

ZZZZ257 - Estimator of error in quantity of interest for the fracture mechanics

Summarized:

This test makes it possible to validate the estimate of error in quantity of interest for the fracture mechanics. One thus tests the 3 methods available in *Code_Aster* (residues, lissage *ZZ1* and lissage *ZZ2*). Moreover command files give a groundwork for the implementation of the estimate of error in quantity of interest and more particularly the definition of the loading for the dual problem.

There are 3 modelizations which decline 3 different problems:

- Modelization a: plates fissured subjected to a uniform tractive effort;
- Modelization b: cantilever beam subjected to a shearing force;
- Modelization C: plate with an inclined crack, subjected to a tractive effort.

1 Problem of reference

1.1 Geometry

In this test, one considers three configurations of fissured plate. The first problem is a fissured plate subjected to a uniform tractive effort (request in mode *I*). The second problem is a cantilever beam subjected to a shearing force (request in mode *I* and mode *II*). Finally the third problem is a plate with an inclined crack, subjected to a tractive effort (request in mode *I* and mode *II*).

The geometrical parameters are the following:

- $L/b=16/7$;
- $h=L/2$;
- $a/b=1/2$;
- $L=16$;
- $\theta=60^\circ$.

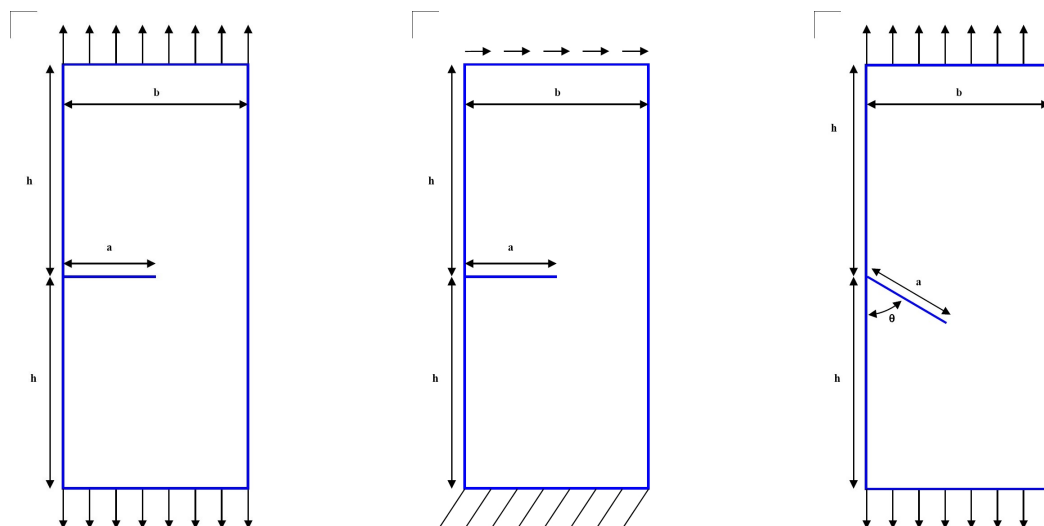


Table 1.1-1: Problem 1 (left), problem 2 (center) and problem 3 (right)

One definite:

- the mesh group *HAUT* like higher edge;
- the group of mesh *BAS* like lower edge;
- the group of node *FONDFISS* (only one node) like the crack tip;
- the group of node *BLOCAGE* (only one node) like the intersection of the prolongation of crack and flat rim.

In addition, for the error analysis in quantity of interest, it is necessary to define another problem (the dual problem) which differs from the initial problem only by the conditions of Neuman (the stiffness matrix and the conditions of Dirichlet are the same ones). The specific loading of the dual problem in the frame of the estimate of error on the factors of intensity of the stresses must be defined by the means of functions to impose on the lips of crack. To know how to define this loading and how to impose it, one will be able to refer on the one hand to the command files and on the other hand in documentation of reference on the estimate of error in quantity of interest [R4.10.06].

1.2 Properties of the material

- Modulus Young: $E = 200000$ MPa
- Poisson's ratio: $\nu = 0.3$

1.3 Boundary conditions and loadings

Problem 1:

- Group of mesh *HAUT* : $FY = 1$
- Group of mesh *BAS* : $FY = -1$
- The node is outside the field of definition with a right profile of the EXCLU type node:
FONDFISS $DY = 0$
- The node is outside the field of definition with a right profile of the EXCLU type node:
BLOCAGE $DX = DY = 0$

Problem 2:

- Group of mesh *HAUT* : $FX = 1$
- Group of mesh *BAS* : $DX = DY = 0$

Problem 3:

- Group of mesh *HAUT* : $FY = 1$
- Group of mesh *BAS* : $FY = -1$
- The node is outside the field of definition with a right profile of the EXCLU type node:
FONDFISS $DY = 0$
- The node is outside the field of definition with a right profile of the EXCLU type node:
BLOCAGE $DX = DY = 0$

2 Reference solution

2.1 Method of calculating

the reference solutions for the factors of intensity of the stresses result from the "Stress Intensity Factors Handbook" of Murakami [bib1]. The reference solutions for the estimate of error are solution of NON-regression. The estimators of error were validated in the thesis of J. Delmas [bib2].

2.2 Quantities and results of reference

the results of references for the factors of intensity of the stresses are:

	K_I	K_{II}
Problem 1	9,37	-
Problem 2	33,93	4,53
Problem 3	6,33	1,86

Table 2.2-1 : Quantities and results of reference

2.3 bibliographical References

- [1] Y. Murakami, "Stress Intensity Factors Handbook", Pergamon Close Oxford, 1987.
- [2] J. Delmas, "Strategies of controls of miscalculation of industrial structures. Implementation of estimate of error in quantity of interest and mesh adaptation", Doctorate, University of Picardy Jules Verne, 2008.

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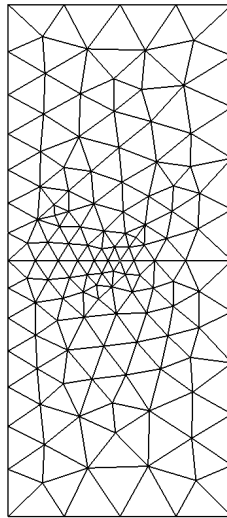
3 Modelization A

3.1 Characteristic of the modelization

The modelization used is a modelization C_PLAN.

3.2 Characteristics of the mesh

The mesh is composed of 240 linear triangles. The mesh is transformed into quadratic mesh in the command file. Moreover elements in crack tip are transformed into elements of Barsoum.



Appear 3.2-a: Mesh for
problem 1

3.3 Quantities tested and results

One by the command tests the values of the factors of intensity of stresses given POST_K1_K2_K3 (comparison analytical and NON-regression) and the value of the estimators of error for the 3 methods implemented in Code_Aster (parameters ERREUR_ERRE, ERREUR_ERZ1, ERREUR_ERZ2, ERREUR_QIRE, ERREUR_QIZ1, ERREUR_QIZ2) for the primal problem and the dual problem (comparison NON-regression).

Quantity tested	Value of reference	Tolerance (relative)
K1 (analytical)	9.37	0.005
ERREUR_ERRE	2.6654055228458E-03	1.E-8
ERREUR_ERZ1	3.0877585644437E-03	1.E-8
ERREUR_ERZ2	7.4767989844696E-03	1.E-8
ERREUR_ERRE	5.2145715958031E+01	1.E-8
ERREUR_ERZ1	6.2002976336900E+01	1.E-8
ERREUR_ERZ2	1.4362442647950E+02	1.E-8
ERREUR_QIRE	9.3257156697600E+01	1.E-8
ERREUR_QIZ1	3.0877585644437E-03	1.E-8
ERREUR_QIZ2	7.4767989844696E-03	1.E-8

Table 3.3-1 : Results for the quantities tested

4 Modelization B

4.1 Characteristic of the modelization

The modelization used is a modelization C_PLAN.

4.2 Characteristics of the mesh

The mesh is the same one as for the modelization A

4.3 Quantities tested and results

One by the command tests the values of the factors of intensity of stresses given POST_K1_K2_K3 (comparison analytical and NON-regression) and the value of the estimators of error for the 3 methods implemented in Code_Aster (parameters ERREUR_ERRE, ERREUR_ERZ1, ERREUR_ERZ2, ERREUR_QIRE, ERREUR_QIZ1, ERREUR_QIZ2) for the primal problem and the dual problem (comparison NON-regression).

Quantity tested	Value of reference	Tolerance (relative)
K2 (analytical)	4.53	0.03
K2 (non regression)	4.65	1.5E-6
ERREUR_ERRE	1.0037405543237E-02	1.E-8
ERREUR_ERZ1	1.1598992325170E-02	1.E-8
ERREUR_ERZ2	4.3649921113998E-02	1.E-8
ERREUR_ERRE	3.1841311747473E+01	1.E-8
ERREUR_ERZ1	5.6752165388391E+01	1.E-8
ERREUR_ERZ2	9.1883438831033E+01	1.E-8
ERREUR_QIRE	4.7392126029165E+01	1.E-8
ERREUR_QIZ1	1.1598992325170E-02	1.E-8
ERREUR_QIZ2	4.3649921113998E-02	1.E-8

Table 4.3-1 : Results for the quantities tested

5 Modelization C

5.1 Characteristic of the modelization

The modelization used is a modelization C_PLAN.

5.2 Characteristics of the mesh

The mesh is composed of 222 linear triangles. The mesh is transformed into quadratic mesh in the command file. Moreover elements in crack tip are transformed into elements of Barsoum.

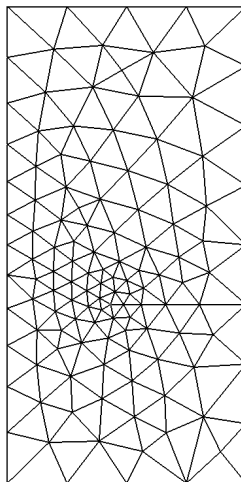


Figure 5.2-a : 5.2-a Mesh
for the problem 3

5.3 Quantities tested and results

One by the command tests the values of the factors of intensity of stresses given POST_K1_K2_K3 (comparison analytical and NON-regression) and the value of the estimators of error for the 3 methods implemented in Code_Aster (parameters ERREUR_ERRE, ERREUR_ERZ1, ERREUR_QIRE, ERREUR_QIZ1) for the primal problem and the dual problem (comparison NON-regression).

Quantity tested	Value of reference	Tolerance (relative)
K1 (analytical)	6.33	0.099
K1 (non regression)	6.95029	1.E-6
ERREUR_ERRE	2.2009669815803E-03	1.E-8
ERREUR_ERZ1	2.2766563775709E-03	1.E-8
ERREUR_ERRE	5.2902256540711E+01	1.E-8
ERREUR_ERZ1	5.5578633368626E+01	1.E-8
ERREUR_QIRE	7.6783302550272E+01	1.E-8
ERREUR_QIZ1	2.2766563775709E-03	1.E-8

Table 5.3-1 : Results for the quantities tested

6 Summary of the results

the got results are satisfactory. The estimate of error in quantity makes it possible well to adapt the mesh.