element with plate to degree 1, by applying a field of temperature which varies linearly on the element and by fixing a side of the element.

This element being of degree 1, the total mechanical deformation will be constant in the element. The fields thermics imposing a linear deformation in the element, it will be necessary to take a dilation coefficient and a sufficiently large heat gradient to make the deformation mechanical total sensitive to the imposed thermal field.

The plate is modelled by an element plan (MECPQ4).
1 Problem of reference

1.1 Geometry

![Diagram of a rectangular element with applied stresses and boundary conditions.](image)

Length: $a = 1$

1.2 Material properties

Isotropic elastic material:

$$E = 200000 \text{ Mpa}$$

$$\nu = 0.$$  

$$\alpha = 1 \times 10^{-6} \circ C$$

1.3 Boundary conditions and loadings

Not $A$:

$$u_x = 0.$$ 

$$u_y = 0.$$ 

On the side $AD$:

$$u_x = 0.$$ 

On the side $BC$:

$$\sigma_D = 100 \text{ MPa}$$

Application of a field of temperature which varies linearly on the element with $T_{max} = 1000 \circ C$.
2 Reference solution

2.1 Method of calculating used for the reference solution

Analytical solution.

2.2 Results of reference

The mechanical deformation is worth:

\[ \varepsilon_{mec} = \varepsilon - \varepsilon_{th} = \varepsilon - \alpha T \]

With an element with the degree one and a diagram \(2 \times 2\) of integration one will have:

\[ \varepsilon_{mec} = \frac{u_{sB} - u_{sA}}{a} - \alpha \left[ \frac{1 + \xi}{2} T_{\text{max}} \right] \]

\[ = \frac{\sigma_d}{E} + \frac{1}{2} \alpha T_{\text{max}} - \alpha \left[ \frac{1 + \xi}{2} T_{\text{max}} \right] \]

The constraint in the test will be worth:

\[ \sigma = E \varepsilon_{mec} \quad \text{with} \quad \varepsilon_{mec} = 10^{-3} - \alpha \left[ \frac{1 + \xi}{2} T_{\text{max}} \right] \]

2.3 Notice

The thermal component of the constraint depending on the intrinsic coordinate, the solution is to consider an average temperature by element.
### 3 Modeling A

#### 3.1 Characteristics of modeling A

![Diagram of plane constraints](image)

Modeling in plane constraints: **C_PLAN**

The loading and the boundary conditions are modelled by:

- **DDL_IMPO** (Node **NO1** \( DX = 0 \) \( DY = 0 \))
  (Node **NO4** \( DX = 0 \))

- nodal forces imposed on the nodes **NO2** and **NO3**

- temperatures imposed on the nodes
  - **NO1**, **NO4**: \( T = 0 \°C \)
  - **NO2**, **NO3**: \( T = 1000 \°C \)

#### 3.2 Characteristics of the grid

- Many nodes: 4
- Many meshes and types: 1 **MECPQU4** with diagram of integration \( 2 \times 2 \)

#### 3.3 Sizes tested and results

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<thead>
<tr>
<th>Identification</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SIXX</strong> ( <strong>NO1</strong> )</td>
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</tr>
<tr>
<td><strong>SIXX</strong> ( <strong>NO4</strong> )</td>
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<tr>
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<tr>
<td><strong>SIXX</strong> ( <strong>NO3</strong> )</td>
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</table>

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4 Summary of the results

The results provided by Code_Aster are very satisfactory.