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.

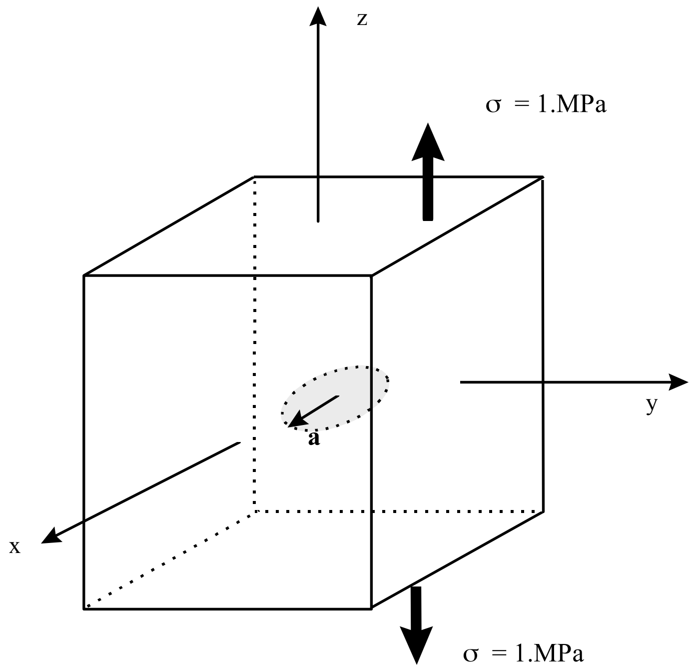
The case treated here is a circular crack plunged in a presumedly infinite medium, resulting from the CAS-test sslv134.

- 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 Oxy . 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: $E=2.10^5\,MPa$

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 σ according to the normal with the plan of the lips, the rate of refund of energy room $G(s)$ 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:

$$G(s)=\frac{(1-\nu^2)}{E}K_1^2 \text{ that is to say } K_I=\frac{2\sigma\sqrt{a}}{\sqrt{\pi}}$$

2.2 Results of reference

For the loading considered and $a=2m$, one obtains:
$G(s)=11.586 J/m^2$
$K_I=1,5958 MPa$.

2.3 Bibliographical references

1) Solution of Sneddon (1946) in G.C. SIH: Handbook of stress-intensity factors Institute of Fracture and Solid Mechanics - Lehigh University Bethlehem, Pennsylvania

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 meshs is of approximately $h_0=1{,}25$ (unit of the grid).

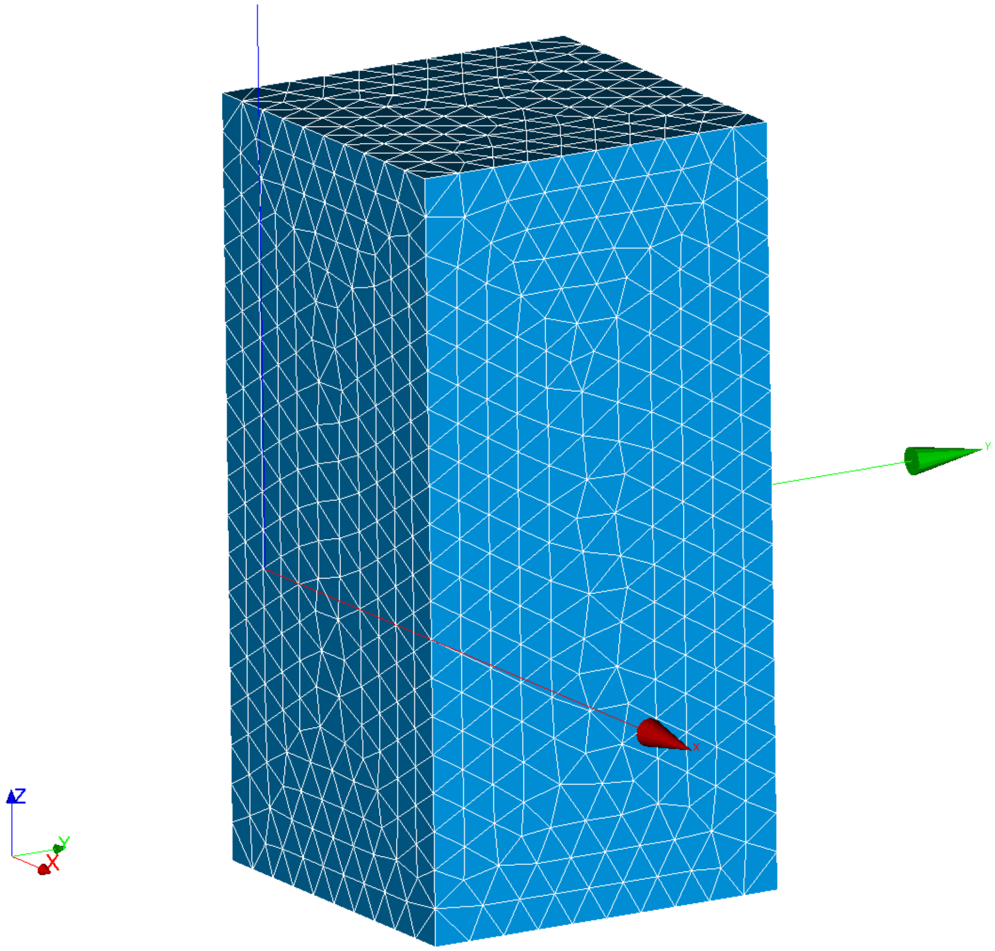


Figure 3.2-a: grid initial 3D

Many nodes: 2946
Number of meshs 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 meshs of the refined grid is $h_c=0{,}15$. That implies 4 calls to Lobster. After refinement, the size of the meshs is of approximately $h=0{,}078$ and the grid comprises:

Many nodes: 13813
Number of meshs and type: 76947 `TETRA4`

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

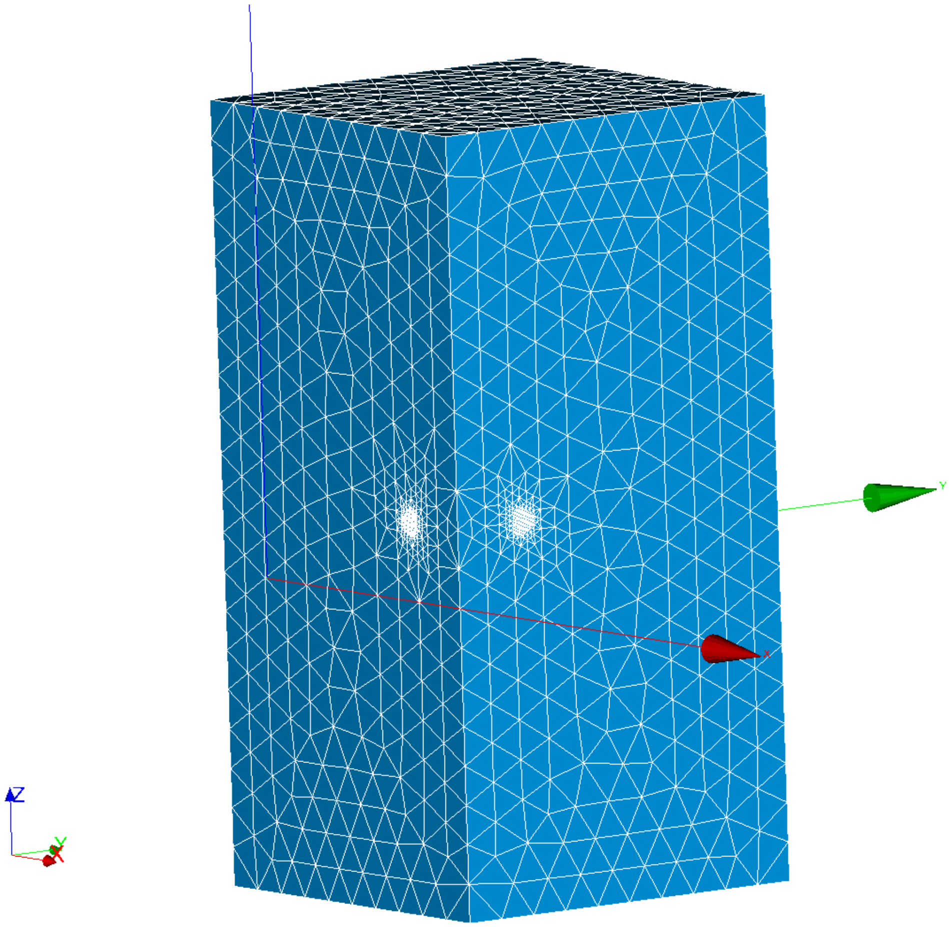


Figure 3.2-b: grid 3D after refinement automatic

3.3 Sizes tested and results

One tests the value of K_I calculated by the order 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: $2\mathrm{h}-5\mathrm{h}$.
Smoothing by default is used.

Identification	Reference	*Type of reference*	$\%$ tolerance
$max(K_I)$	1.595 10^6	ANALYTICAL	3,0
$min(K_I)$	1.595 10^6	ANALYTICAL	3,0

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 meshs is of approximately $h_0=1{,}25$ (unit of the grid).

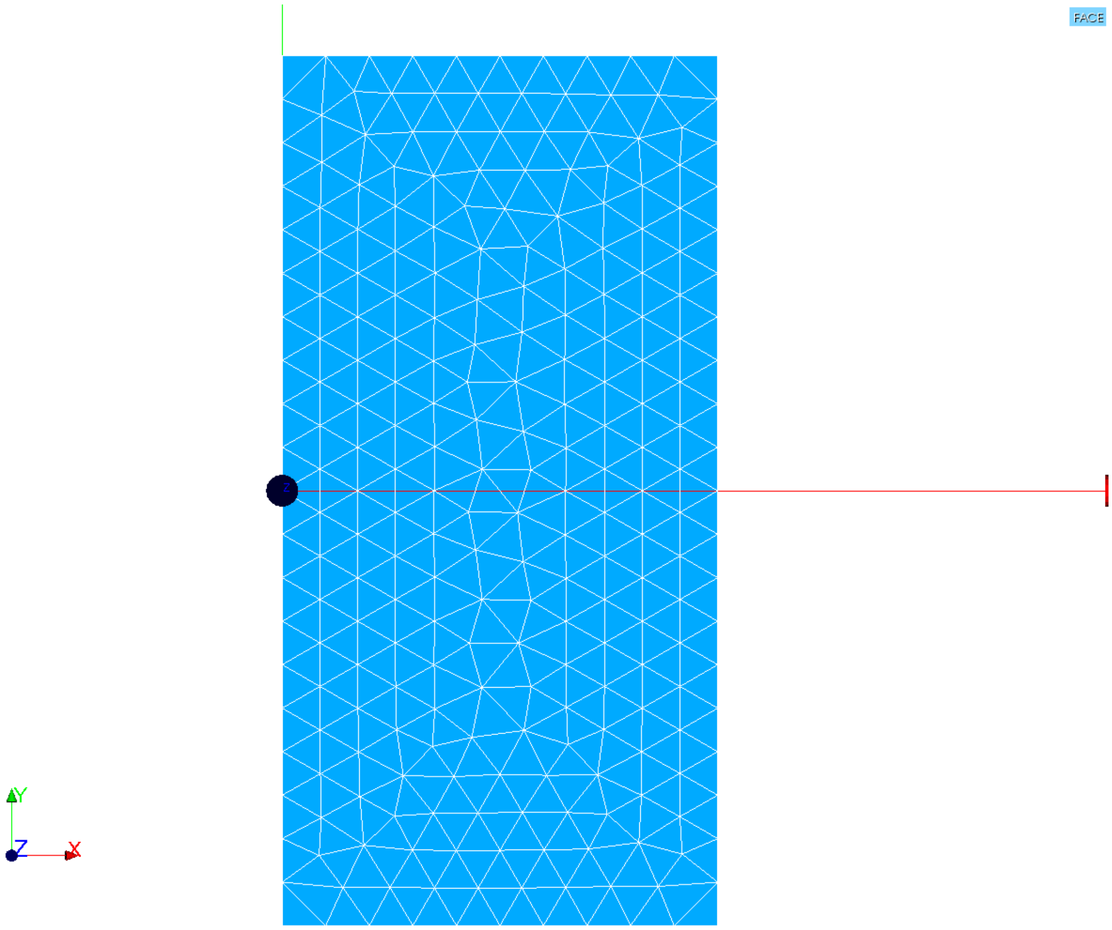


Figure 4.2-a: initial grid 2d axisymmetric

Many nodes: 250
Number of meshs 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 meshs of the refined grid is $h_c=0{,}15$. That implies 4 calls to Lobster. After refinement, the size of the meshs is of approximately $h=0{,}078$ and the grid comprises:
Many nodes: 424
Number of meshs and type: 786 TRIA3
The ray of the refined zone east $R_{raff}=6\text{h}$.

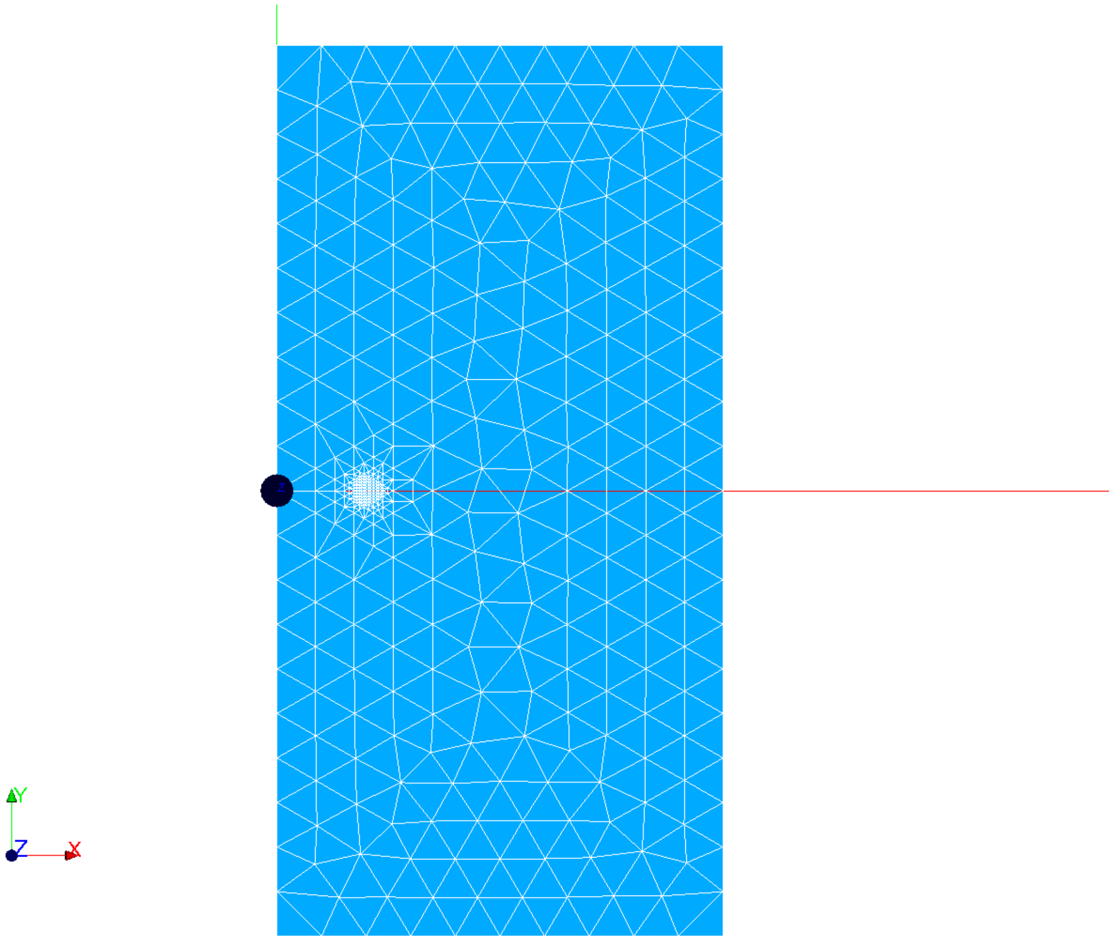


Figure 4.2-b: axisymmetric grid 2d after automatic refinement

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 .valor 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]: $G_{réf}(\theta)=G(s)\cdot a$, that is to say here $G_{réf}=23.172 J/m$ for the value of G calculated with the option 'CALC_G'.

The crown of integration is: $2\text{h}-5\text{h}$.

Identification	Reference	*Type of reference*	$\%$ tolerance
G (option 'CALC_K_G')	11.586	ANALYTICAL	3,0
K_I	1.595 10^6	ANALYTICAL	3,0
G (option 'CALC_G')	23,172	ANALYTICAL	3.0

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.