ZZZZ314 – Data-processing validation of Summarized

DEFI_FOND_FISS:
The purpose of this test is validating in an elementary way operator DEFI_FOND_FISS through six modelizations comprising each one a crack with a grid in stuck configuration (CONFIGURATION_INIT='COLLEE'). This test does not have physical meaning inevitably, it is primarily a data-processing test.
The benchmark consists in testing the vectors of the local base to the crack tip following various configurations of DEFI_FOND_FISS.

Case of a rectilinear crack tip :

Modelization a:
- Mesh 2D .

Modelization b:
- Mesh 2D symmetric.

Modelization C:
- Mesh 3D

Modelization D:
- Mesh 3D symmetric.

Case of a curved crack tip :

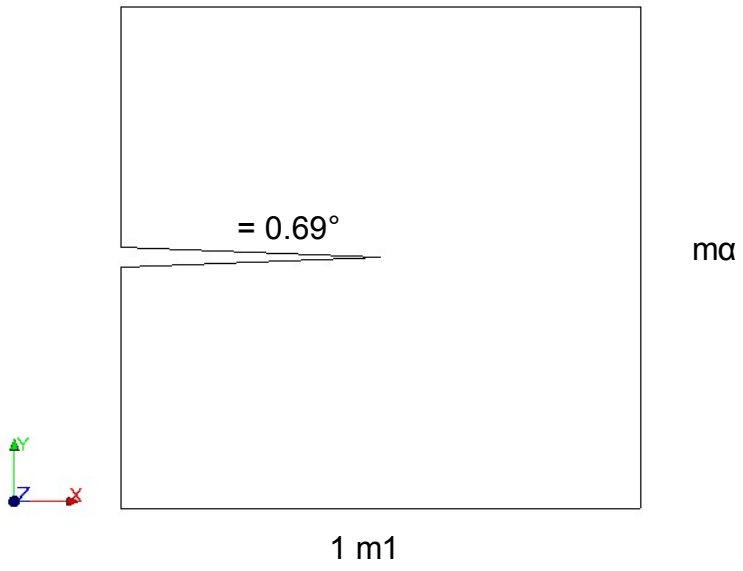
Modelization E:
- Modelization 3D with a bottom in quadrant, resulting from the sslv134b benchmark.

Modelization F:
- Modelization 3D with symmetry and a circular closed bottom, resulting from the sslv134a benchmark.

1 Problems of reference

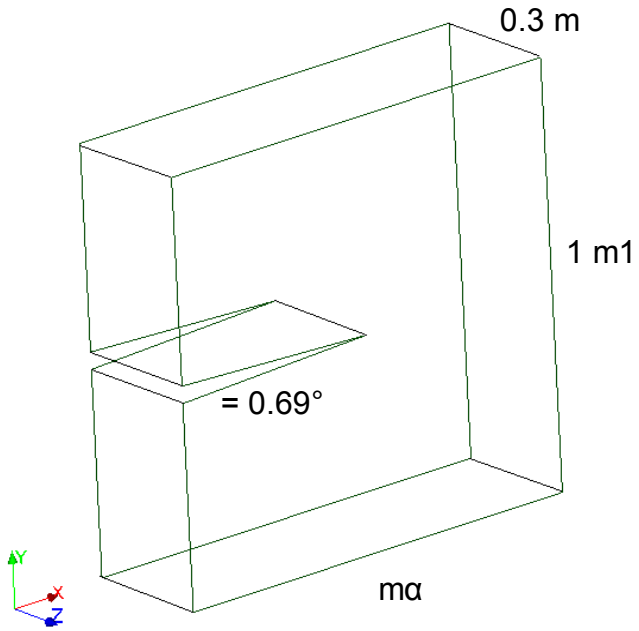
1.1 Geometry for the modelizations A and B

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 the modelization B, one considers only the part located under this axis.



1.2 Geometry for the modelizations 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 the modelization D, one considers only the part located under this plane.



1.3 Tests and references

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

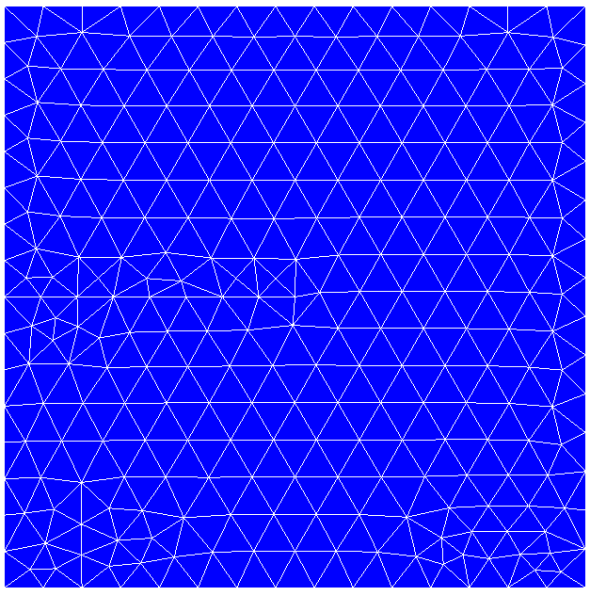
In the tables of results, the components of the normal vector are (VNORX, VNORY, VNORZ) and those of the vector of direction of propagation are (VDIRX, VDIRY, VDIRZ).

2 Modelization A

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

2.1 Characteristics of the mesh

The mesh is presented by the following figure:



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

2.2 Quantities tested and results

•DEFI_FOND_FISS with LEVRE_SUP and LEVRE_INF:

Quantities	analytical Value
VNORX	0.0
VNORY	-1.0
VDIRX	1.0
VDIRY	0.0

•DEFI_FOND_FISS without LEVRE_SUP and LEVRE_INF:

Quantities	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 meaning as if the lips lower and higher are defined.

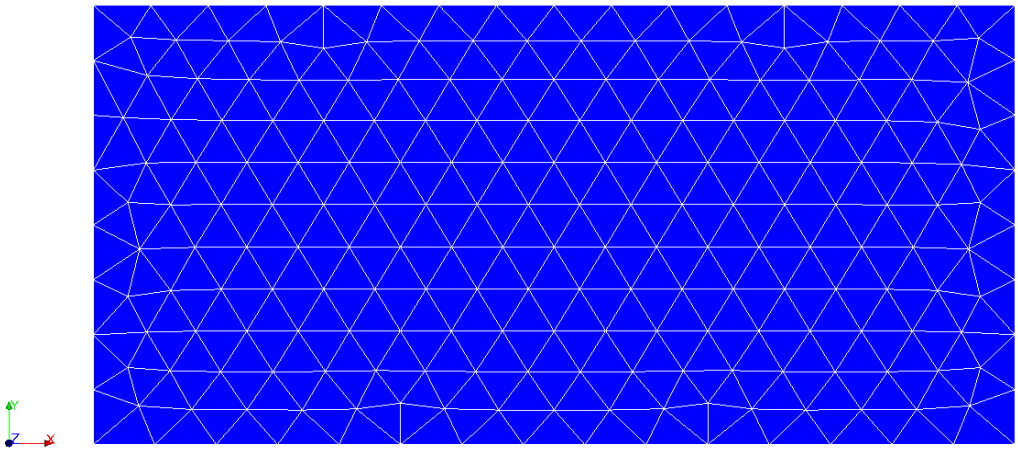
In the operator POST_K1_K2_K3, where one calculates the factors of intensity of nodal stress of the crack tip, one requires that the normal vectors of the base are directed lower lip towards the upper lip. Instead of directing these vectors in POST_K1_K2_K3, it was decided to carry out this task directly 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 Modelization B

In **the modelization B**, one studies that half of a structure 2D with, initially, the definition of the upper lip of crack then by defining only the node of the bottom. One tests thus key word SYME=' OUI' of the command DEFI_FOND_FISS in 2D.

3.1 Characteristics of the mesh

The mesh is presented by the following figure:



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

3.2 Quantities tested and results

•DEFI_FOND_FISS with SYME=' OUI' and LEVRE_SUP :

Quantities	analytical Value
VNORX	0.0
VNORY	-1.0
VDIRX	1.0
VDIRY	0.0

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

Quantities	analytical Value
VNORX	0.0
VNORY	1.0
VDIRX	1.0
VDIRY	0.0

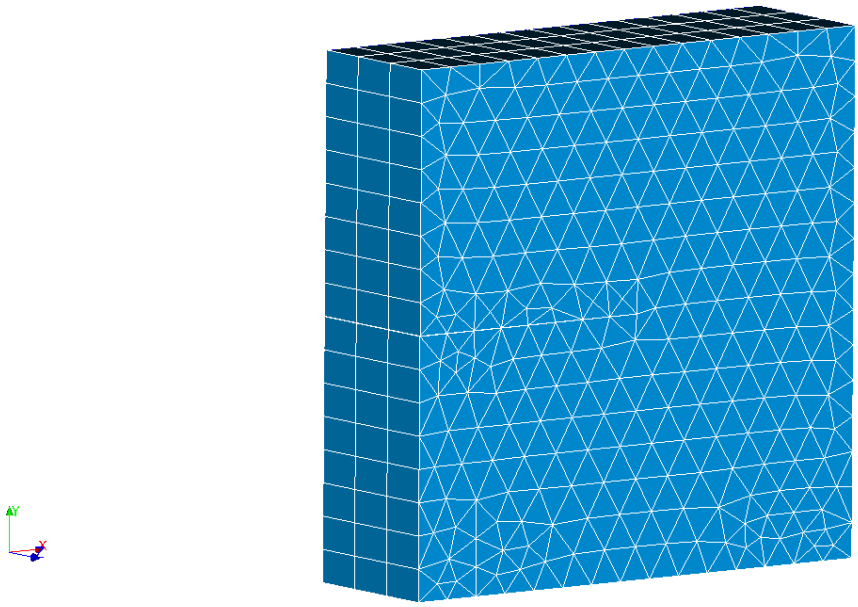
In 2D and with symmetry of the model, vector VDIR are exact because the values of the components stored are those indicated in key word DTAN_ORIG, a key word is compulsory in DEFI_FOND_FISS with symmetry and without lip of definite.

4 Modelization C

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

4.1 Characteristics of the mesh

The mesh is presented by the following figure:



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

4.2 Quantities 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:

Quantities	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:

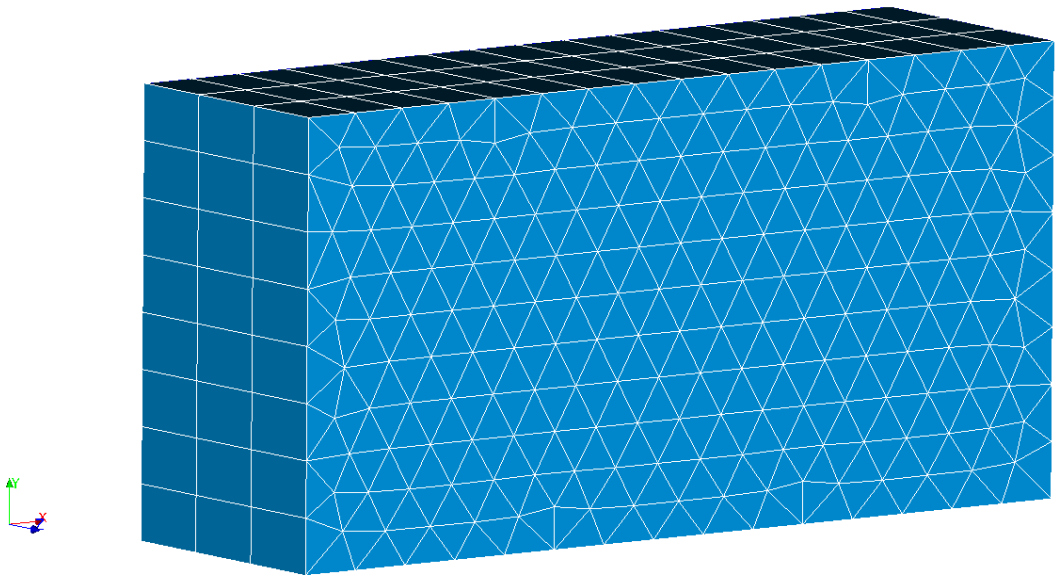
Quantities	analytical Value
VNORX	0.0
VNORY	1,0
VNORZ	0.0
VDIRX	1.0
VDIRY	0.0
VDIRZ	0.0

5 Modelization D

In **the modelization D** , one study that half of structure 3D with initially the definition of the upper lip of crack then by defining only the group of the nodes of the bottom. One tests thus key word SYME=' OUI' of the command DEFI_FOND_FISS in 3D.

5.1 Characteristics of the mesh

The mesh is presented by the following figure:



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

5.2 Quantities 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 :

Quantities	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:

Quantities	analytical Value
VNORX	0.0
VNORY	-1.0
VNORZ	0.0
VDIRX	1.0
VDIRY	0.0
VDIRZ	0.0

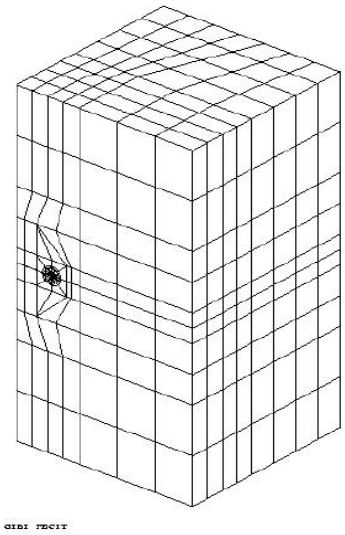
One saw with the modelization C that in 2D, the values of the components of vector VDIR to the node of the bottom are those indicated in key word DTAN_ORIG. In 3D, this key word is not taken into account if the crack is emerging. Indeed, the vectors at the ends of the bottom are automatically modified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

6 Modelization E

In **the modelization E**, one 3D studies a structure whose geometry is based on that of the sslv134b benchmark. One tests DEFI_FOND_FISS in the case of a crack with a bottom and the curves two definite lips.

6.1 Characteristics of the mesh

The mesh and the geometry used are those of the sslv134b benchmark. The mesh is presented by the following figure:



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

6.2 Quantities tested and results

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

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

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

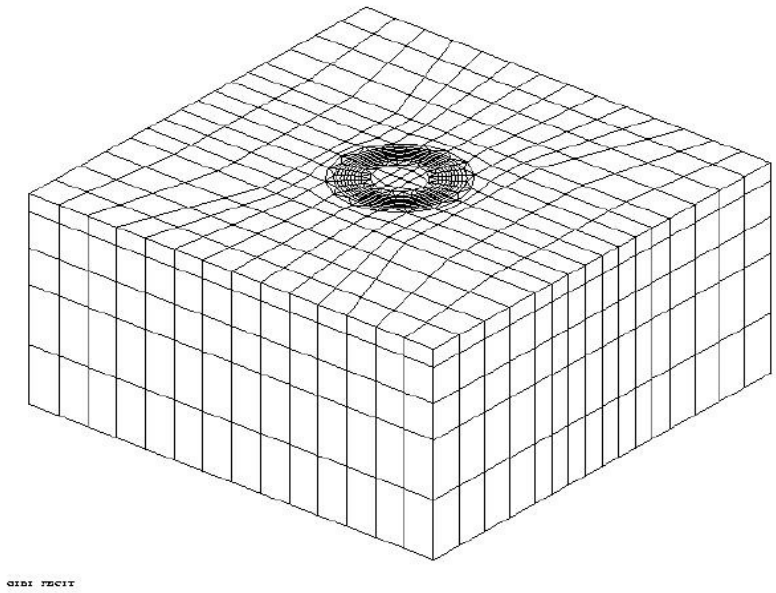
For all these values, it is tolerated 0.1% of error between the analytical value and the computed value.

7 Modelization F

In **the modelization F**, one 3D studies a structure whose geometry is based on that of the sslv134a benchmark. 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 mesh

The mesh and the geometry used are those of the sslv134a benchmark. The mesh is presented by the following figure:



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

7.2 Quantities tested and results

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

With the node of the bottom number i of coordinates $(COORX_i, COORY_i, COORZ_i)$, the vector of direction of crack propagation 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 plane 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 plane of the lip. However, the definite lip is not completely plane. Therefore, the accuracy of the results is faded along the axis Z for VDIR and like the norm with the plane of crack is calculated from VDIR, the accuracy 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 crack tip 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 plane of the lip and VNOR is calculated by making the cross product between VDIR and the vector carried by the segment of the crack tip to which this node belongs.
Thus, the values of this base strongly depend on the angle of 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 (CONFIGURATION_INIT=' DECOLLEE').