

SSLA311 – Subjected circular crack has an annular load

Summary:

This case test treats the case of an internal crack located at the center of a circular bar, in axisymmetric mode. The characteristic of the loading is that the linear load applies has a ring very close to the bottom of crack. The fixed parameter is the ray of the crack a , and the parameter to be explored is the ray of application of the load c . The medium is elastic, linear, homogeneous and isotropic. The geometrical field is supposed to be unlimited in r and z .

The grids must thus take account of the proximity of the load in such manner to respect the bridge of application of the load.

The load being normal has the crack, we calculate the coefficient characteristic of the breaking process K in mode I pure. Then, we use the formula of Irwin in deformation plane to deduce some G .

This constitutes an approximation of course.

1 Problem of reference

1.1 Geometry

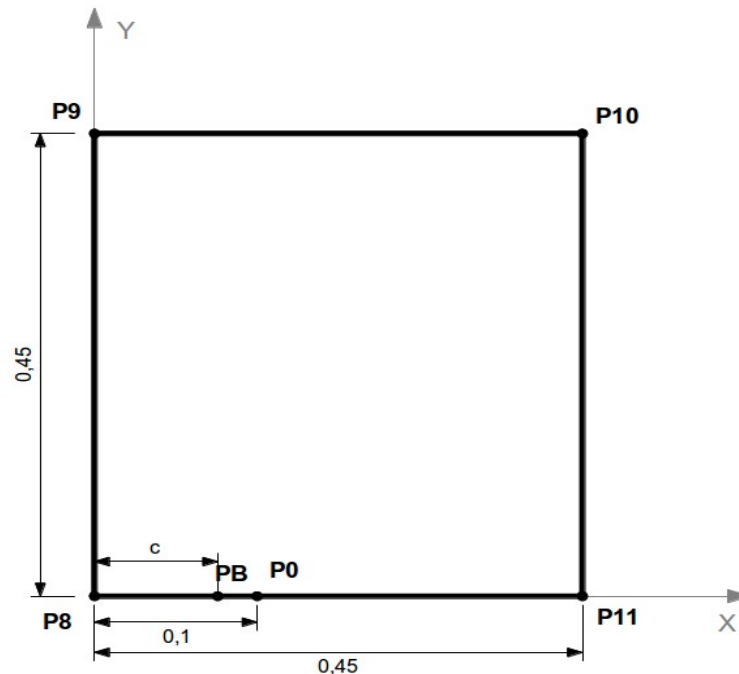


Figure 1.1 Geometry of the problem

1.2 Properties of material

Young modulus	$E = 2 \times 10^{11} \text{ Pa}$
Poisson's ratio	$\nu = 0.3$

1.3 Boundary conditions and loadings

The point PB is useful has the application of the force F_y .

The position of the point PB is different according to modelings, and is managed by the parameter C .

The distance a separating the points $P8$ and $P0$ is a constant parameter ($a = 0,1$).

In different modeling, the ratio is modified c/a .

The lip of the crack is the line $P8P0$. $P0$ is thus the face of crack.

For all modelings (A, B, C and D):

Imposed displacement:

Embedding of with dimensions one $P8P9$	$DX = 0$
Embedding of with dimensions one $P0P11$	$DY = 0$

Imposed loading:

Nodal force on the point PB

$$F_y = 159,15 \times 10^6 \text{ N}$$

Only the position of the point PB , and the grid which results from this are different between modelings (the size of the ray of the radiant grid in bottom of crack is different according to modelings).

2 Reference solution

2.1 result of reference

The value of G which is used as reference solution is extracted from a publication from Y. MURAKAMI: "Stress Intensity Factor" (puts 9.12)

2.2 Bibliographical references

- 1) Y. MURAKAMI: Stress Intensity Factor, box 9.12.
The Society of Materials Science, Japan, Pergamon Close 1987.

3 Modeling A

3.1 Characteristics of modeling A

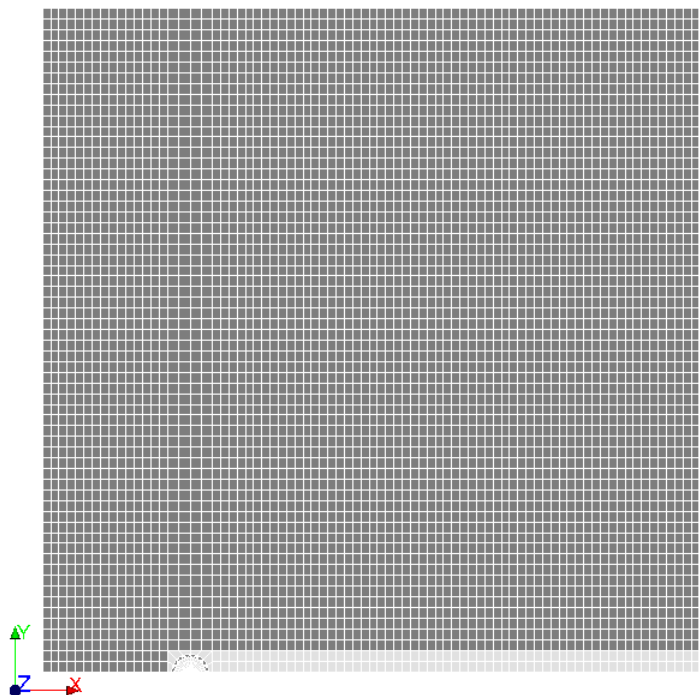


Figure 3.1 Grid of modeling A

Modeling AXIS .

Not application of the force PB (parameter C) = 0,09

3.2 Characteristics of the grid

Ray of the radiant grid in bottom of crack (not $P0$) = 0,01

Many nodes: 15209

Many meshes and types: 4986 QUAD8

3.3 Sizes tested and results

Size	Value of reference	Type of reference	Tolerance (%)
G	$7,72 E-5$	NON-DEFINI	0,02

4 Modeling B

4.1 Characteristics of modeling B

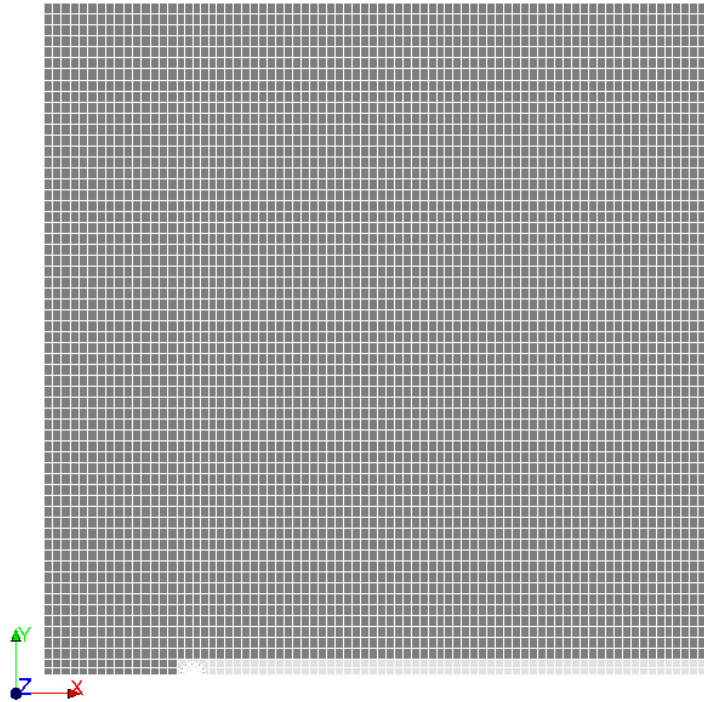


Figure 4.1 Grid of modeling B

Modeling `AXIS`.

Not application of the force `PB` (parameter `C`) = 0,093

4.2 Characteristics of the grid

Ray of the radiant grid in bottom of crack (not `P0`) = 0,007

Many nodes: 15209

Many meshes and types: 4986 `QUAD8`

4.3 Sizes tested and results

Size	Value of reference	Type of reference	Tolerance (%)
G	1,08619 E - 4	NON-DEFINI	0,01

5 Modeling C

5.1 Characteristics of modeling C

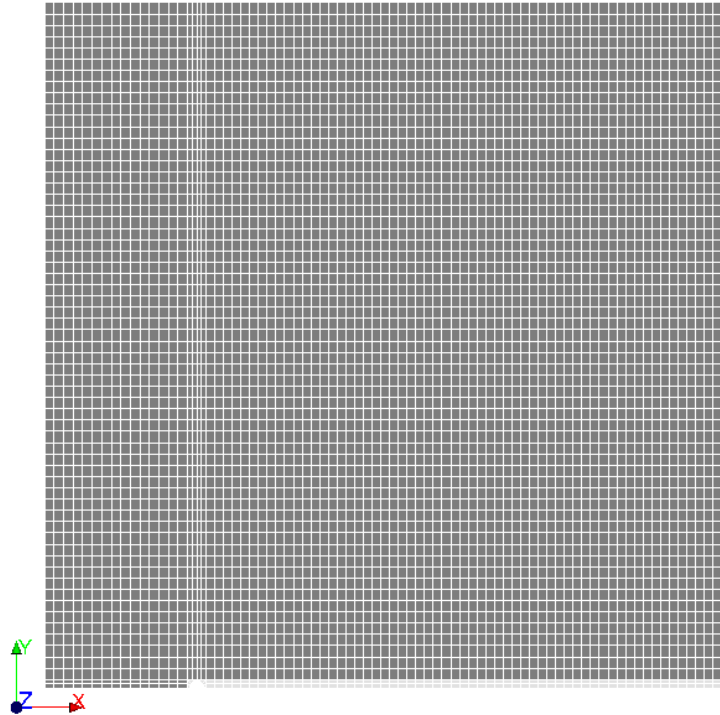


Figure 5.1 Grid of modeling C

Modeling `AXIS` .
Not application of the force `PB` (parameter `C`) = 0,096

5.2 Characteristics of the grid

Ray of the radiant grid in bottom of crack (not `P0`) = 0,004
Many nodes: 15209
Many meshes and types: 4986 `QUAD8`

5.3 Sizes tested and results

Size	Value of reference	Type of reference	Tolerance (%)
G	1,87174 E-4	NON-DEFINI	0,01

6 Modeling D

6.1 Characteristics of modeling D

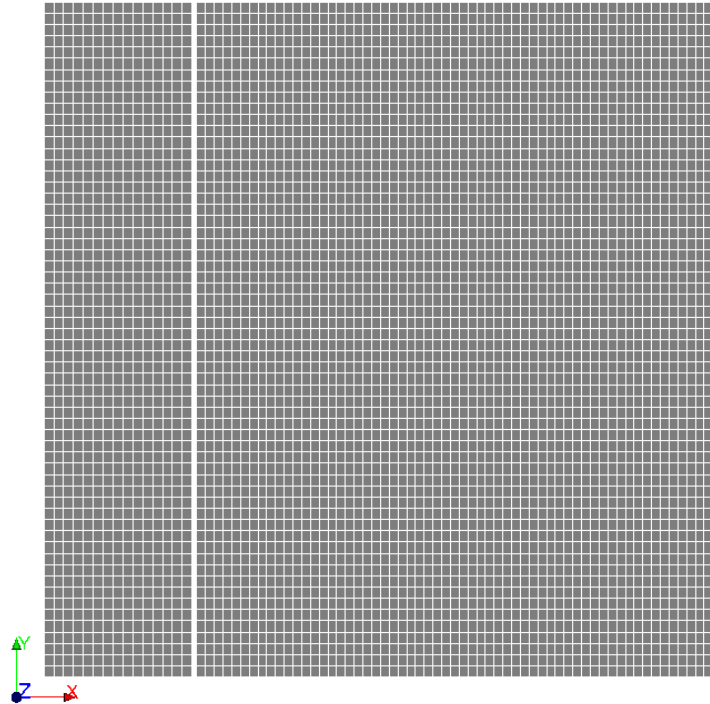


Figure 6.1 Grid of modeling D

Modeling `AXIS`.

Not application of the force `PB` (parameter `C`) = 0,099

6.2 Characteristics of the grid

Ray of the radiant grid in bottom of crack (not `P0`) = 0,001

Many nodes: 15209

Many meshes and types: 4986 `QUAD8`

6.3 Sizes tested and results

Size	Value of reference	Type of reference	Tolerance (%)
G	$7,37409 E - 4$	NON-DEFINI	0,02

7 Summary of the results

On these 4 modelings, one numerically finds the solution exposed by Y. MURAKAMI. The maximum variation enters the reference solution and the solution calculated by `CODE_ASTER` is of 0,02 %.

This test validates the use of the operators of `RUPTURE` on axisymmetric modelings.

8 Remarks

It is necessary to take precautions for the use of keyword `FORCE_NODALE` of order `CALC_G_THETA`. The load created a singular stress field in the vicinity of its point of application. In the typical case which we treat, where the load is close to the bottom of crack, therefore crowns, the higher ray of the crown of calculation of G does not have to reach the singular field created by the load (with the risk to have false results).