

## ZZZZ393 - Predeformations by function for plates, grids and membranes

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### Summary:

This test validates the taking into account of predeformations affected under-form of function for the elements DKT, DKTG, GRILLE\_EXCENTRE, GRILLE\_MEMBRANE and MEMBRANE.

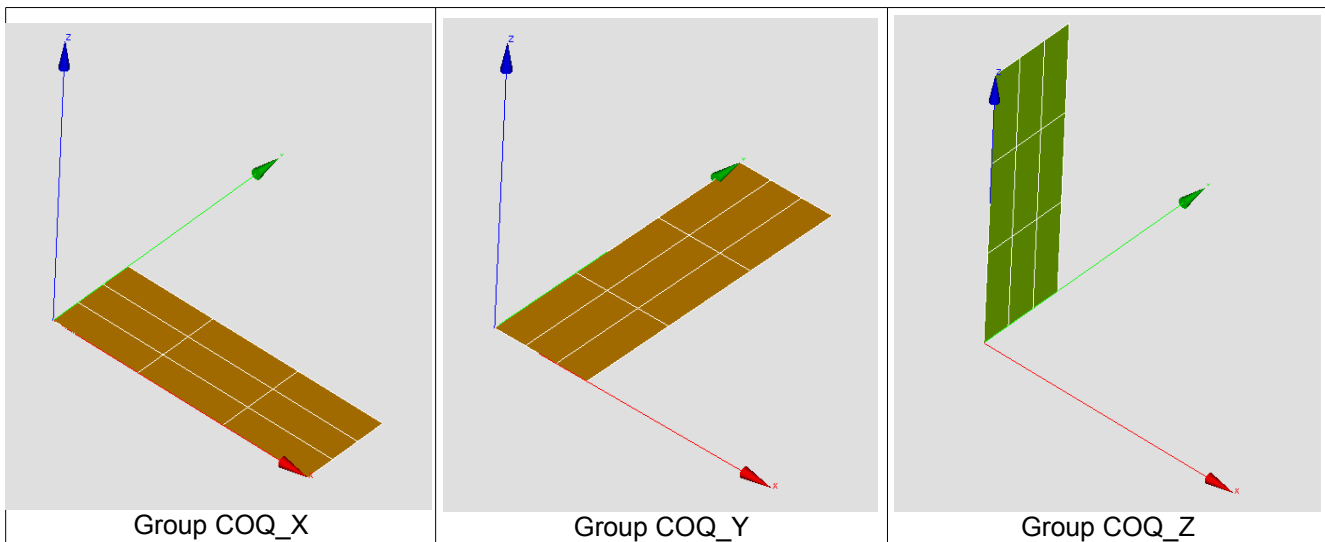
It valid also the taking into account of predeformations affected by value for the elements GRILLE\_MEMBRANE and by comparison with the elements GRILLE\_EXCENTRE.

## 1 Problem of reference

### 1.1 Geometry

#### 1.1.1 Grid for validation on linear elements

The grid is composed three plates directed in the 3 directions of space:



These three plates make it possible to simply validate the dependence of the functions of predeformation to the variables of space  $X$ ,  $Y$  and  $Z$ . They all are rectangular of dimensions 3 meters out of 1 meter.

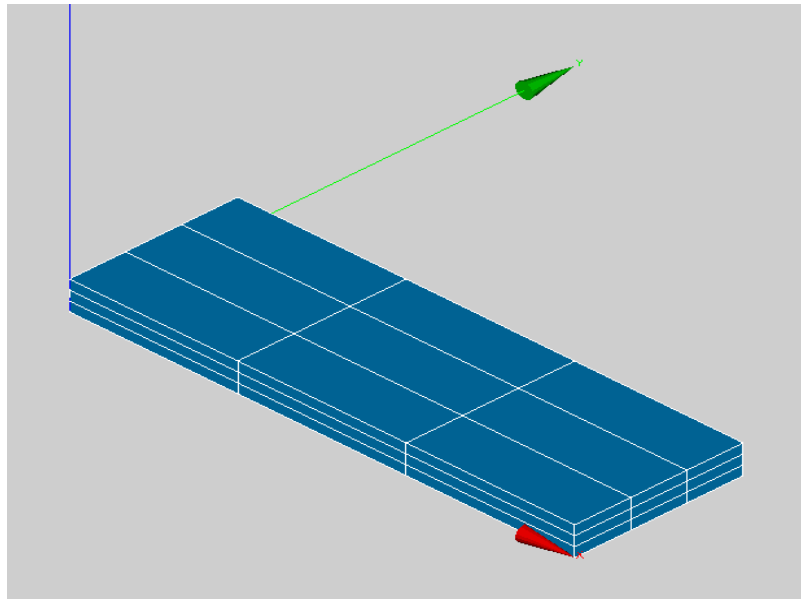
For each plate of the grid, several groups of meshes and nodes are defined:

- ENCX, ENCY and ENCZ : Groups of nodes made up of the two points to the corners  $X=0$ ,  $Y=0$  and  $Z=0$ .
- FLX, FLY and FLZ : Nodes located respectively in  $X=3, Y=0$ ,  $Y=3, X=0$  and  $Z=3, Y=0$ .
- G1X, G1Y and G1Z : Groups of three meshes located between 0 and 1 according to the coordinate length of the plate.
  - G2X, G2Y and G2Z : Groups of three meshes located between 1 and 2 according to the coordinate length of the plate.
  - G3X, G3Y and G3Z : Groups of three meshes located between 2 and 3 according to the coordinate length of the plate.

#### 1.1.2 Grid for validation on quadratic elements

It is about a grid made up of 27 elements 3D. Volume has a 3 meters length, a width of one meter and a thickness of 0.5 meter.

The face located in  $X=0$  set up the group ENCAST, the surface meshes of the higher face are duplicated for formed the group GRID. Same manner that in the preceding grid one has the groups G1X, G1Y and G1Z. Finally the node is defined FLX located in  $(3,0,0)$ .



## 1.2 Material properties

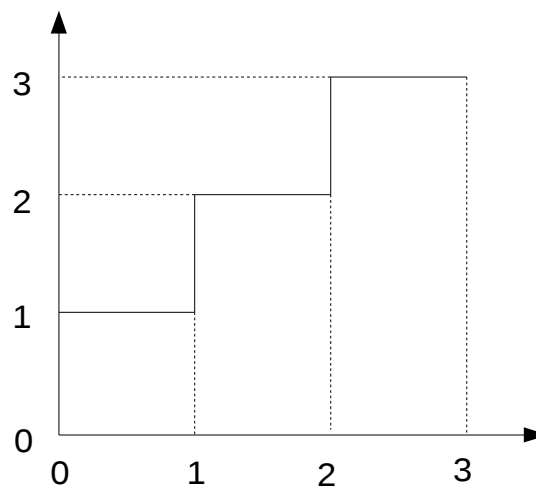
The material is elastic linear.  
Young modulus  $E = 1E9 Pa$   
Poisson's ratio:  $\nu = 0.3$

## 1.3 Boundary conditions and loadings

### 1.3.1 Linear grid

Embedding in `ENCX`, `ENCY` and `ENCZ` :  $DX = DY = DZ = DRX = DRY = DRZ = 0$  .

The loadings of predeformation will be detailed in each modeling. As regards the loadings by functions, it will depend each time on the following function:



Function "staircase"

### 1.3.2 Quadratic grid

Embedding in `ENCAST` :  $DX = DY = DZ = 0$  .

The loadings of predeformation will be detailed in each modeling. As regards the loadings by functions, it will each time depend on the function "staircase".

## 2 Reference solution

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### 2.1 Results of reference

In all calculations, the results of references are got by carrying out same calculation with the predeformations affected by values groups of meshes by groups of meshes.

The displacement of the nodes is compared `FLX`, `FLY` and `FLZ`.

### 2.2 Uncertainty on the solution

None. The results must be exactly the same ones as those of the reference solution.

## 3 Modeling A

### 3.1 Characteristics of modeling

This modeling rests on the linear grid. 9 surface meshes (QUAD4) of each plate are affected modeling DKT.

### 3.2 Calculations and loadings

One carries out two calculations on each plate of the grid. One details loadings of calculation on the group COQ\_X. It is then enough to replace X by Y then Z to obtain the loadings of other calculations.

#### 3.2.1 Calculation of reference, predeformation defined by value

In the calculation of reference, one affects the following values of predeformation:

	G1X	G2X	G3X
EPXX	1E-3	2nd-3	3rd-3
EPYY	2nd-3	4th-3	6th-3
EPXY	3rd-3	6th-3	9th-3
KXX	4E-3	8E-3	12E-3
KYY	5E-3	10E-3	15E-3
KXY	6E-3	12E-3	18E-3

The taking into account of the dependence at time is made by the addition of a multiplying function "identity" with the loading.

#### 3.2.2 The second calculation, predeformation defined by function

The loading of predeformation according to is affected on all the meshes of the plate COQ\_X :

EPXX	$1E-3 \cdot \text{escalier}(X) \cdot INST$
EPYY	$2E-3 \cdot \text{escalier}(X) \cdot INST$
EPXY	$3E-3 \cdot \text{escalier}(X) \cdot INST$
KXX	$4E-3 \cdot \text{escalier}(X) \cdot INST$
KYY	$5E-3 \cdot \text{escalier}(X) \cdot INST$
KXY	$6E-3 \cdot \text{escalier}(X) \cdot INST$

## 3.3 Sizes tested and results

Calculation on **COQ\_x** :

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLX , DX	'NON_REGRESSION'	-	-
Moment 1, FLX , DY	'NON_REGRESSION'	-	-
Moment 1, FLX , DZ	'NON_REGRESSION'	-	-
Moment 2 , FLX , DX	'NON_REGRESSION'	-	-
Moment 2 , FLX , DY	'NON_REGRESSION'	-	-
Moment 2 , FLX , DZ	'NON_REGRESSION'	-	-

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLX , DX	'AUTRE_ASTER '	0.00631037083998	1E-6
Moment 1, FLX , DY	'AUTRE_ASTER '	0.0327934215069	1E-6
Moment 1, FLX , DZ	'AUTRE_ASTER '	-0.011685267293	1E-6
Moment 2 , FLX , DX	'AUTRE_ASTER '	0.01262074168	1E-6
Moment 2 , FLX , DY	'AUTRE_ASTER '	0.0655868430138	1E-6
Moment 2 , FLX , DZ	'AUTRE_ASTER '	-0.023370534587	1E-6

Calculation on **COQ\_y** :

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLY , DX	'NON_REGRESSION'	-	-
Moment 1, FLY , DY	'NON_REGRESSION'	-	-
Moment 1, FLY , DZ	'NON_REGRESSION'	-	-

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLY , DX	'AUTRE_ASTER '	-0.0392065784931	1E-6
Moment 1, FLY , DY	'AUTRE_ASTER '	0.00631037083998	1E-6
Moment 1, FLY , DZ	'AUTRE_ASTER '	-0.0468734663462	1E-6

Calculation on **COQ\_z** :

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLZ , DX	'NON_REGRESSION'	-	-
Moment 1, FLZ , DY	'NON_REGRESSION'	-	-
Moment 1, FLZ , DZ	'NON_REGRESSION'	-	-

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLZ , DX	'AUTRE_ASTER '	0.0116852672935	1E-6
Moment 1, FLZ , DY	'AUTRE_ASTER '	0.0327934215069	1E-6
Moment 1, FLZ , DZ	'AUTRE_ASTER '	0.00631037083998	1E-6

## 4 Modeling B

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Modeling B is identical to the modeling A, except which it uses of the elements `DKTG` instead of `DKT`.

To refer to modeling A.



## 5 Modeling C

### 5.1 Characteristics of modeling

This modeling rests on the linear grid. 9 surface meshes (QUAD4) of each plate are affected modeling GRILLE\_EXCENTRE and duplicated to form the groups DKT\_X, DKT\_Y and DKT\_Z that one affects modeling DKT.

In each case the grids are directed in the direction length of the plate. In the case  $X$ , the grid is offset (of 0.5 meter), in order to check that does not affect the taking into account of the predeformation.

### 5.2 Calculations and loadings

One carries out two calculations on each plate of the grid. One details loadings of calculation onS groupS COQ\_X/DKT\_X. It is then enough to replace  $X$  by  $Y$  then  $Z$  to obtain the loadings of other calculations.

#### 5.2.1 Calculation of reference, predeformation defined by value

In the calculation of reference, one affects the following values of predeformation:

	G1X	G2X	G3X
EXX	1E-3	2nd-3	3rd-3

The taking into account of the dependence at time is made by the addition of a multiplying function "identity" with the loading.

#### 5.2.2 The second calculation, predeformation defined by function

The loading of predeformation according to is affected on all the meshes of the group COQ\_X :

EXX	1E-3.escalier( $X$ ).INST
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### 5.3 Sizes tested and results

Calculation on COQ\_X/DKT\_X :

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLX , DX	'NON_REGRESSION'	-	-
Moment 2 , FLX , DX	'NON_REGRESSION'	-	-

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLX , DX	'AUTRE_ASTER'	7.77024811041E-05	1E-6
Moment 2 , FLX , DX	'AUTRE_ASTER'	0.000155404962208	1E-6

Calculation on COQ\_Y/DKT\_Y :

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLY , DY	'NON_REGRESSION'	-	-

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLY , DY	'AUTRE_ASTER'	0.00298308765372	1E-6

Calculation on COQ\_Z/DKT\_Z :

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FL Z , DZ	'NON_REGRESSION'	-	-

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FL Z , DZ	'AUTRE_ASTER'	0.00298308765372	1E-6

## 6 Modeling D

### 6.1 Characteristics of modeling

This modeling rests on the linear grid. 9 surface meshes (QUAD4) of each plate are affected modeling GRILLE\_MEMBRANE and duplicated to form the groups DKT\_X, DKT\_Y and DKT\_Z that one affects modeling DKT.

In each case the grids are directed in the direction length of the plate.

### 6.2 Calculations and loadings

One carries out two calculations on each plate of the grid. One details loadings of calculation on LES groupS COQ\_X/DKT\_X. It is then enough to replace X by Y then Z to obtain the loadings of other calculations.

#### 6.2.1 Calculation of reference, predeformation defined by value

In the calculation of reference, one affects the following values of predeformation:

	G1X	G2X	G3X
EXX	1E-3	2nd-3	3rd-3

The taking into account of the dependence at time is made by the addition of a multiplying function "identity" with the loading.

**Note:** this calculation validates the taking into account of the predeformations by value for modeling GRILLE\_MEMBRANE by comparison with same calculation with modeling GRILLE\_EXCENTRE (modeling C).

#### 6.2.2 The second calculation, predeformation defined by function

The loading of predeformation according to is affected on all the meshes of the group COQ\_X :

EXX	1E-3.escalier(X).INST
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### 6.3 Sizes tested and results

Calculation on COQ\_X/DKT\_X :

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLX , DX	'NON_REGRESSION'	-	-
Moment 2 , FLX , DX	'NON_REGRESSION'	-	-

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLX , DX	'AUTRE_ASTER '	0.00298308765372	1E-6
Moment 2 , FLX , DX	'AUTRE_ASTER '	0.00596617530744	1E-6

## Calculation on COQ\_Y/DKT\_Y :

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLY , DY	'AUTRE_ASTER'	0.00298308765372	1E-6

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLY , DY	'AUTRE_ASTER'	0.00298308765372	1E-6

## Calculation on COQ\_Z/DKT\_Z :

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FL Z , DZ	'AUTRE_ASTER'	0.00298308765372	1E-6

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FL Z , DZ	'AUTRE_ASTER'	0.00298308765372	1E-6

## 7 Modeling E

### 7.1 Characteristics of modeling

This modeling rests on the grid quadratic. 27 meshes voluminal (HEXA20) are affected modeling 3D, surface meshes (QUAD8) group GRID (higher face) are affected modeling GRILLE\_MEMBRANE.

Lbe grids are directed in the direction  $X$ .

### 7.2 Calculations and loadings

Two calculations are carried out.

#### 7.2.1 Calculation of reference, predeformation defined by value

In the calculation of reference, one affects the following values of predeformation:

	G1X	G2X	G3X
EXX	1E-3	2nd-3	3rd-3

The taking into account of the dependence at time is made by the addition of a multiplying function "identity" with the loading.

#### 7.2.2 The second calculation, predeformation defined by function

The loading of predeformation according to is affected on all the meshes of the group GRID :

EXX	1E-3.escalier( $X$ ).INST
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### 7.3 Sizes tested and results

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLX , DX	'NON_REGRESSION'	-	-

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLX , DX	'AUTRE_ASTER'	-0.00235783307917	1E-6

## 8 Modeling F

### 8.1 Characteristics of modeling

This modeling rests on the linear grid. 9 surface meshes (QUAD4) of each plate are affected modeling MEMBRANE and duplicated to form the groups DKT\_X, DKT\_Y and DKT\_Z that one affects modeling DKT.

In each case them membranes are directed in the direction length of the plate.

### 8.2 Calculations and loadings

One carries out two calculations on each plate of the grid. One details loadings of calculation on LES groups COQ\_X/DKT\_X. It is then enough to replace X by Y then Z to obtain the loadings of other calculations.

#### 8.2.1 Calculation of reference, predeformation defined by value

In the calculation of reference, one affects the following values of predeformation:

	G1X	G2X	G3X
EXX	1E-3	2nd-3	3rd-3
EYY	2nd-3	4th-3	6th-3
EXY	3rd-3	6th-3	9th-3

The taking into account of the dependence at time is made by the addition of a multiplying function "identity" with the loading.

#### 8.2.2 The second calculation, predeformation defined by function

The loading of predeformation according to is affected on all the meshes of the group COQ\_X :

EXX	$1E-3 \cdot \text{escalier}(X) \cdot INST$
EYY	$2E-3 \cdot \text{escalier}(X) \cdot INST$
EXY	$3E-3 \cdot \text{escalier}(X) \cdot INST$

### 8.3 Sizes tested and results

Calculation on COQ\_X/DKT\_X :

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLX , DX	'NON_REGRESSION'	-	-
Moment 1, FLX , DY	'NON_REGRESSION'	-	-
Moment 2 , FLX , DX	'NON_REGRESSION'	-	-
Moment 2 , FLX , DY	'NON_REGRESSION'	-	-

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLX , DX	'AUTRE_ASTER '	0.00426667367479	1E-6
Moment 1, FLX , DY	'AUTRE_ASTER '	0.000347860558941	1E-6
Moment 2 , FLX , DX	'AUTRE_ASTER '	0.00853334734958	1E-6
Moment 2 , FLX , DY	'AUTRE_ASTER '	0.000695721117883	1E-6

Calculation on COQ\_Y/DKT\_Y :

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLY , DX	'NON_REGRESSION'	-	-
Moment 1, FLY , DY	'NON_REGRESSION'	-	-

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLY , DX	'AUTRE_ASTER '	0.000341832038815	1E-6
Moment 1, FLY , DY	'AUTRE_ASTER '	0.00426668139186	1E-6

Calculation on COQ\_Z/DKT\_Z :

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FL Z , DY	'NON_REGRESSION'	-	-
Moment 1, FL Z , DZ	'NON_REGRESSION'	-	-

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FL Z , DY	'AUTRE_ASTER '	0.000347860558942	1E-6
Moment 1, FL Z , DZ	'AUTRE_ASTER '	0.00426667367479	1E-6

## 9 Modeling G

### 9.1 Characteristics of modeling

This modeling rests on the grid quadratic. 27 meshes voluminal (HEXA20) are affected modeling 3D, surface meshes (QUAD8) group GRID (higher face) are affected modeling MEMBRANE.

Lbe membranes are directed in the direction  $X$ .

### 9.2 Calculations and loadings

Two calculations are carried out.

#### 9.2.1 Calculation of reference, predeformation defined by value

In the calculation of reference, one affects the following values of predeformation:

	G1X	G2X	G3X
EXX	1E-3	2nd-3	3rd-3
EYY	2nd-3	4th-3	6th-3
EXY	3rd-3	6th-3	9th-3

The taking into account of the dependence at time is made by the addition of a multiplying function "identity" with the loading.

#### 9.2.2 The second calculation, predeformation defined by function

The loading of predeformation according to is affected on all the meshes of the group GRID :

EXX	$1E-3.escalier(X).INST$
EYY	$2E-3.escalier(X).INST$
EXY	$3E-3.escalier(X).INST$

### 9.3 Sizes tested and results

Calculation of reference:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLX , DX	'NON_REGRESSION'	-	-
Moment 1, FLX , DY	'NON_REGRESSION'	-	-

The second calculation:

Identification	Type of reference	Values of Référence	Tolerance
Moment 1, FLX , DX	'AUTRE_ASTER'	-0.00267922249412	1E-6
Moment 1, FLX , DY	'AUTRE_ASTER'	-0.0470255296821	1E-6



## 10 Summary of the results

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The results of these tests validate the taking into account of the loading of predeformation by functions for the elements `DKT`, `DKTG`, `GRILLE_EXCENTRE`, `GRILLE_MEMBRANE` and `MEMBRANE` on linear and quadratic meshes when available. It checks the good taking into account of the 3 variables of space and the variable in time in the definition of the formulas and that for all the components available.