SSNV259– Circular crack in a solid cylinder under tension

Summary:

The aim of this test is to verify all keywords of the POST_JMOD macro_command except for ETAT_INIT. The testcase allows the computation of J-integrals in the presence of an initial stress state, within the framework of linear elasticity.

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1.Reference problem

2.1 Geometry

As shown in Figure 1, the structure under investigation is a cylinder (of radius b=10mm) containing a circular penny-shaped crack subjected to a uniform tensile loading condition. The crack is circular (penny shaped crack) of radius a=2mm, as shown in Figure 1. The cube's length is L=10a.

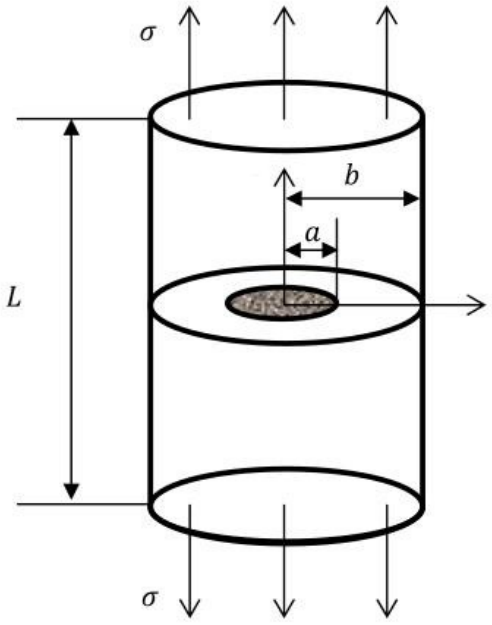


Figure 1: Geometry of a circular solid cylinder with central circular crack under tension.

2.2 Material properties

Material is linear elastic isotropic homogeneous with following characteristics:

- Young modulus: E=197 000 MPa
- Poisson's ratio: ν =0.3

2.3 Boundary conditions and loading

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A uniform tension stress σ = 100 MPa is applied. Also, only one eighth of the structure is modeled with appropriate symmetry boundary conditions.

2. Reference solution

The analytical SIF solution for this crack geometry (Figure 1) is given by Eshraghi *et al.* [1]:

$$K_I = \frac{2}{\pi}\sigma\sqrt{\pi a}\,F\left(\frac{a}{b}\right)$$

where:

$$F\left(\frac{a}{b}\right) = \frac{1-0.5\frac{a}{b}+0.148\left(\frac{a}{b}\right)^3}{\sqrt{1-\frac{a}{b}}}$$

And the energy release rate for mode I pure reads:

$$J = \frac{K_I^2 \times \left(1-\nu^2\right)}{E}$$

In this calculation, the input parameters are: a = 2 mm, b = 10 mm, which gives the values of J = 0.118 N/mm.

[1] I. Eshraghi and N. Soltani. Stress intensity factor calculation for internal circumferential cracks in functionally graded cylinders using the weight function approach. *Engineering Fracture Mechanics* , *134* : 1-19, 2015.

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1 Model A

1.1 Characteristics of the mode

In this model, the crack is meshed (FEM case).

We use the SYME=YES keyword for the crack.

The result rmed has been generated beforehand.

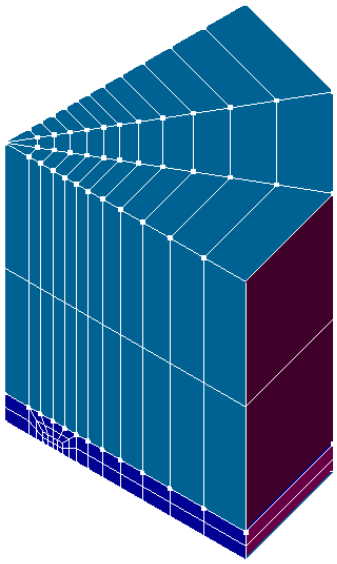


Figure 1.1: maillage de la structure

1.2 Caractéristiques du maillage

Number of nodes: 317

Number of cells and type: 562 POI1, 24 SEG2, 9 TRIA3, 239 QUAD4, 12 PENTA6, et 180 HEXA8.

1.3 Calculs effectués

The POST_J operator is tested against POST_K1 and CALC_G option G.

1.4 Grandeurs testées

Test des taux de restitution d'énergie :

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Identification	Référence	Type de référence	Tolérance
G CALC_G option G NUME_PT=1	0.118	'ANALYTIQUE'	5 %
G POST_K1_K2_K3/G NUME_PT=1	0.118	'ANALYTIQUE'	5%
J POST_JMOD/option J NUME_PT=1	0.118	'ANALYTIQUE'	3%
J POST_JMOD/option JMOD NUME_PT=1	0.118	'ANALYTIQUE'	3%
J POST_JMOD/option J NB_POINT_FOND=2 NUME_PT=1	0.118	'ANALYTIQUE'	3%
J POST_JMOD/option J NB_POINT_FOND=2 and a dummy ETAT_INIT field NUME_PT=1	0.118	'ANALYTIQUE'	3%

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2 Synthèse des résultats

- This POST_JMOD development allows to calculate J for symmetric and non-symmetric problems, linear and quadratic meshes, opened and closed cracks, linear and non-linear problems (Models A to J).

- The solutions are well agreed with the reference ones with a fine mesh (Model C).

- POST_JMOD provides in general better results than CALC_G and POST_K1K2K3 and does not significantly depend on the contour.

- The desired outputs may be selected for calculating and printing via the options of POST_JMOD.

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