

ZZZZ318 – Validation of method SOUS_POINT of the command PROJ_CHAMP

Summarized:

The purpose is to validate method SOUS_POINT PROJ_CHAMP of the command . For that it should be checked that:

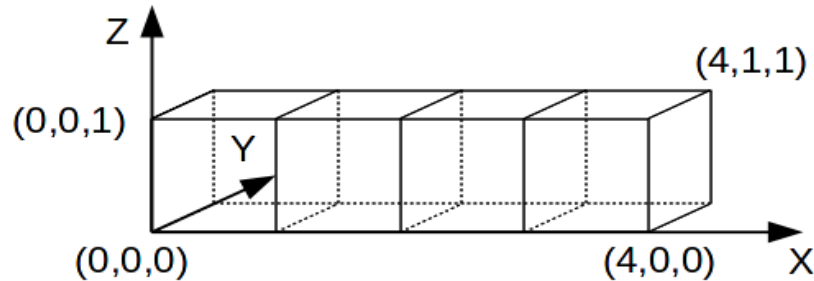
- the coordinates of the subpoints on the families of list MATER calculated by PROJ_CHAMP are exact for elements POU_D_EM , POU_D_TGM and DKT and GRILLE_EXCENTREE (TRIA3 and QUAD4).
- the projection of the thermal fields (TEMP, HYDR_ELNO) on a model 3D is correct on the model mechanical at subpoints corresponding
- projection functions for a field isolated and result from type EVOL_THER.

Note: the fields in output of this command are of the fields of the type ELGA .

1 Problem of reference

1.1 Geometry

One considers a parallelepiped length 4 m and on side 1 m , made up of 4 cubes.



1.2 Modelization

One meshes assigns the thermal MODELIZATION 3D to each of the four HEXA8 of the mesh.

1.3 Thermal fields

Of thermal fields TEMP and HYDR_ELNO are created on this model starting from the following formulas:

$$\begin{aligned} \text{TEMP:} & \quad t = 2X + 3Y + 4Z + 5T \\ \text{HYDR_ELNO:} & \quad h = -2X - 3Y - 4Z - 5T \end{aligned}$$

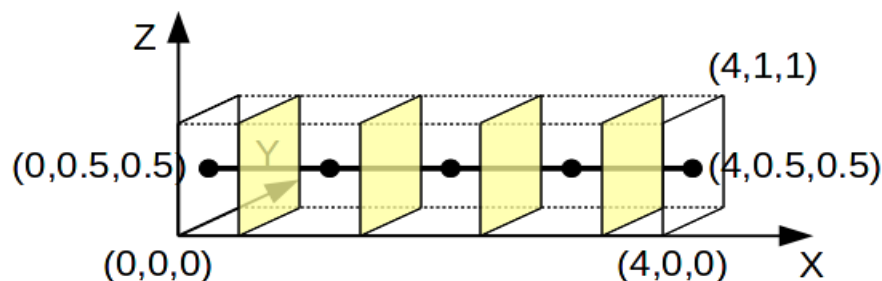
where X, Y, Z are the coordinates of space and T time. These fields are created at the same time in the form of fields isolated and result from evol_ther TYPE.

1.4 Projection

These fields are projected on the subpoints of the mechanical models of multifibre beams and multi-layer shells representing same "physical space", although the meshes of beam are 1D and the meshes of shells 2D.

1.4.1 Multifibre beam

Each beam element is length 1 m and has a square section on side 1 m . The figure below illustrates well that the model beam represents of the same space than the model 3D.

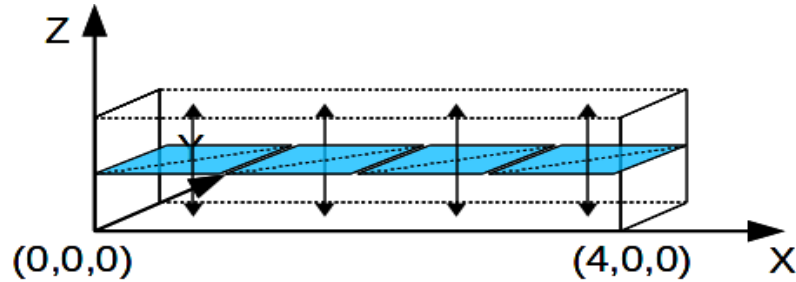


The multifibre section is made up of 4 fibers whose coordinates compared to the axis of the beam are the following ones:

	y	z
Fiber or subpoint 1	-0,25	-0,25
Fiber or subpoint 2	-0,25	0,25
Fiber or subpoint 3	0,25	0,25
Fiber or subpoint 4	0,25	-0,25

1.4.2 multi-layer Shell

Each shell element has one thickness of 1m. The shell elements (in blue) are in a case of the squares on 1m side, in the other case of the isosceles right-angled triangles on 1m side. The figure below illustrates well that the model shell represents same space as the model 3D.

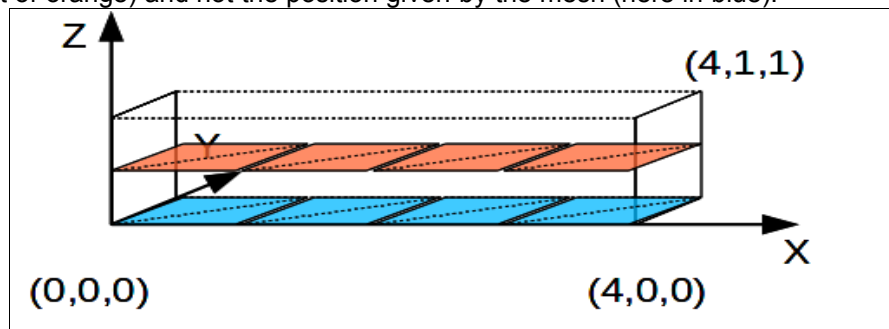


The shells consist of 2 layers, each layer is made up of three levels. The table below gives the position of the subpoints **compared to the median layer of the shell**.

	Z
Subpoint 1	-0,5
Subpoint 2	-0,25
Subpoint 3	0
Subpoint 4	0
Subpoint 5	0,25
Subpoint 6	0,5

1.4.3 Grids offset

the offset grids do not have subpoints. But as their name indicates it, they can be offset. This method then makes it possible to assign to the elements of grids the temperature the "real" position of the grid (here out of orange) and not the position given by the mesh (here in blue).



2 Reference solution

2.1 Method of calculating

the projection carried out by PROJ_CHAMP is linear in space and time. The functions t and h being linear, it is enough to them to apply the coordinates of the subpoints (and time) to determine the values of reference.

2.2 Quantities and results of reference

to get the results of references, it is thus necessary to have following information:

- families present in list MATER of each type of element (see catalog of elements).
- positions of Gauss points of the various families (see R3.01.01).
- positions of the subpoints (see § 2).

2.3 Uncertainties on the solution

None.

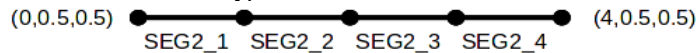
3 Modelization A

3.1 Characteristic of the modelization

One uses a modelization `POU_D_EM` for the model at subpoints.

3.2 Characteristics of the mesh

The mesh contains 4 elements of the type `SEG2`.



3.3 Coordinated Gauss points

list `MATER` of elements `POU_D_EM` contains the rigi `FAMILY`, `NOEU` and `FPG1`.

Family `RIGI` consists of 2 points. On an element length 1, the positions according to the axis of the element are:

P oint 1	$\frac{1}{2} + \frac{1}{(2\sqrt{3})}$
P oint 2	$\frac{1}{2} - \frac{1}{(2\sqrt{3})}$

the coordinates of the points of family `NOEU` are the coordinates of the nodes. Family `FPG1` has a point which is the center of the element.

With the total there are thus 5 points, numbered from 1 to 5 (the second point of family `NOEU` has number 4).

3.4 Quantities tested and results

One tests the values of temperature and hydration in several meshes, points, subpoints and times. The tests are on the isolated fields and result.

The following table gives the coordinates of the points tested:

Do not net		Subpoint	<i>X</i>	<i>Y</i>	<i>Z</i>
SEG2_1	1	3	0.788675134	0.75	0.75
SEG2_2	2	1	1.211324865	0.25	0.25
SEG2_3	3	4	2.000000000	0.75	0.25
SEG2_4	5	2	3.500000000	0.25	0.75

3.4.1 Field isolated `TEMP`

time considered is 0. The concept is `TEMP_SP`. The values of reference are calculated with the function `t`.

Do not net		Subpoint	Component	Value of reference	Tolerance
SEG2_1	1	3	TEMP	6.82735026918963	1.E-6
SEG2_2	2	1	TEMP	4.17264973081037	1.E-6
SEG2_3	3	4	TEMP	7.250000000	1.E-6
SEG2_4	5	2	TEMP	10.750000000	1.E-6

3.4.2 Field isolated HYDR_ELNO

time considered is 0. The concept is HYDR_SP. The values of reference are calculated with the function h .

Do not net		Subpoint	Component	Value of reference	Tolerance
SEG2_1	1	3	HYDR	- 6.82735026918963	1.E-6
SEG2_2	2	1	HYDR	- 4.17264973081037	1.E-6
SEG2_3	3	4	HYDR	- 7.25000000	1.E-6
SEG2_4	5	2	HYDR	- 10.7500000	1.E-6

3.4.3 Result EVOL_THER

the concept is RESU_SP. The values of reference are calculated with function t for the field TEMP and h for the field HYDR_ELNO.

INST	Does not net		Subpoint	Field	comp.	Value of reference	Tolerance
0	SEG2_1	1	3	TEMP	TEMP	6.82735026918963	1.E-6
1	SEG2_2	2	1	TEMP	TEMP	9.17264973081037	1.E-6
2	SEG2_3	3	4	TEMP	TEMP	17.25000000	1.E-6
2	SEG2_4	5	2	TEMP	TEMP	20.7500000	1.E-6

INST	Does not net		Subpoint	Field	comp.	Value of reference	Tolerance
0	SEG2_1	1	3	HYDR_ELNO	HYDR	- 6.82735026918963	1.E-6
1	SEG2_2	2	1	HYDR_ELNO	HYDR	-9.17264973081037	1.E-6
2	SEG2_3	3	4	HYDR_ELNO	HYDR	-17.25000000	1.E-6
2	SEG2_4	5	2	HYDR_ELNO	HYDR	-20.7500000	1.E-6

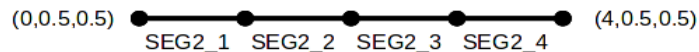
4 Modelization B

4.1 Characteristic of the modelization

One use a modelization `POU_D_TGM` for the model at subpoints.

4.2 Characteristics of the mesh

The mesh contains 4 elements of the type `SEG2`.



4.3 Coordinated Gauss points

list `MATER` of elements `POU_D_TGM` contains family `RIGI` and `FPG1`.

Family `RIGI` consists of 3 points. On an element length 1 the positions according to the axis of the element are:

Point 1	$\frac{1}{2} - \frac{1}{(2\sqrt{(5/3)})}$
Point 2	0
Item 3	$\frac{1}{2} + \frac{1}{(2\sqrt{(5/3)})}$

family `FPG1` has a point which is the center of the element. On the whole, there are thus 4 points, numbered from 1 to 4 (the first point of family `FPG1` has number 4).

4.4 Quantities tested and results

One tests the values of temperature and hydration in several meshes, points, subpoints and times. The tests are made on the isolated fields and result.

The following table gives the coordinates of the points tested:

Do not net		Subpoint	X	Y	Z
SEG2_1	1	4	0.112701665	0.75	0.25
SEG2_2	3	1	1.887298334	0.25	0.25
SEG2_3	4	2	8.750000000	0.25	0.75

4.4.1 Field isolated `TEMP`

time considered is 0. The concept is `TEMP_SP`. The values of reference are calculated with the function `t`.

Do not net		Subpoint	Component	Value of reference	Tolerance
SEG2_1	1	4	TEMP	3.47540333075852	1.E-6
SEG2_2	3	1	TEMP	5.52459666924148	1.E-6
SEG2_3	4	2	TEMP	8.750000000	1.E-6

4.4.2 Field isolated HYDR_ELNO

time considered is 0. The concept is HYDR_SP. The values of reference are calculated with the function h .

Result	do not net		Subpoint	Component Value of reference	
Tolerance	1	4	4	HYDR	-3.47540333075852
1.E-6	3	1	1	HYDR	-5.52459666924148
1.E-6	4	2	2	HYDR	-8.75000000

4.4.3 1.E-6 EVOL_THER

the concept is RESU_SP. The values of reference are calculated with the function t for the field TEMP and with h for the field HYDR_ELNO.

INST	Does not net		Subpoint	Field	comp.	Value of reference	Tolerance
0	SEG2_1	1	4	TEMP	TEMP	3.47540333075852	1.E-6
1	SEG2_2	3	1	TEMP	TEMP	10.52459666924148	1.E-6
2	SEG2_3	4	2	TEMP	TEMP	18.75000000	1.E-6

INST	Does not net		Subpoint	Field	comp.	Value of reference	Tolerance
0	SEG2_1	1	4	HYDR_ELNO	HYDR	-3.47540333075852	1.E-6
1	SEG2_2	3	1	HYDR_ELNO	HYDR	-10.52459666924148	1.E-6
2	SEG2_3	4	2	HYDR_ELNO	HYDR	-18.75000000	1.E-6

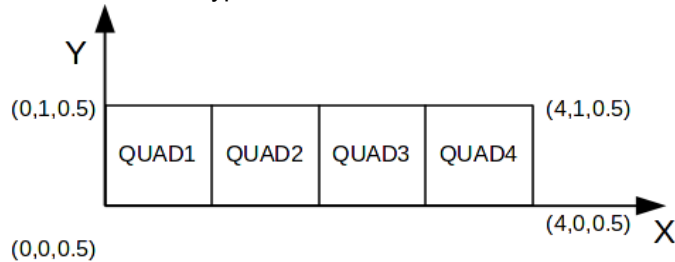
5 Modelization C

5.1 Characteristic of the modelization

One uses a modelization `DKT` for the model at subpoints.

5.2 Characteristics of the mesh

The mesh contains 4 elements of the type `QUAD4`.



5.3 Coordinated Gauss points

list `MATER` of quadrangular elements `DKT` contains family `RIGI`, `NOEU` and `FPG1`. Family `RIGI` consists of 4 points. On a square element $(N1, N2, N3, N4)$ on side 1, whose axis x east defines by the vector $\overrightarrow{N1N2}$ and the axis y by the vector $\overrightarrow{N1N4}$ the positions (x, y) compared to $N1$ are:

	x	y
Point 1	$\frac{1}{2} - \frac{1}{2\sqrt{3}}$	$\frac{1}{2} - \frac{1}{2\sqrt{3}}$
Point 2	$\frac{1}{2} + \frac{1}{2\sqrt{3}}$	$\frac{1}{2} - \frac{1}{2\sqrt{3}}$
Point 3	$\frac{1}{2} + \frac{1}{2\sqrt{3}}$	$\frac{1}{2} + \frac{1}{2\sqrt{3}}$
Point 4	$\frac{1}{2} - \frac{1}{2\sqrt{3}}$	$\frac{1}{2} + \frac{1}{2\sqrt{3}}$

the coordinates of the points of family `NOEU` are the coordinates of the nodes. Family `FPG1` has a point which is the center of the element $(0.5, 0.5)$.

On the whole there are thus 9 points, numbered from 1 to 9 (the first point of family `FPG1` has number 9).

5.4 Quantities tested and results

One tests the values of temperature and hydration in several meshes, points, subpoints and times. The tests are made on the isolated fields and result.

The following table gives the coordinates of the points tested:

Do not net		Subpoint	X	Y	Z
QUAD1	1	4	0.211324865	0.211324865	0.5000000
QUAD2	3	1	1.788675134	0.788675134	0.0000000
QUAD3	6	2	3.000000000	0.0000000	0.2500000
QUAD4	9	5	3.500000000	0.5000000	0.7500000

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

5.4.1 Field isolated TEMP

time considered is 0. The concept is TEMP_SP. The values of reference are calculated with the function t .

Do not net		Subpoint	Component	Value of reference	Tolerance
QUAD1	1	4	TEMP	3.05662432702594	1.E-6
QUAD2	3	1	TEMP	5.94337567297406	1.E-6
QUAD3	6	2	TEMP	7.00000000	1.E-6
QUAD4	9	5	TEMP	11.5000000	1.E-6

5.4.2 Field isolated HYDR_ELNO

time considered is 0. The concept is HYDR_SP. The values of reference are calculated with the function h

Component t	Mesh	Result	Not	Subpoint Value of reference	
Tolerance	1	4	4	HYDR	-3.05662432702594
1.E-6	3	1	1	HYDR	-5.94337567297406
1.E-6	6	2	2	HYDR	-7.00000000
1.E-6	9	5	5	HYDR	-11.5000000

5.4.3 1.E-6 EVOL_THER

the concept is RESU_SP. The values of reference are calculated with the function t for the field TEMP and with h for the field HYDR_ELNO.

INST	Does not net		Subpoint	Field	comp.	Value of reference	Tolerance
0	QUAD1	1	4	TEMP	TEMP	3.05662432702594	1.E-6
1	QUAD2	3	1	TEMP	TEMP	10.94337567297406	1.E-6
2	QUAD3	6	2	TEMP	TEMP	17.00000000	1.E-6
2	QUAD4	9	5	TEMP	TEMP	21.5000000	1.E-6

INST	Does not net		Subpoint	Field	comp.	Value of reference	Tolerance
0	QUAD1	1	4	HYDR_ELNO	HYDR	-3.05662432702594	1.E-6
1	QUAD2	3	1	HYDR_ELNO	HYDR	-10.94337567297406	1.E-6
2	QUAD3	6	2	HYDR_ELNO	HYDR	-17.00000000	1.E-6
2	QUAD4	9	5	HYDR_ELNO	HYDR	-21.5000000	1.E-6

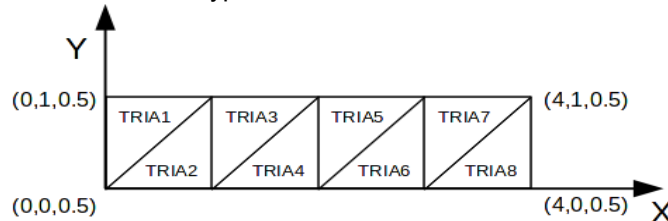
6 Modelization D

6.1 Characteristic of the modelization

One uses a modelization `DKT` for the model at subpoints.

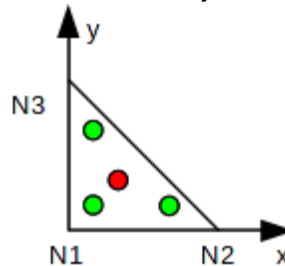
6.2 Characteristics of the mesh

The mesh contains 8 elements of the type `TRIA3`.



6.3 Coordinated Gauss points

list `MATER` of triangular elements `DKT` contains family `RIGI`, `NOEU` and `FPG1`.



The `rigi` FAMILY consists of 3 points (green points on the figure). The positions (x, y) are:

	x	y
Point 1	1/6	1/6
Point 2	2/3	1/6
Point 3	1/6	2/3

the coordinates of the points of family `NOEU` are the coordinates of the nodes. Family `FPG1` has a point (not red) coordinates $(1/3, 1/3)$.

On the whole there are thus 7 points, numbered from 1 to 7 (the first point of family `FPG1` has number 7).

6.4 Quantities tested and results

One tests the values of temperature and hydration in several meshes, points and subpoints and times. The tests are made on the isolated fields and result.

The following table gives the coordinates of the points tested:

Do not net		Subpoint	X	Y	Z
<code>SORTED 1</code>	1	4	0.1666666666	0.8333333333	0.5000000
<code>TRIA4</code>	3	1	1.3333333333	0.1666666667	0.0000000
<code>TRIA6</code>	5	2	3.0000000000	1.0000000	0.2500000
<code>TRIA7</code>	7	5	3.3333333333	0.6666666667	0.7500000

6.4.1 Field isolated TEMP

time considered is 0. The concept is TEMP_SP. The values of reference are calculated with the function t .

Do not net		Subpoint	Component	Value of reference	Tolerance
SORTED 1	1	4	4	TEMP	4.833333333333333
1.E-6	3	1	1	TEMP	1.E-6
TRIA6	5	2	TEMP	10.00000000	1.E-6
TRIA7	7	5	TEMP	11.66666666666667	1.E-6

6.4.2 Field isolated HYDR_ELNO

time considered is 0. The concept is HYDR_SP. The values of reference are calculated with the function h .

Do not net		Subpoint	Component	Value of reference	Tolerance
SORTED 1	1	4	4	HYDR	-4.833333333333333
1.E-6	3	1	1	HYDR	-3.166666666666667
1.E-6	5	2	2	HYDR	-10.00000000
1.E-6	7	5	5	HYDR	-11.66666666666667

6.4.3 1.E-6 EVOL_THER

the concept is RESU_SP. The values of reference are calculated with the function t for the field TEMP and with h for the field HYDR_ELNO.

Inst	Does not net		Subpoint	Field	comp.	Value of reference	Tolerance
0	SORTED 1	1	4	TEMP	TEMP	4.833333333333333	1.E-6
1	TRIA4	3	1	TEMP	TEMP	8.166666666666667	1.E-6
2	TRIA6	5	2	TEMP	TEMP	20.00000000	1.E-6
2	TRIA7	7	5	TEMP	TEMP	21.66666666666667	1.E-6

Inst	Does not net		Subpoint	Field	comp.	Value of reference	Tolerance
0	SORTED 1	1	4	HYDR_ELNO	HYDR	-4.833333333333333	1.E-6
1	TRIA4	3	1	HYDR_ELNO	HYDR	-8.166666666666667	1.E-6
2	TRIA6	5	2	HYDR_ELNO	HYDR	-20.00000000	1.E-6
2	TRIA7	7	5	HYDR_ELNO	HYDR	-21.66666666666667	1.E-6

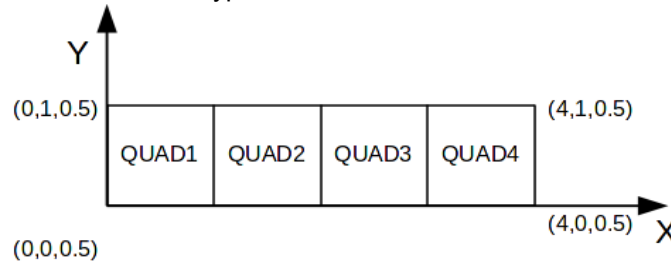
7 Modelization E

7.1 Characteristic of the modelization

One uses a modelization `GRILLE_EXCENTREE`.

7.2 Characteristics of the mesh

The mesh contains 4 elements of the type `QUAD4`.



7.3 Coordinated Gauss points

list `MATER` of quadrangular elements `GRILLE_EXCENTREE` contains family `RIGI` and `FARMHOUSE`. These two families correspond to family `FPG1`.

Family `FPG1` has a point which is the center of the element $(0.5, 0.5)$.

On the whole there are thus 2 points which coincide.

7.4 Quantities tested and results

One tests the values of temperature and hydration in several meshes, points, subpoints and times. The tests are made on the isolated fields and result.

The following table gives the coordinates of the points tested:

Do not net		Subpoint	X	Y	Z
QUAD1	1	2			0.5
QUAD2	2	1			0.5

7.4.1 Field isolated `TEMP`

time considered is 0. The concept is `TEMP_SP`. The values of reference are calculated with the function `t`.

Do not net		Subpoint	Component	Value of reference	Tolerance
QUAD1	1	1	TEMP	4.5E0	1.E-6
QUAD2	2	1	TEMP	6.5E0	1.E-6

7.4.2 Field isolated `HYDR_ELNO`

time considered is 0. The concept is `HYDR_SP`. The values of reference are calculated with the function `h`.

Result	do not net		Subpoint	Component Value of reference	
Toleranc e	1	1	1	HYDR	-4.5E0
1.E-6	2	1	1	HYDR	-6.5E0

7.4.3 1.E-6 EVOL_THER

the concept is RESU_SP. The values of reference are calculated with the function t for the field TEMP and with h for the field HYDR_ELNO.

INST	Does not net		Subpoint	Field	comp.	Value of reference	Tolerance
0	QUAD1	1	1	TEMP	TEMP	4.5E0	1.E-6
2	QUAD2	2	1	TEMP	TEMP	16.5E0	1.E-6

INST	Does not net		Subpoint	Field	comp.	Value of reference	Tolerance
0	QUAD1	1	1	HYDR_ELNO	HYDR	-4.5E0	1.E-6
2	QUAD2	2	1	HYDR_ELNO	HYDR	-16.5E0	1.E-6

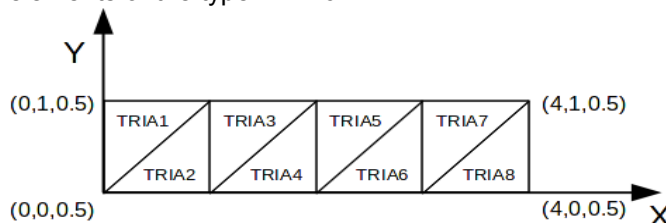
8 Modelization F

8.1 Characteristic of the modelization

One uses a modelization `GRILLE_EXCENTREE`.

8.2 Characteristics of the mesh

The mesh contains 8 elements of the type `TRIA3`.



8.3 Coordinated Gauss points

list `MATER` of triangular elements `GRILLE_EXCENTREE` contains family `RIGI` and `FARMHOUSE`. These two families correspond in fact to family `FPG1`.

Family `FPG1` has a point which is the center of the element $(1/3, 1/3)$.

On the whole there are thus 2 points which coincide.

8.4 Quantities tested and results

One tests the values of temperature and hydration in several meshes, points, subpoints and times. The tests are made on the isolated fields and result.

The following table gives the coordinates of the points tested:

Do not net		Subpoint	X	Y	Z
TRIA1	1	2	0.333333334	0.666666667	0.5
TRIA2	2	1	0.666666667	0.333333334	0.5

8.4.1 Field isolated TEMP

time considered is 0. The concept is `TEMP_SP`. The values of reference are calculated with the function `t`.

Do not net		Subpoint	Component	Value of reference	Tolerance
QUAD1	1	1	TEMP	4.666666666666E0	1.E-6
QUAD2	2	1	TEMP	4.333333333333E0	1.E-6

8.4.2 Field isolated HYDR_ELNO

time considered is 0. The concept is `HYDR_SP`. The values of reference are calculated with the function `h`.

Do not net		Subpoint	Component	Value of reference	Tolerance
QUAD1	1	1	HYDR	- 4.666666666666E0	1.E-6
QUAD2	2	1	HYDR	- 4.333333333333E0	1.E-6

8.4.3 Result EVOL_THER

the concept is RESU_SP. The values of reference are calculated with the function t for the field TEMP and with h for the field HYDR_ELNO.

INST	Does not net		Subpoint	Field	comp.	Value of reference	Tolerance
0	QUAD1	1	1	TEMP	TEMP	4.666666666666E0	1.E-6
2	QUAD2	2	1	TEMP	TEMP1	4.333333333333E0	1.E-6

INST	Does not net		Subpoint	Field	comp.	Value of reference	Tolerance
0	QUAD1	1	1	HYDR_ELNO	HYDR	- 4.666666666666E0	1.E-6
2	QUAD2	2	1	HYDR_ELNO	HYDR	-1 4.333333333333E0	1.E-6

9 Summary of the results

Thanks to formulas giving the fields of temperature and hydration according to the coordinates of the points, one can check simply that coordinates of the subpoints is well calculated for all element types concerned and that the projection made with method `SOUS_POINT` of the command `PROJ_CHAMP` gives the expected results. This projection functions for fields isolated from type `NOEU` or `ELNO` and for results of the type `EVOL_THER`.