SSLS111 - Simple eccentring of plate

Summarized:

This test makes it possible to validate the eccentring of the simple plates (i.e. that it is neither about multi-layer, nor of a homogenized behavior).

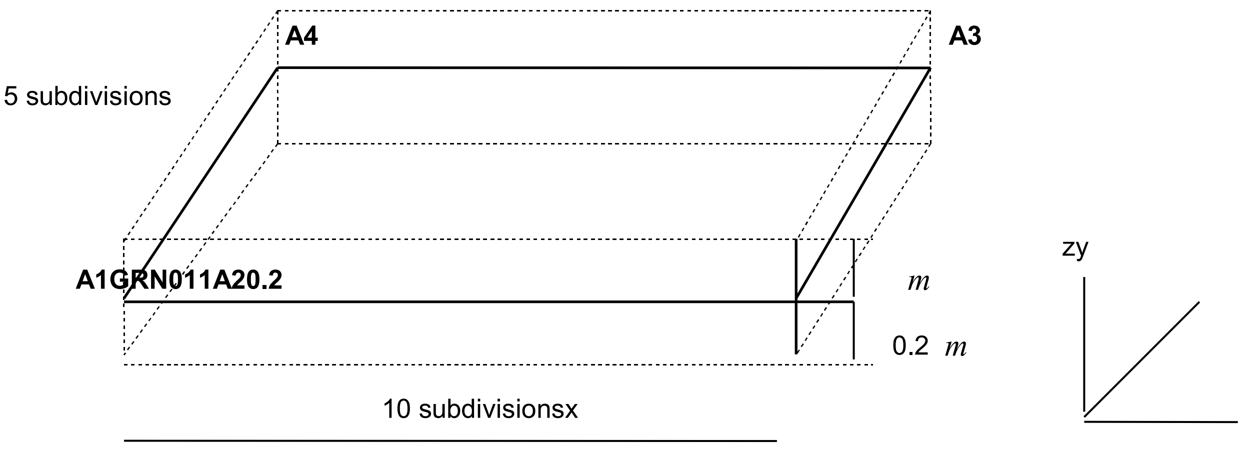
Three modelizations are used: DST (modelization A), DKT (modelization B) and DST (modelization C).

Modelizations A and B : one models 2 plates offset compared to the average plane and one compares the results with an analytical solution.

Modelization C :
The reference is given by a first resolution where one models double-layered made up of 2 materials.
The validation is done in the second computation where one models the 2 layers of the preceding model by 2 plates offset compared to the average plane of the first computation.

1 Problem of reference

1.1 Geometry



the coordinates of the points are given in meters (m):

$A1(0,0,0)$ $A3(10,5,0)$
$A2(10,0,0)$ $A4(0,5,0)$

1.2 Material properties

1.2.1 Modelizations A and B

the material has an isotropic elastic behavior:

Young modulus: $E=20000.\text{MPa}$
Poisson's ratio: $\nu=0.$
Density: $\rho=1000.\text{Kg}/m^3$

1.2.2 Modelization C

the material is double-layered.

The material constituting the first layer is elastic orthotropic and is characterized by the following data:

$EL=20000.\text{MPa}$ $ET=20000.\text{MPa}$ $VLT=0.3$ $GLT=2000.\text{MPa}.$

The material constituting the second layer is also elastic orthotropic and is characterized by the following data:

$EL=15000.\text{MPa}$ $ET=15000.\text{MPa}$ $VLT=0.3$ $GLT=1500.\text{MPa}$

1.3 Boundary conditions and loadings

1.3.1 Modelizations A and B

the edge $A1A4$ is clamped.
One applies a nodal force $Fz=-1000\,\mathrm{N}$ to the edge $A1A2$.

1.3.2 Modelization C

the node $A1$ is clamped:

$$dx=0. \quad dy=0. \quad dz=0.$$

$$dRx=0. \quad dRy=0. \quad dRz=0.$$

The node $A2$ is blocked according to the following degrees of freedom:

$$dx=0. \quad dy=0.$$

One applies a nodal force $Fz=-1000\,\mathrm{N}$ to the node $A3$.

In addition, one applies to 3 meshes (see drawing into 5.2) the distributed loading in local coordinate system according to (key word FORCE_COQUE):

$$F1=200\,N/m^2 \quad F2=-500\,N/m^2 \quad F3=-500\,N/m^2 \quad MF1=100\,N/m\,,\ MF2=40\,N/m$$

in the plane of the mesh.

2 Reference solution

2.1 Méthode de calcul used for the reference solution

2.1.1 Modelizations A and B

the deflection fl is given by the formula: $fl=FlL^3/3\mathrm{EI}$
where l is the width, L the length of the plate, and $I=lh^3/12$, h being the thickness.

2.1.2 Modelization C

The computation with double-layered material is used as reference. The non regression one of the results got for this first computation is checked.

2.2 Results of reference

2.2.1 Modelizations A and B

They are made up by the values of the field of displacement DZ at the point $A3$ and the forces at the point $A1$. In addition, the 4 smaller frequencies of structure are calculated.

2.2.2 Modelization C

They are made up by the values of the field of displacement DX , DY , DZ , DRX , DRY at the point $A3$ (node $N1$ for `Code_Aster`) and at the point of coordinates $(9,2,0)$.

One compares also the forces with the point $A1$.

In addition, the 4 smaller frequencies of structure are calculated.

2.3 Uncertainty on the solution

For the modelizations A and B , the reference solution is analytical. There is thus no uncertainty.

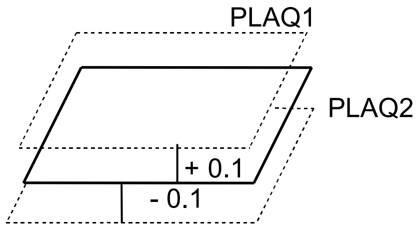
For the modelization C , uncertainties are null since it is about the same computation carried out by two different ways.

3 Modelization A

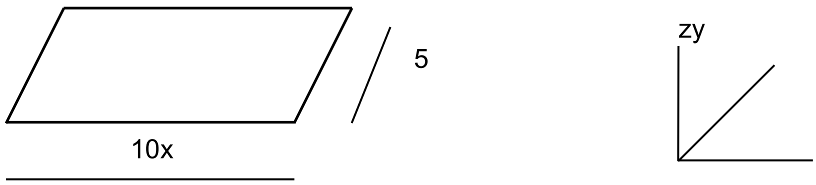
3.1 Characteristic of the modelization

The model consists of 2 offset plates of the distances -0.1m and 0.1m.

The elements used are shell elements `DSQ`.



3.2 Characteristics of the mesh



The mesh is regular. There are 10 subdivisions according to x and 5 subdivisions according to y ; that is to say on the whole 50 meshes `DSQ` (`QUAD4`) and 66 nodes.

3.3 Quantities tested and Standard

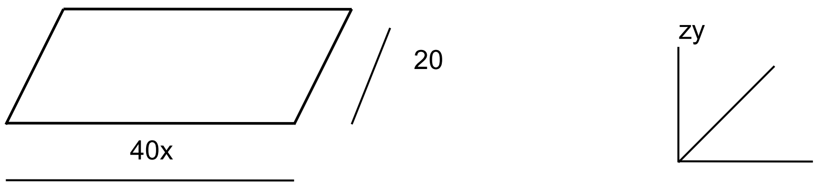
Identification	results of reference	Values of reference	Tolerance
`DZ` ($A3$)	"ANALYTIQUE"	– 3.90625 10-5	0.005
`MXX` ($A1$)	"ANALYTIQUE"	5000.	0.001
`QX` ($A1$)	"ANALYTIQUE"	-500.	0.001
`SIXX` ($M1, PT1, SSPT1$)	"ANALYTIQUE"	0.	1.0E-8
`SIXX` ($M1, PT1, SSPT2$)	"ANALYTIQUE"	990.585	0.001
Frequency 1st mode	"NON_REGRESSION"	18.2	0.001
Frequency 2nd mode	"NON_REGRESSION"	84.6	0.001
Frequency 3rd mode	"NON_REGRESSION"	101.21	0.001
Frequency 4th mode	"NON_REGRESSION"	111.28	0.001

4 Modelization B

4.1 Characteristic of the modelization

The model is the same one as that of the modelization A, with this close instead of having shell elements DSQ, one has elements DKT.

4.2 Characteristic of the mesh



The mesh is regular. There are 40 subdivisions according to x and 20 subdivisions according to y ; i.e. a total of 1600 meshes DKT and 861 nodes.

4.3 Quantities tested and Standard

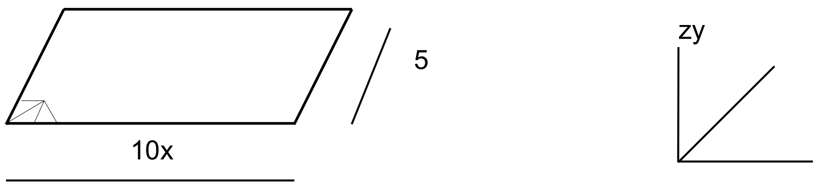
Identification	results of reference	Values of reference	Tolerance
DZ ($A3$)	"ANALYTIQUE"	– 3.90625 10-5	0.005
MXX ($A1$)	"ANALYTIQUE"	5000.	0.3
QX ($A1$)	"ANALYTIQUE"	-500.	0.15
Frequency 1st mode	"NON_REGRESSION"	18.25	0.001
Frequency 2nd mode	"NON_REGRESSION"	88.35	0.001
Frequency 3rd mode	"NON_REGRESSION"	100.1	0.001
Frequency 4th mode	"NON_REGRESSION"	113.5	0.001

5 Modelization C

5.1 Characteristic of the modelization

The model are the same one as that of the modelization A , with this close instead of having shell elements `DSQ` , one has elements `DST` . (Modelization `DST` with meshes `TRIA3`).

5.2 Characteristics of the mesh



The mesh is regular. There are 10 subdivisions according to x and 5 subdivisions according to y ; i.e. a total of 100 meshes `DST` and 66 nodes.

5.3 Quantities tested and Standard

Identification	results of reference	Values of reference	Tolerance
DEPL DX $N66$	"AUTRE_ASTER"	– 6.49678E-06	0.01
DEPL DY $N66$	"AUTRE_ASTER"	– 6.08932E-07	0.01
DEPL DZ $N66$	"AUTRE_ASTER"	– 5.33844E-03	0.01
DEPL DRX $N66$	"AUTRE_ASTER"	– 4.29182E-04	0.01
DEPL DRY $N66$	"AUTRE_ASTER"	4.75601E-04	0.01
DEPL DX $N53$	"AUTRE_ASTER"	-3.58293E-06	0.01
DEPL DY $N53$	"AUTRE_ASTER"	– 1.18788E-06	0.01
DEPL DZ $N53$	"AUTRE_ASTER"	– 3.63885E-03	0.01
DEPL DRX $N53$	"AUTRE_ASTER"	– 4.05175E-04	0.01
DEPL DRY $N53$	"AUTRE_ASTER"	4.23116E-04	0.01
EFGE NXX $N6$	"AUTRE_ASTER"	1.70005E+04	0.01
EFGE NYY $N6$	"AUTRE_ASTER"	1.14438E+04	0.016
EFGE NXY $N6$	"AUTRE_ASTER"	3.53598E+03	0.022
EFGE MXX $N6$	"AUTRE_ASTER"	2.14585E+04	0.01
EFGE MYY $N6$	"AUTRE_ASTER"	1.53094E+04	0.012
EFGE MXY $N6$	"AUTRE_ASTER"	5.71331E+03	0.02
EFGE QX $N6$	"AUTRE_ASTER"	– 3.03380E+03	0.08
EFGE QY $N6$	"AUTRE_ASTER"	1.76436E+03	0.025
MODE 1	"AUTRE_ASTER"	1.01181E+00	0.003
MODE 2	"AUTRE_ASTER"	4.27003E+00	0.003
MODE 3	"AUTRE_ASTER"	8.39151E+00	0.004
MODE 4	"AUTRE_ASTER"	1.72305E+01	0.006

5.4 Remarks

One notes a difference between the solution obtained for a double-layered shell and that resulting from two offset full-course shells, without it being possible at the time of the drafting of the test to determine from which the variation comes.

6 Summary of the results

the results of the 3 modelizations are very good, except for the shears of the modelizations B and C (respectively 10% and 7% of error).