ZZZZ314 – Data-processing validation of DEFI_FOND_FISS

Summary:
The purpose of this test is to validate in an elementary way the operator DEFI_FOND_FISS through six modelings comprising each one a crack with a grid in stuck configuration (CONFIG_INIT=' COLLEE'). This test does not have physical meaning inevitably, it is primarily a data-processing test.
The cas-test consists in testing the vectors of the local base at the bottom of crack according to various configurations of DEFI_FOND_FISS.

Case of a rectilinear bottom of crack :

Modeling a:
- Grid 2D .

Modeling b:
- Grid 2D symmetrical.

Modeling C:
- Grid 3D

Modeling D:
- Grid 3D symmetrical.

Case of a curved bottom of crack :

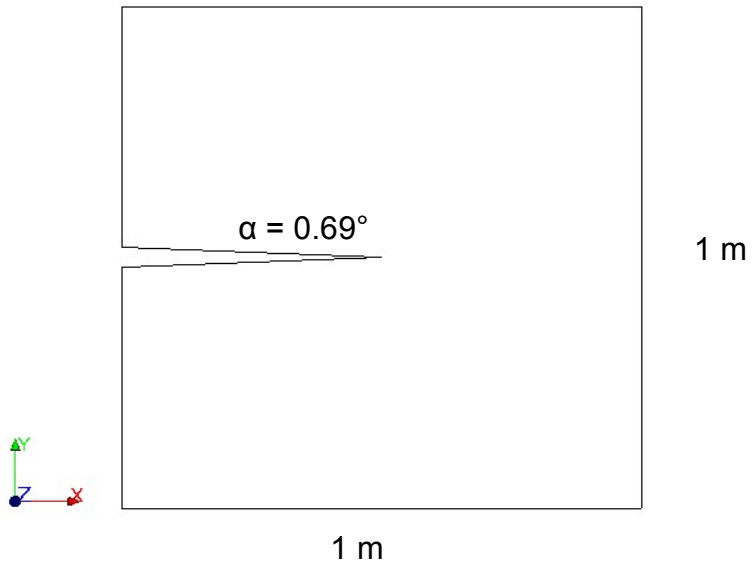
Modeling E:
- Modeling 3D with a bottom in quadrant, resulting from the CAS-test sslv134b.

Modeling F:
- Modeling 3D with symmetry and a circular closed bottom, resulting from the CAS-test sslv134a.

1 Problems of reference

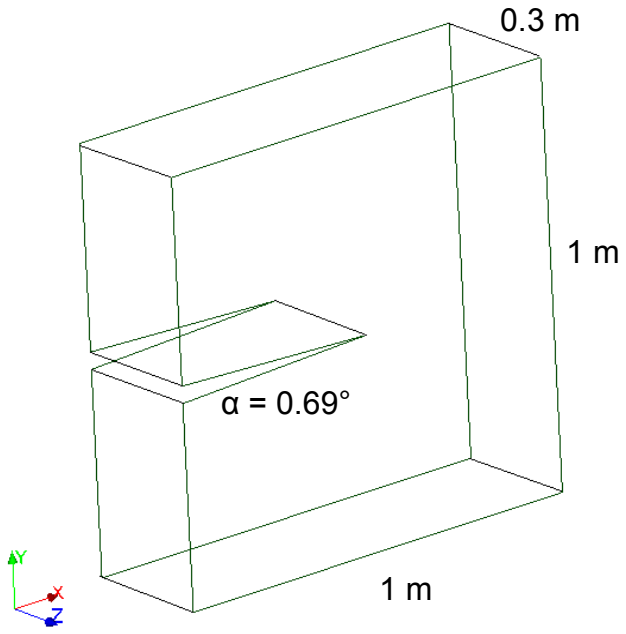
1.1 Geometry for modelings A and B

The structure in 2D is a square on side $1\mathrm{m}$, comprising an angular crack $0.69°$ whose bottom is with the coordinates $(0.5, 0.5)$.
This geometry comprises an axis of symmetry in $y=0.5$. For modeling B, one considers only the part located under this axis.



1.2 Geometry for modelings C and D

The structure studied in 3D is a paving stone of $1\times1\times0.3\,m$ comprising a plane crack with middle height whose lips are separated from an angle from $0.69°$.
This geometry comprises a symmetry plane Oxz in $y=0.5$. For modeling D, one considers only the part located under this plan.



1.3 Tests and references

The tests relate to the values of the components normal vectors and vectors of direction of propagation to the nodes of the bottom of crack. The references are analytical.

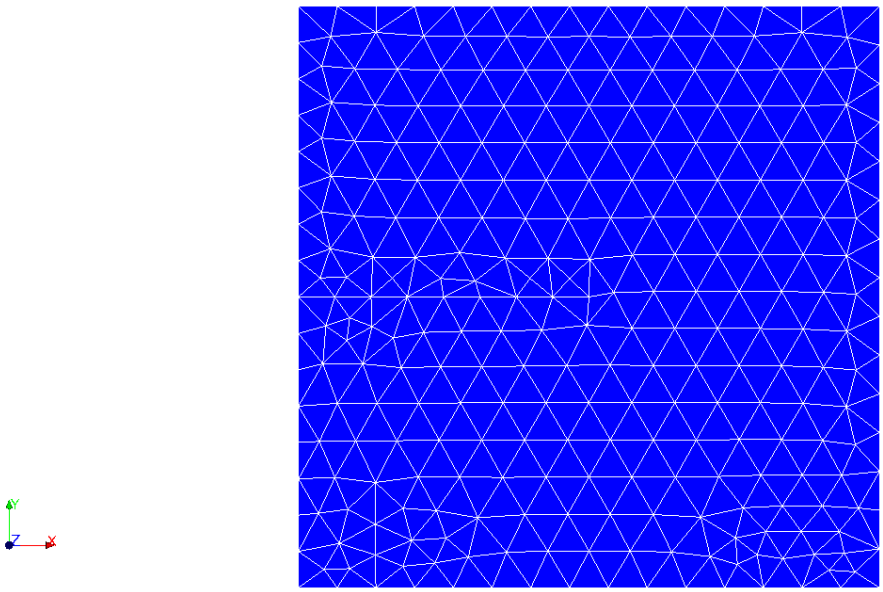
In the tables of results, the components of the normal vector are (VNORX, VNORY, VNORZ) and those of the vector of direction of propagation are (VDIRX, VDIRY, VDIRZ).

2 Modeling A

In **modeling A**, one studies the structure 2D with, initially, the definition of the lips lower and higher of the crack then by defining only the node of the bottom.

2.1 Characteristics of the grid

The grid is presented by the following figure:



It is composed of 296 nodes for 513 elements TRIA3. The bottom of crack is composed of only one node located at the coordinates $(0.5,0.5)$.

2.2 Sizes tested and results

- DEFI_FOND_FISS with LEVRE_SUP and LEVRE_INF:

Sizes	Analytical value
VNORX	0,0
VNORY	-1,0
VDIRX	1,0
VDIRY	0,0

- DEFI_FOND_FISS without LEVRE_SUP and LEVRE_INF:

Sizes	Analytical value
VNORX	0,0
VNORY	1,0
VDIRX	1,0
VDIRY	0,0

As one can note it in the table above, VNOR is not in the same direction as if the lips lower and higher are defined.

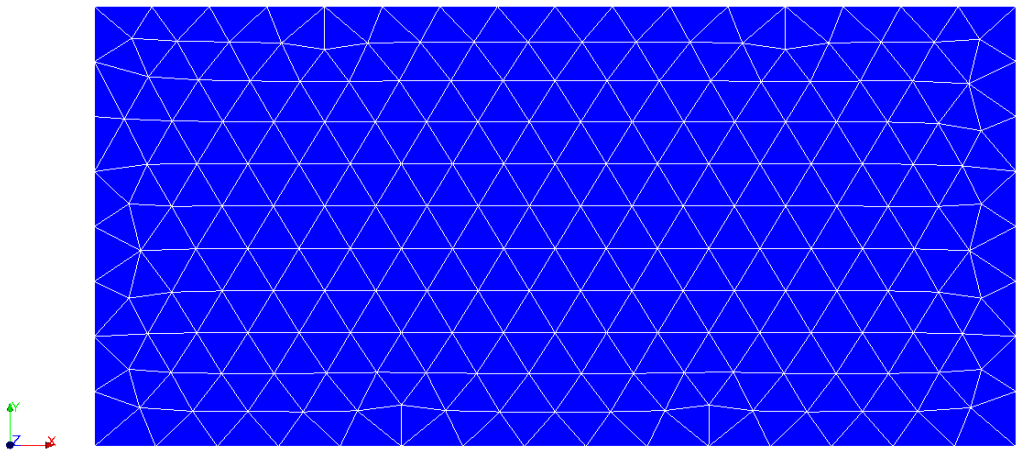
In the operator POST_K1_K2_K3, where they are calculated stress intensity factors to the nodes of the bottom of crack, one requires that the normal vectors of the base are directed lower lip towards the upper lip. Instead of directing these vectors in POST_K1_K2_K3, it was decided to carry out this task directly in DEFI_FOND_FISS. However, when no lip is defined it is not possible to make this reorientation. One can thus observe differences in values of the components of VNOR between the two cases presented above.

3 Modeling B

In **modeling B**, one studies that half of a structure 2D with, initially, the definition of the upper lip of the crack then by defining only the node of the bottom. The keyword thus is tested SYME=' OUI' order DEFI_FOND_FISS in 2D.

3.1 Characteristics of the grid

The grid is presented by the following figure:



It is composed of 222 nodes for 395 elements TRIA3. The bottom of crack is composed of only one node located at the coordinates $(0.5,0.5)$.

3.2 Sizes tested and results

- DEFI_FOND_FISS with SYME=' OUI' and LEVRE_SUP :

Sizes	Analytical value
VNORX	0,0
VNORY	-1,0
VDIRX	1,0
VDIRY	0,0

- DEFI_FOND_FISS with SYME=' OUI' and without LEVRE_SUP:

Sizes	Analytical value
VNORX	0,0
VNORY	1,0
VDIRX	1,0
VDIRY	0,0

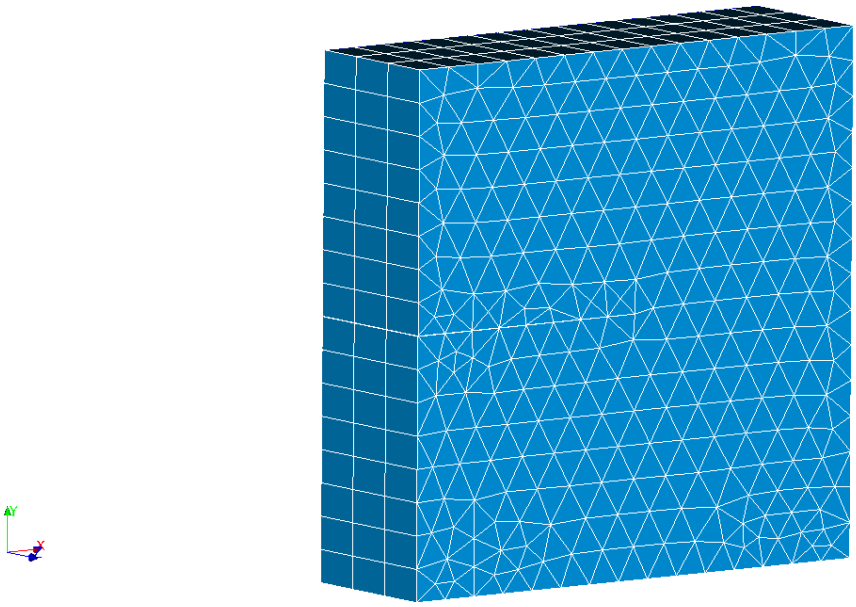
In 2D and with symmetry of the model, the vector VDIR is exact because the values of the stored components are those indicated in the keyword DTAN_ORIG, keyword obligatory in DEFI_FOND_FISS with symmetry and without lip of definite.

4 Modeling C

In **modeling C**, one studies the structure 3D with initially the definition of the lips lower and higher of the crack then by defining only the group of the nodes of the bottom.

4.1 Characteristics of the grid

The grid is presented by the following figure:



It is composed of 1184 nodes for 1539 voluminal elements PENTA6. The bottom of crack is composed of 4 nodes located along the axis z in $x=0.5$ and $y=0.5$.

4.2 Sizes tested and results

The vectors of the base are identical for the 4 nodes of the bottom.

- DEFI_FOND_FISS with LEVRE_SUP and LEVRE_INF:

Sizes	Analytical value
VNORX	0,0
VNORY	-1,0
VNORZ	0,0
VDIRX	1,0
VDIRY	0,0
VDIRZ	0,0

- DEFI_FOND_FISS without LEVRE_SUP and LEVRE_INF:

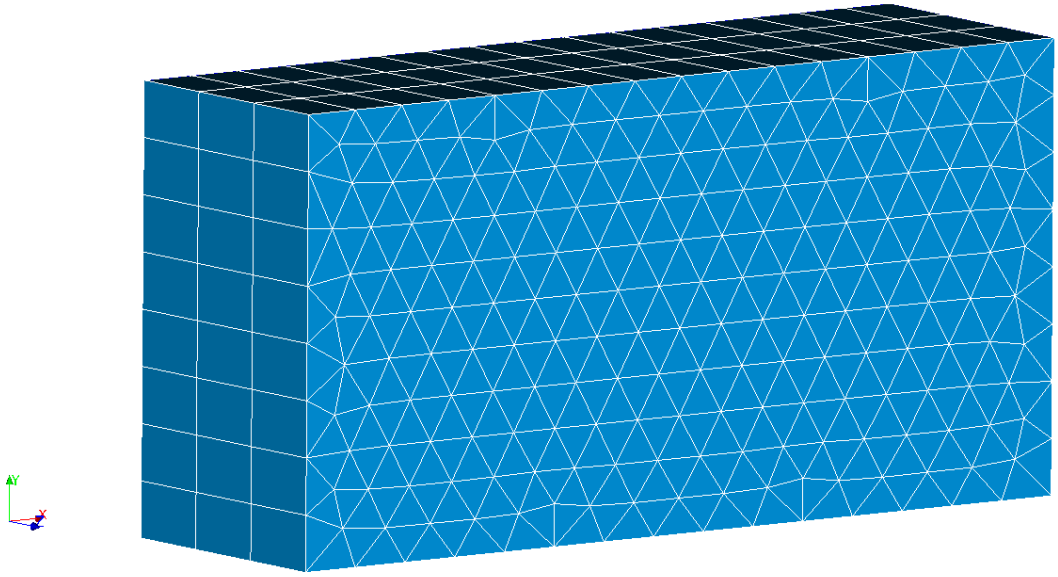
Sizes	Analytical value
VNORX	0,0
VNORY	1.0
VNORZ	0,0
VDIRX	1,0
VDIRY	0,0
VDIRZ	0,0

5 Modeling D

In **modeling D** , one studies that half of the structure 3D with initially the definition of the upper lip of the crack then by defining only the group of the nodes of the bottom. The keyword thus is tested SYME=' OUI' order DEFI_FOND_FISS in 3D.

5.1 Characteristics of the grid

The grid is presented by the following figure:



It is composed of 888 nodes for 1185 voluminal elements PENTA6. The bottom of crack is composed of 4 nodes located along the axis z in $x=0.5$ and $y=0.5$.

5.2 Sizes tested and results

The vectors of the base are identical for each node of the bottom.

- DEFI_FOND_FISS with SYME=' OUI' and LEVRE_SUP :

Sizes	Analytical value
VNORX	0,0
VNORY	-1,0
VNORZ	0,0
VDIRX	1,0
VDIRY	0,0
VDIRZ	0,0

- DEFI_FOND_FISS with SYME=' OUI' and without LEVRE_SUP:

Sizes	Analytical value
VNORX	0,0
VNORY	-1,0
VNORZ	0,0
VDIRX	1,0
VDIRY	0,0
VDIRZ	0,0

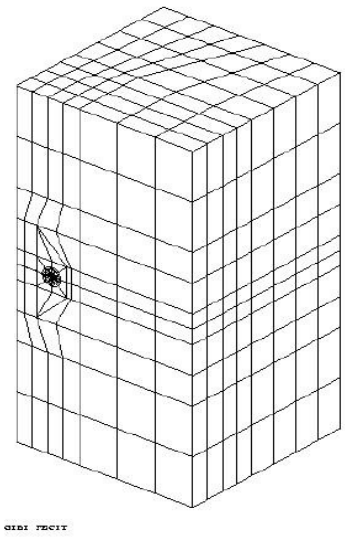
One saw with modeling C that in 2D, the values of the components of the vector VDIR with the node of the bottom are those indicated in the keyword DTAN_ORIG. In 3D, this keyword is not taken into account if the crack is emerging. Indeed, the vectors at the ends of the bottom are automatically modified if the nodes concerned are located at the edge of the structure. That makes it possible to make sure that these vectors belong well to the surface of the structure.

6 Modeling E

In **modeling E**, a structure 3D is studied whose geometry is based on that of the CAS-test sslv134b. One tests DEFI_FOND_FISS in the case of a crack with a curved bottom and two definite lips.

6.1 Characteristics of the grid

The grid and the geometry used are those of the CAS-test sslv134b. The grid is presented by following figure:



It is composed of 5527 nodes, of 784 voluminal elements HEXA20 and 432 PENTA15. The bottom is a quadrant in the plan Oxy composed of 17 nodes.

6.2 Sizes tested and results

The crack is a quadrant having for center the origin of the reference mark. Thus, the analytical values of the vectors of direction of propagation of the crack are the normalized coordinates of the nodes of the bottom.

With the node of the bottom number i coordinates $(COORX_i, COORY_i, COORZ_i)$:

The vector of direction of propagation of crack is:

$$VDIRX_i = \frac{COORX_i}{\sqrt{(COORX_i{}^2 + COORY_i{}^2 + COORZ_i{}^2)}}$$

$$VDIRY_i = \frac{COORY_i}{\sqrt{(COORX_i{}^2 + COORY_i{}^2 + COORZ_i{}^2)}}$$

$$VDIRZ_i = \frac{COORZ_i}{\sqrt{(COORX_i{}^2 + COORY_i{}^2 + COORZ_i{}^2)}}$$

The normal vector with the plan of crack for each node of the bottom is directed lower lip towards the upper lip. It is worth $(0,0,1)$.

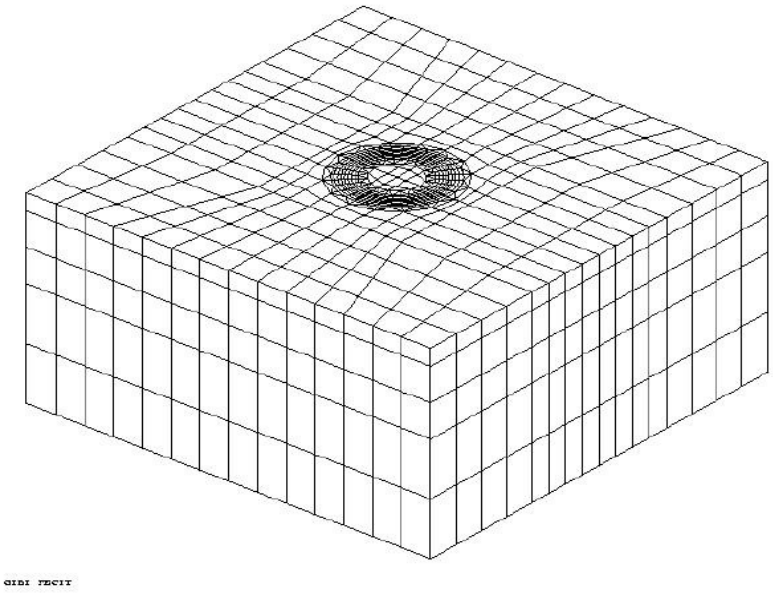
For all these values, it is tolerated 0.1% of error between the analytical value and the computed value.

7 Modeling F

In **modeling F**, a structure 3D is studied whose geometry is based on that of the CAS-test sslv134a. One tests DEFI_FOND_FISS in the case of a circular closed bottom and a structure presenting a symmetry plane.

7.1 Characteristics of the grid

The grid and the geometry used are those of the CAS-test sslv134a. The grid is presented by following figure:



It is composed of 10135 nodes, of 1568 voluminal elements HEXA20 and 864 PENTA15. The circular closed bottom is composed of 65 nodes.

7.2 Sizes tested and results

The crack is a circle having for center the origin of the reference mark. Thus, the analytical values of the vectors of direction of propagation of the crack are the coordinates of the nodes of the bottom, normalized.

With the node of the bottom number i coordinates $(COORX_i, COORY_i, COORZ_i)$, the vector of direction of propagation of crack is:

$$VDIRX_i = \frac{COORX_i}{\sqrt{(COORX_i{}^2 + COORY_i{}^2 + COORZ_i{}^2)}}$$

$$VDIRY_i = \frac{COORY_i}{\sqrt{(COORX_i{}^2 + COORY_i{}^2 + COORZ_i{}^2)}}$$

$$VDIRZ_i = \frac{COORZ_i}{\sqrt{(COORX_i{}^2 + COORY_i{}^2 + COORZ_i{}^2)}}$$

The normal vector with the plan of crack for each node of the bottom is carried by the axis z : $(0,0,-1)$.

When the crack is defined with a symmetry plane, the vector of direction of propagation belongs to the plan of the lip. However, the definite lip is not completely plane. Therefore, the precision of the results is faded along the axis Z for VDIR and like the normal with the plan of the crack is calculated from VDIR, precision of VNORX and/or of VNORY is also.

For VDIRZ, VNORX and VNORY the percentage of error tolerated is of 1.8% compared with 1% for the other components.

8 Summary of the results

The values of the vectors of the local base to the nodes of the bottom of crack are correctly evaluated even when the bottom is curved.

It is noticed nevertheless that the results are less precise when one studies a structure with symmetry. Indeed, without symmetry, the final vectors of the base are calculated by making the average between the vectors of the lower lip and those of the upper lip. With symmetry, the vectors are those of the only modelled lip.

In a node of the bottom, VDIR belongs to the plan of the lip and VNOR is calculated by making the vector product enters VDIR and the vector carried by the segment of the bottom of crack to which this node belongs.
Thus, the values of this base strongly depend on the angle of the crack and are all the more exact as the angle is small. To avoid having a false base, this one is thus not calculated when the crack is in separated configuration (CONFIG_INIT=' DECOLLEE').