CRACK01 - Validation of *Wizard Analysis Ace module Aster of Salomé-Meca*

**Summary**

This test makes it possible to validate the command file obtained thanks to Wizard (assistant) *Analysis ace module Aster of Salomé-meca*. One recalls that this Wizard allows a calculation of the rate of refund and stress intensity factors in 2D, in axi-symmetry and 3D, starting from a healthy grid of a structure, by using the method X-FEM and the level-sets as well as automatic refinement of grid.

The case treated here is a circular crack plunged in a presumably infinite medium, resulting from the CAS-test sslv134.

- Modeling A deals with the problem in 3D (similar to the case test sslv134h),
- Modeling B deals with the axisymmetric problem in 2D (similar to the case test sslv134i).

Each time, the value of the factor of intensity of the constraints in mode $I$ is compared with the theoretical value resulting from an analytical solution.
1 Problem of reference

1.1 Geometry

The crack is circular (penny shaped ace) of ray \( a \), in the plan \( O_{xy} \). So that the medium is regarded as infinite, the sizes characteristic of the solid mass are about 5 times higher than the ray \( a \).

1.2 Material properties

Young modulus: \( E = 2 \times 10^5 \, MPa \)

Poisson's ratio: \( \nu = 0.3 \)

Density: \( \rho = 7850 \, kg/m^3 \)

1.3 Boundary conditions and loadings

- Lower face: uniform constraint of traction \( \sigma_z = 1 \, MPa \)
- Higher face: uniform constraint of traction \( \sigma_z = 1 \, MPa \)
2 Reference solution

2.1 Method of calculating used for the reference solution

For a circular crack of ray \( a \) in an infinite medium, subjected to a uniform traction \( \sigma \) according to the normal with the plan of the lips, the rate of refund of energy \( G(s) \) is independent of the curvilinear X-coordinate \( s \) and is worth [bib1]:

\[
G(s) = \frac{(1-\nu^2)}{\pi E} 4 \sigma^2 a
\]

then the coefficient of intensity of constraint \( K_I \) is given by the formula of Irwin:

\[
G(s) = \frac{(1-\nu^2)}{E} K_I^2 \text{ that is to say } K_I = \frac{2 \sigma \sqrt{a}}{\sqrt{\pi}}
\]

2.2 Results of reference

For the loading considered and \( a = 2 \) m, one obtains:

\[
G(s) = 11.586 J/m^2
\]

\[
K_I = 1,5958 \text{ MPa}
\]

2.3 Bibliographical references

3 Modeling a: modeling in 3D

3.1 Characteristics of modeling

The crack is not with a grid.
A quarter of the structure is modelled.
Conditions of symmetry on the side faces will be applied.

3.2 Characteristics of the grid

The initial grid is healthy and relatively coarse. The initial size of the meshes is of approximately $h_0 = 1.25$ (unit of the grid).

![Figure 3.2-a: grid initial 3D](image)

Many nodes: 2946
Number of meshes and type: 14192 TETRA4

This grid will be refined in an automatic way before the mechanical resolution thanks to the software Lobster in a zone around the bottom of crack. The target size of the meshes of the refined grid is $h_c = 0.15$. That implies 4 calls to Lobster. After refinement, the size of the meshes is of approximately $h = 0.078$ and the grid comprises:

- Many nodes: 13813
- Number of meshes and type: 76947 TETRA4
The ray of the refined zone east $R_{\text{ref}} = 6h$.

![Figure 3.2-b: grid 3D after refinement automatic](image)

### 3.3 Sizes tested and results

One tests the value of $K_I$ calculated by the order \texttt{CALC\_G} along the bottom of crack. Theoretically, $K_I$ is constant along the bottom of crack. It is thus checked that the max and the min of the values of $K_I$ along the bottom of crack are close to the value of reference.

The crown of integration is: $2h - 5h$.

<table>
<thead>
<tr>
<th>Identification</th>
<th>Reference</th>
<th>Type of reference</th>
<th>% tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\max (K_I)$</td>
<td>$1.595 \times 10^6$</td>
<td>ANALYTICAL</td>
<td>3.0</td>
</tr>
<tr>
<td>$\min (K_I)$</td>
<td>$1.595 \times 10^6$</td>
<td>ANALYTICAL</td>
<td>3.0</td>
</tr>
</tbody>
</table>
4 Modeling b: modeling in 2D axi-symmetry

4.1 Characteristics of modeling

The crack is not with a grid.
Only one section of the structure is modelled.

4.2 Characteristics of the grid

The initial grid is healthy and relatively coarse. The initial size of the meshes is of approximately \( h_0 = 1.25 \) (unit of the grid).

![Figure 4.2-a: initial grid 2d axisymmetric](image)

Many nodes: 250
Number of meshes and type: 438 TRIA3

This grid will be refined in an automatic way before the mechanical resolution thanks to the software Lobster in a zone around the bottom of crack. The target size of the meshes of the refined grid is \( h_c = 0.15 \). That implies 4 calls to Lobster. After refinement, the size of the meshes is of approximately \( h = 0.078 \) and the grid comprises:

Many nodes: 424
Number of meshes and type: 786 TRIA3

The ray of the refined zone east \( R_{raff} = 6h \).  

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### 4.3 Sizes tested and results

One tests the values of $G$ and $K_I$ calculated by the order `CALC_G` option `CALC_K_G'`, as well as the value of $G$ calculated by the order `CALC_G` (option `CALC_G`). Since modeling is axisymmetric, the relation between the rates of refund of energy total and local is [R7.02.01]: 

$$G_{\text{ref}}(\theta) = G(s) \cdot a,$$

that is to say here $G_{\text{ref}} = 23.172 \text{ J} / \text{m}$ for the value of $G$ calculated with the option `CALC_G'.

The crown of integration is: $2h - 5h$.

<table>
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<tr>
<th>Identification</th>
<th>Reference</th>
<th>Type of reference</th>
<th>% tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>$G$ (option `CALC_K_G')</td>
<td>11.586</td>
<td>ANALYTICAL</td>
<td>3.0</td>
</tr>
<tr>
<td>$K_I$</td>
<td>1.595 $10^6$</td>
<td>ANALYTICAL</td>
<td>3.0</td>
</tr>
<tr>
<td>$G$ (option `CALC_G')</td>
<td>23,172</td>
<td>ANALYTICAL</td>
<td>3.0</td>
</tr>
</tbody>
</table>

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5 Summaries of the results

This test shows that the command file Aster obtained thanks to Wizard (assistant) Ace-Analysis module Aster of Salomé-meca makes it possible to conclude a calculation of harmfulness of crack in 3D and 2D axisymmetric because the got results (rate of refund of energy and stress intensity factor) are in accordance with the analytical solution.