

ZZZZ218 – Validation of the order MACR_ECREVISSE

Summary:

This CAS-test makes it possible to validate the cha by means of computer stroke of Code_Aster with Crayfish, realized via the macro-order MACR_ECREVISSE, to estimate the flows of fluid (air/water/vapor) which can cross a crack.

Three modelings are proposed, whose first and second are of not-regression. In the first modeling, there is a horizontal crack in a structure; in the second, there are 2 vertical cracks which interact; in the third, one tests the macro-order compared to a rotation-translation.

1 Problem of reference

This test is inspired by test SIMIBE carried out at the ECA.

Three different modelings are described. The material and the characteristics of the flow are the same ones for three modelings, and they are described in the section §1. The geometry changes slightly for three modelings. One shows in the §1.1 a diagram of the geometry for modeling A; for other modelings one goes will describe the differences.

1.1 Geometry and material

The total geometry is presented on Figure 1.1-a. The characteristics of the crack are given in bottom. To notice that the unit are expressed in system international S.I. As also specified in the user's documentation U7.03.41, that is made compulsory by the software *Crayfish*, which contains not adimensionalized formulas.

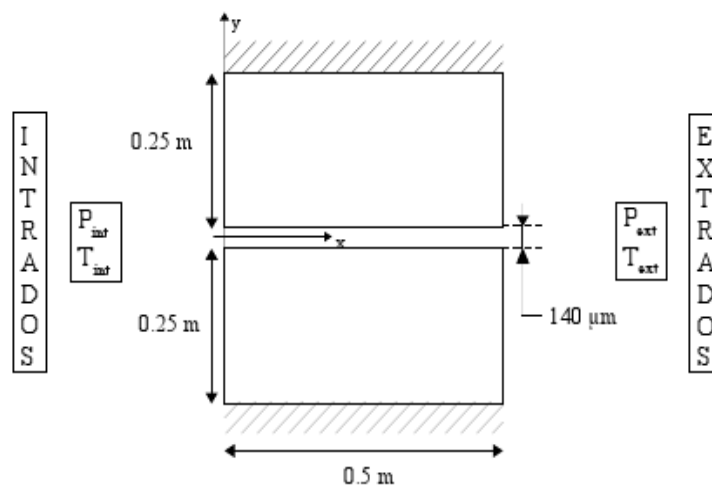


Figure 1.1-a : geometry of the CAS-test

Details of the crack:

- section: RECTANGLE
- direction of the flow: X , in the positive direction
- absolute roughness of the wall: $0,5 \cdot 10^{-6} m$
- loss ratio of singular load at the entry: none ($ZETA = 0$)
- dimension of the crack in the normal direction with the plan (z): $0.5 m$ ($LIST_VAL_BL = (0.5, 0.5)$)
- remanent opening fixed at $30 \mu m$

Flow:

- pressure of stagnation at the entry: $10 \cdot 10^5 Pa$
- pressure of stagnation at the exit: $10^5 Pa$
- condition of the fluid at the entry: air alone ($FLUIDE_ENTREE = 6$)
- temperature at the entry: $140^\circ C$

Model:

- model of flow with SATURATION
- friction calculated directly starting from the absolute roughness of the wall (FRICTION = 1)
- transfer of heat with a correlation of Sieder & Touches into monophasic laminar and a correlation of Mac Adams in the other modes. In the event of gas mixture/liquid, calculation either in gas, or in the liquid, or via the correlation of Chen according to the mass title of gas and the rate of vacuum (TRANSFERT_CHAL = 1).

1.2 Properties of material

The selected values are representative of a concrete.

$$E = 35\,000\text{ MPa}$$

$$\nu = 0.25$$

$$\alpha = 10^{-5} / ^\circ\text{C}$$

$$\lambda = 2.3\text{ J/m}^2\text{ s}^\circ\text{C/m}$$

$$\rho C_p = 2500000\text{ J/m}^3\text{ }^\circ\text{C}$$

1.3 Boundary conditions and loading

The parts higher and lower are embedded.

It is supposed that the crack cannot be entirely closed. Thus, the remanent opening is fixed at $30\ \mu\text{m}$ to leave a minimum fluid flow not no one.

With the suction face, the temperature is always worth $T_{ext} = 20\ ^\circ\text{C}$ and pressure $P_{ext} = 1.105\ \text{Pa}$.

On the faces internal and external, one supposes that the exchanges with the ambient conditions take place with the coefficients of following exchange: $h_{int} = 8\text{ W/m}^2$ and $h_{ext} = 4\text{ W/m}^2$

One injects hot air under pressure is $T_{int} = 140\ ^\circ\text{C}$ and $P_{int} = 10.10^5\ \text{Pa}$.

1.4 Initial conditions

The concrete is at rest, with $20\ ^\circ\text{C}$, with a crack crossing of $140\ \mu\text{m}$ of opening.

2 Reference solution

Modelings A and B are test of nonregression.

Modeling C checks the behavior of the macro-order for an oblique crack, and that the macro one is robust compared to a rotation-translation. The response of the structure to a position of reference is compared with that of the same turned and relocated structure.

3 Modeling A

3.1 Characteristics of modeling

The behavior of the order here is validated MACR_ECREVISSE in the presence of a crossing crack horizontal. One chooses a modeling in plane deformations for mechanics D_PLAN, and a thermal modeling PLAN_DIAG, with a matrix of mass diagonalized for thermics.

The characteristics of the flow have summers described with the geometry with the §1.1.

3.2 Characteristics of the grid

The grid used is presented Figure 3.2-a :

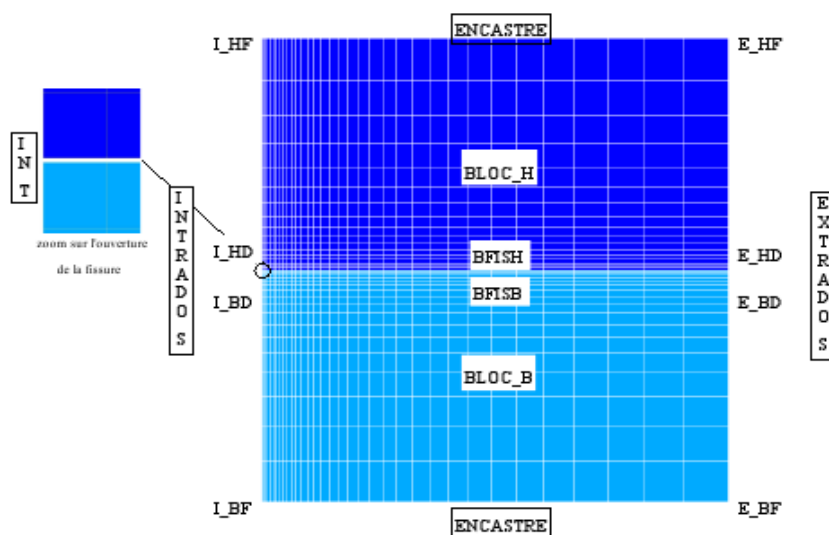


Figure 3.2-a : Complete grid

Dimensions are the same ones as for the geometry.

Many Nœuds: 1260

Many meshes: 1156 QUAD4

The parameters of growth used to carry out the grid are the following: of 0.002 m (under-surface) with 0.05 m (suction face), and idem of BFISH and BFISB with EMBED.

3.3 Sizes and results

One tests the significant sizes of this calculation namely: flow, as well as the displacement and the temperature as starter and at exit of cracks. Two moments are tested.

With $t=500\text{ s}$:

Identification	Tolerance
Displacement DY with Nœud E_{HD} [m]	1.0E-06
Temperature of material with Nœud E_{HD} [$^{\circ}C$]	1.0E-06
Displacement DY with Nœud I_{HD} [m]	1.0E-06
Temperature with Nœud I_{HD} [$^{\circ}C$]	1.0E-06
Flow	1.0E-06

With $t=10000\text{ s}$:

Identification	Tolerance
Displacement DY with Nœud E_{HD} [m]	1.0E-06
Temperature of material with Nœud E_{HD} [$^{\circ}C$]	1.0E-06
Displacement DY with Nœud I_{HD} [m]	1.0E-06
Temperature with Nœud I_{HD} [$^{\circ}C$]	1.0E-06
Flow	1.0E-06

3.4 Remarks

With $t=10000\text{ s}$, Nœud I_{HD} moved approximately $-70\mu m$, (in particular because of thermal dilation) what corresponds to the half opening of the crack. That means that the lips are in contact (keyword `DEFI_CONTACT` activated) and fissures it closed. On the other hand, for the hydraulic part (managed by *Crayfish*), a remanent opening is fixed, so that the flow is never null.

4 Modeling B

4.1 Characteristics of modeling

In this modeling, one validates the use of the macro-order `MACR_ECREVISSE` in the presence of 2 vertical cracks. The geometry is slightly different from that of modeling A. It is described with the grid in Figure 4.2-a. The characteristics of the flow and material have summers described with the § 1.

As for modeling A, one works in plane deformations for mechanics (`D_PLAN`), and with a matrix of mass diagonalized for thermics (`PLAN_DIAG`).

4.2 Grid and boundary conditions

The grid used is presented Figure 4.2-a :

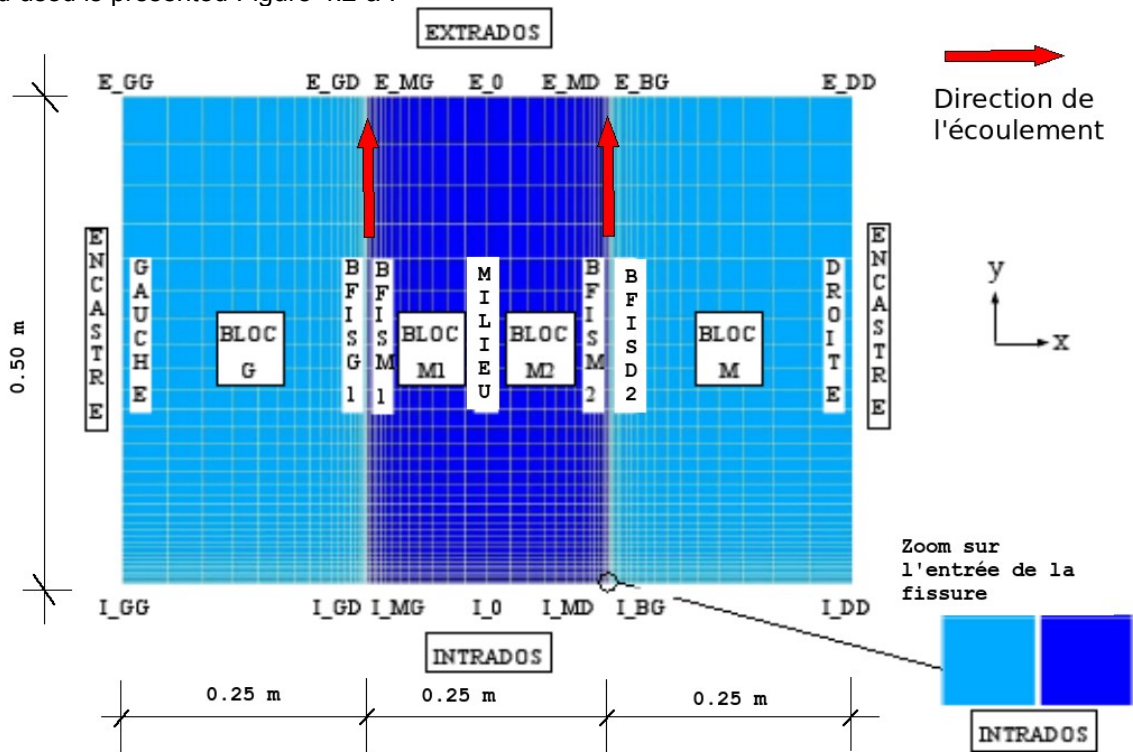


Figure 4.2-a : Complete grid

Dimensions of each of the three blocks are of 0.50 m of top and 0.25 m of broad.

Many Nœuds: 2275
Many meshes: 2108 QUAD4

The parameters of growth of the sizes of meshes used to carry out the grid are the following: of 0.002 m (under-surface) with 0.05 m (suction face), and idem of `BFISG1/BFISD2` with `EMBED`; of 0.025 m with `MEDIUM` with 0.002 m on `BFISM1/BFISM2`.

The cracks are called with the name of the lips: `BFISG1-BFISM1` (CRACK 1), (CRACK 2).

Boundary conditions:

1. The with dimensions ones named `EMBED` are embedded ($DX=0$, $DY=0$).

2. On with dimensions one MEDIUM (line of symmetry) one block displacement in direction X ($DX=0$).
3. A condition of contact is defined between the lips BFISG1-BFISM1 and BFISM2-BFISD2 (DEFI_CONTACT).
4. Pressure and the temperature on the under-surface UNDER-SURFACE are larger than on the suction face SUCTION FACE ($1.E6 Pa$ and $140^{\circ}C$ versus $1.E6 Pa$ and $20^{\circ}C$), which causes the flow of the under-surface to the suction face.
5. The material is considered, at the beginning of calculation, the temperature environment $20^{\circ}C$, which is the temperature of reference.

4.3 Sizes and results

One tests at 2 different moments, displacements and the temperature as starter of the crack of left and at exit of the crack of right-hand side. Lastly, one tests the flow of the crack of right-hand side with $t=500 s$ and of the crack of left with $t=10000 s$.

With $t=500 s$:

Identification	Tolerance
Displacement DX with Nœud E_{MD} [m]	1.0E-06
Temperature of material with Nœud E_{MD} [$^{\circ}C$]	1.0E-06
Displacement DX Nœud I_{GD} [m]	1.0E-06
Temperature of material with Nœud I_{GD} [$^{\circ}C$]	1.0E-06
Crack BFISG1-BFISM1, flow	1.0E-06

With $t=10000 s$:

Identification	Tolerance
Displacement DX with Nœud E_{MD} [m]	1.0E-06
Temperature of material with Nœud E_{MD} [$^{\circ}C$]	1.0E-06
Displacement DX with Nœud I_{GD} [m]	1.0E-06
Temperature of material with Nœud I_{GD} [$^{\circ}C$]	1.0E-06
Crack BFISM2-BFISD2, flow	1.0E-06

4.4 Remarks

The opening of the crack with $t=10000 s$ is about 10^{-9} , therefore is almost closed because of thermal dilation due to the high temperature with the under-surface. In this case also, it is the remanent opening which is retained for the calculation of the flow.

5 Modeling C

5.1 Characteristics of modeling

In this modeling, one validates the use of the macro-order `MACR_ECREVISSE` by report a rotation and with a translation has. It is not thus about a test of not-regression.

Indeed, results of *Crayfish* depend only on the characteristics of the crack, including the direction. This one is influenced by gravity. Thus, cracks with same the characteristics and having a symmetrical direction compared to the vertical must give the same flows.

One works with the same parameters (of material, of the flow of the crack) that in modeling A (§ 1.1). The grid is also the same one, except that it is turned and relocated. The detail of the grid is given to the §5.2.

5.2 Grid and boundary conditions.

The two grids used were obtained by rotation and translation of the grid of modeling A, therefore they preserve same dimensions of them. They are presented in Figure 5.2-a and Figure 5.2-b.

For the first grid, the first curvilinear X-coordinate of the crack is the point of origin of the axes $(0;0)$.

The second grid results from a rotation of 120 degrees of the first grid around the origin and from a translation of vector $(-10; 20)$.

The boundary conditions for the two grids are similar to modeling a:

1. The with dimensions ones named `FIXE1` (or `FIXE2`) are embedded ($DX=0$, $DY=0$).
2. A condition of contact is defined between the lips `BFISH1`-`BFISB1` (`BFISH2`-`BFISB2`) (`DEFI_CONTACT`).
3. Pressure and the temperature on the under-surface `INTRA1` (`INTRA2`) are larger than on the suction face `EXTRA1` (`EXTRA2`) : ($1.E6 Pa$ and $140^{\circ}C$ versus P_{atm} and $20^{\circ}C$). That causes the flow of the under-surface to the suction face.
4. The material is considered, at the beginning of calculation, the room temperature $20^{\circ}C$, which is the temperature of reference.

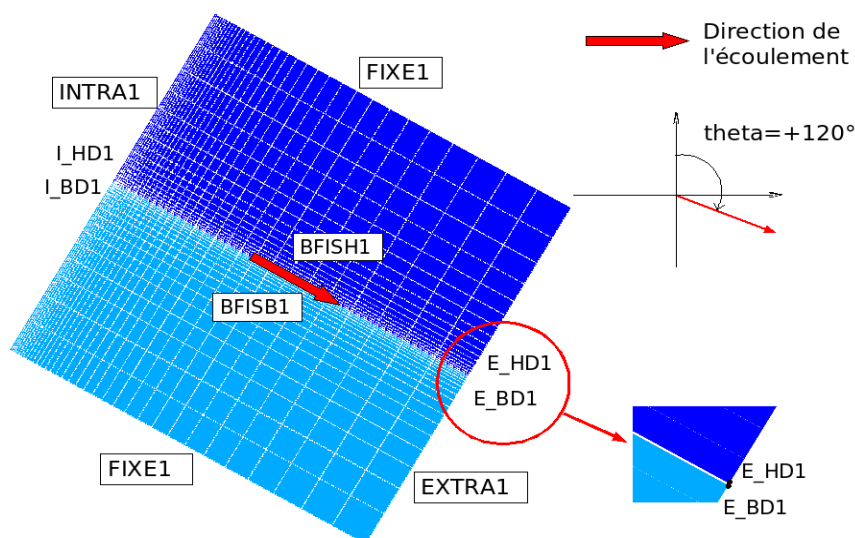


Figure 5.2-a : Grid 1 for the direction $\theta = 120^\circ$ (compared to the vertical).

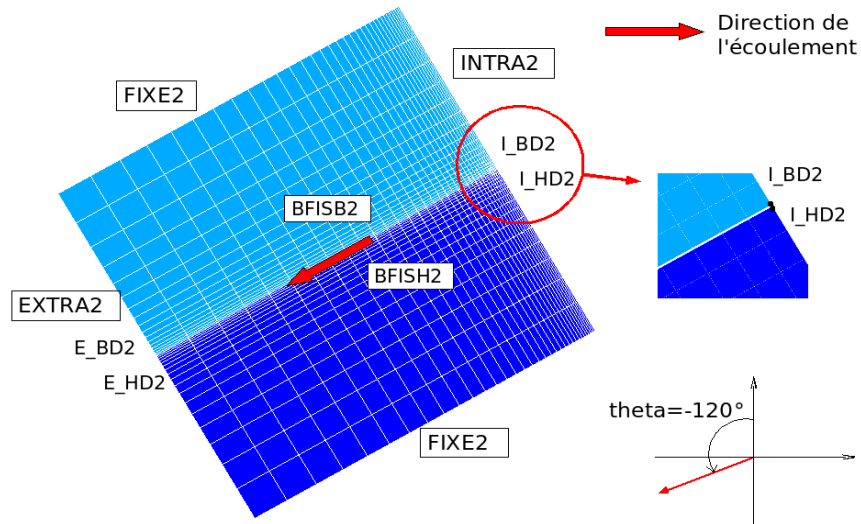


Figure 5.2-b : Grid 2 for the direction $\theta = -120^\circ$ (compared to the vertical).

5.3 Sizes tested and results

One tests the results at the moment $t = 10000 \text{ s}$. One extracts the values from the result of the grid 2, and one compared to those corresponding them to grid 1.

Grid 1	Grid 2
Displacement DX with Nœud E_{HD1}	by symmetry: $(-1) * \text{Displacement } DX \text{ with Nœud } E_{BD2}$
Displacement DX with Nœud E_{BD1}	by symmetry: $(-1) * \text{Displacement } DX \text{ with Nœud } E_{HD2}$
Displacement DY with Nœud E_{HD1}	by symmetry: Displacement DY with Nœud E_{BD2}
Displacement DY with Nœud E_{BD1}	by symmetry: Displacement DY with Nœud E_{HD2}
Temperature of material with Nœud I_{HD1}	Temperature of material with Nœud I_{HD2}
Total flow	Total flow
Coefficient Convection the first ABS. curv.	Coefficient Convection the first ABS. curv.
Pressure the first ABS. curv.	Pressure the first ABS. curv.
Temperature of the fluid first ABS. curv.	Temperature of the fluid first ABS. curv.
Heat flow of the fluid first ABS. curv.	Heat flow of the fluid first ABS. curv.

Size	Tolerance
Displacement DX with Nœud E_{HD1}	1.0E-05
Displacement DX with Nœud E_{BD1}	1.0E-05

Displacement DY with Nœud E_{HD1}	1.0E-05
Displacement DY with Nœud E_{BD1}	1.0E-05
Temperature of material with Nœud I_{HD1}	1.0E-04
Total flow	1.0E-03
Coefficient Convection the first ABS. curv.	1.0E-04
Pressure the first ABS. curv.	1.0E-04
Temperature of the fluid first ABS. curv.	1.0E-04
Heat flow of the fluid first ABS. curv.	1.0E-03

5.4 Remarks

The lips are in contact, the order `DEFI_CONTACT` is activated. The calculation of flow is carried out with the remanent opening.

6 Summary of the results

The results are coherent with it what physically one expected.