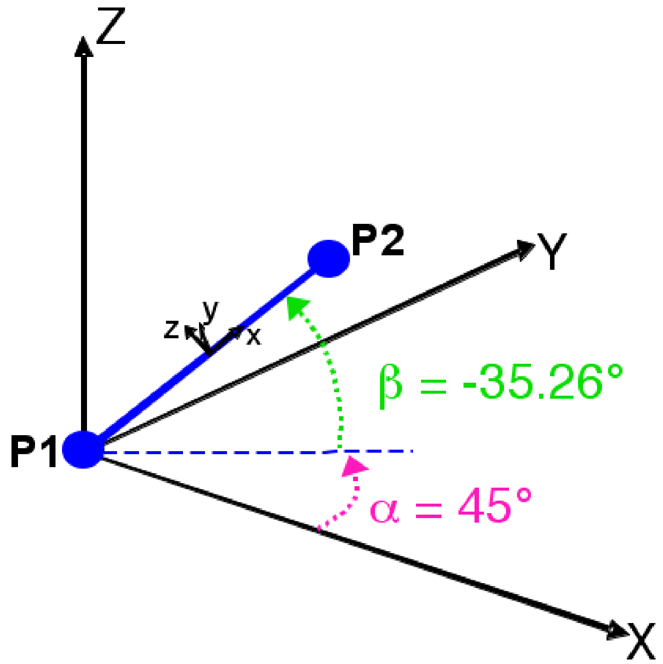
ZZZZ296 – Validation of the position of the subpoints of the pipes

Summarized:
This test validates the computation of the position of the subpoints of integration in the total reference for modelization TUYAU_3M. An elementary mechanical computation is carried out in order to allow the creation of an array with CREA_TABLE from result. Only the coordinates of some subpoints are tested in the array.

1 Problem of reference

1.1 Geometry



Appears 1.1-a directional sense of the element

the pipe is directed in space as indicated on the Figure 1.1-a:
Total coordinates of the points $P1$ and $P2$:

$$X_{P1}=0.0 ; Y_{P1}=0.0 ; Z_{P1}=0.0$$
$$X_{P2}=2.0 ; Y_{P2}=2.0 ; Z_{P2}=2.0$$

Length: $L=2\cdot\sqrt{3}\,m$

1.2 Properties of the materials

Concrete:

Young's modulus: $E=3.7272^{10}\,Pa$
Poisson's ratio: $\nu=0.0$

1.3 Boundary conditions and loadings

On the point $P1$ one blocks displacements according to X , Y , Z and rotation around the axes X , Y , Z :

$$D_X^{P1}=0.0 ; D_Y^{P1}=0.0 ; D_Z^{P1}=0.0 ; DR_X^{P1}=0.0 ; DR_Y^{P1}=0.0 ; DR_Z^{P1}=0.0$$

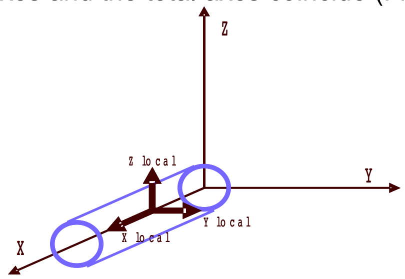
To the point $P2$ one applies a loading according to X , Y , Z :

$$F_X=100.0\,N ; F_Y=100.0\,N ; F_Z=-100.0\,N$$

2 Reference solution

2.1 Method of calculating

One calculates the position of the nodes, points of integration and subpoints of integration from their cordonnées in the local axes of the pipe, and the transition matrixes between the local axes and the total axes. By defaults, the local axes and the total axes coincide (Figure 2.1).



Appear 2.1-a position by default

One applies two rotations (see Figure 1.1-a):

$\alpha=45°$ around Z

$\beta=-35,26°$ around the new axis $Y1$

Note:

one uses conventions of the nautical angles of Code_Aster (see key word `ORIENTATION` *of* `AFFE_CARA_ELEM, U4.42.01`*)*

rotation around the axis Z (α) is made from the following matrix:

$$Tz(\alpha)=\begin{bmatrix}\cos(\alpha) & -\sin(\alpha) & 0\\ \sin(\alpha) & \cos(\alpha) & 0\\ 0 & 0 & 1\end{bmatrix}$$

Rotation around the new axis $Y1$ (β) is made from the following matrix:

$$Ty1(\beta)=\begin{bmatrix}\cos(\beta) & 0 & \sin(\beta)\\ 0 & 1 & 0\\ -\sin(\beta) & 0 & \cos(\beta)\end{bmatrix}$$

For any point of coordinates (X,Y,Z) before rotations, one can calculate his coordinates (X',Y',Z') after rotations with the following transformation:

$$\begin{bmatrix}X'\\ Y'\\ Z'\end{bmatrix}=[Tz(\alpha)][Ty(\beta)]\begin{bmatrix}X\\ Y\\ Z\end{bmatrix}$$

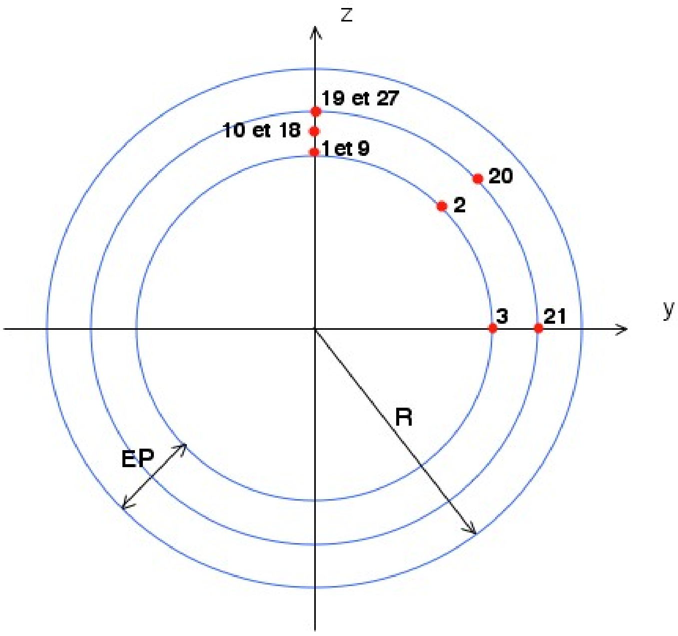
2.2 Quantities and results of reference

One calculates the position of some subpoints of integration in the total reference knowing their position in the local axes.
With the angles chosen, the numerical application gives:

$$Ty1(\beta)=\begin{bmatrix}0.8165 & 0 & -0.5774\\ 0 & 1 & 0\\ 0.5774 & 0 & 0.8165\end{bmatrix} \text{ and } Tz(\alpha)=\begin{bmatrix}0.7071 & -0.7071 & 0\\ 0.7071 & 0.7071 & 0\\ 0 & 0 & 1\end{bmatrix}$$

For a mesh SEG3 of pipe length $L=2\cdot\sqrt{3}\,m$, the distance from the first points from integration compared to the first node is (see R3.01.01): $x_1=0.39041002106984068\,m$

The section of the pipe, radius $R=10\,m$ and thickness $EP=1\,m$, is discretized in 2 layers and 4 sectors (see Figure 2.2), which makes 45 subpoints.



Appear Discretization of the section, position of some subpoints

In the reference of the section, the position of under selected points is :

Subpoint	y	z
1	0	9
2	6.3639610306789	6.3639610306789
3	9	0
19	0	9.5
21	9.5	0

2.3 Uncertainties on the solution

No, exact solution.

3 Modelization A

3.1 Characteristic of the mesh

Mesh of the pipe: the mesh is composed of a standard mesh SEG3.

The nodes group ENC is composed of the node $P1$.

The nodes group CHA is composed of the node $P2$.

3.2 Characteristics of the modelization

Modelization:

```
MOPOU=AFFE_MODELE (MAILLAGE=MAPOU,
   AFFE=_F (TOUT=' OUI', PHENOMENE=' MECANIQUE',
      MODELISATION=' TUYAU_3M',),
)
```

Boundary conditions:

```
BLOCAGE=AFFE_CHAR_MECA (MODELE=MO,
   DDL_IMPO=_F (GROUP_NO=' ENC',
      DX=0.0, DY=0.0, DZ=0.0, DRX=0.0, DRY=0.0, DRZ=0.0,),
)
```

mechanical Loading:

```
CHARGE=AFFE_CHAR_MECA (MODELE=MO,
   FORCE_NODALE=_F (GROUP_NO=' CHA',
      FX = 100, FY = 100, FZ = 100.),
)
```

Assignment of the characteristics of the elements:

```
POUCA_0=AFFE_CARA_ELEM (MODELE=MOPOU,
   POUTRE=_F (GROUP_MA= ("POUTRE"), SECTION=' CERCLE',
      CARA= ("R", "EP"), VALE= (10. , 1.),
      TUYAU_NSEC = 4, TUYAU_NCOU = 2,),
)
```

3.3 Values tested and results

Coordinated mesh SG01	not of integration	subpoint	Reference
COOR_X	1	1	-3.4488316
COOR_Y	1	1	-3.4488316
COOR_Z	1	1	7.5738722
COOR_X	1	2	-6.8726732
COOR_Y	1	2	2.1273268
COOR_Z	1	2	5.4215554
COOR_X	1	3	-6.1385580
COOR_Y	1	3	6.5893640
COOR_Z	1	3	0.2254030
COOR_X	1	19	-3.6529558
COOR_Y	1	19	-3.6529558
COOR_Z	1	19	7.9821205
COOR_X	1	21	-6.4921114
COOR_Y	1	21	6.9429174
COOR_Z	1	21	0.2254030

the tolerance is fixed at $1.0\mathrm{E}-03$ for all the values.

4 The purpose of summary of the results

This test is checking that the positions of the subpoints of integration of modelization TUYAU_3M are well calculated.

For this modelization, the found maximum error is of $1.5E-04\%$.