SSLS117 - Eccentring of Summarized asymmetric

plates:

This test validates the eccentring of asymmetric simple plates compared to the plane of the mesh or plane of diagram (key word EXCENTREMENT of the command AFFE_CARA_ELEM).

The reference is given by a first resolution where one models double-layered made up of two layers of various thickness and two materials.

It is used to validate the second computation where one models two layers offset compared to the plane of the mesh.

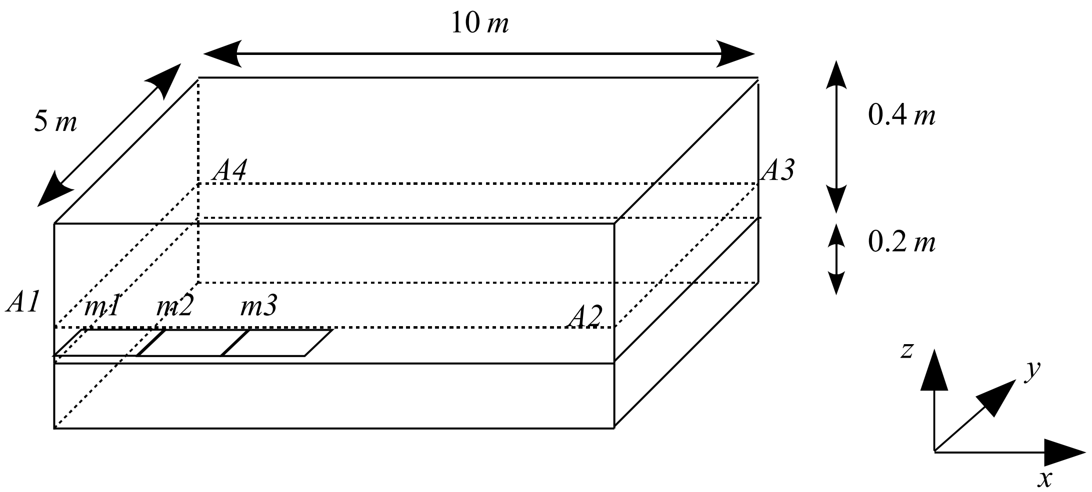
It differs from test SSLS111 only by the fact that the 2 layers are different thickness.

Four modelizations implement elements DKT, DKQ, DST, DSQ.

One highlights on the double-layered case the difference between the modelizations, due to the effect of shears transverse.

1 Problem of reference

1.1 Geometry



1.2 Properties of the materials

1.2.1 Modelizations A and B

the material has an isotropic elastic behavior:

Young's modulus: $E=20000\,MPa$

Poisson's ratio: $\nu=0.$

Density: $\rho=1000\,kg/m^3$

1.2.2 Modelizations C and D

the material is double-layered.

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

$E_L=20000\,MPa$ $E_T=20000\,MPa$ $\nu_{LT}=0.3$ $G_{LT}=2000\,MPa$

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

$E_L=15000\,MPa$ $E_T=15000\,MPa$ $\nu_{LT}=0.3$ $G_{LT}=1500\,MPa$

1.3 Boundary conditions and loadings

1.3.1 Modelizations A and B

the edge $A1A4$ is clamped.
One applies a distributed force $F_z=-1000\,N/m$ to the edge $A2A3$.

1.3.2 Modelizations C and D

the node $A1$ is clamped $DX = DY = DZ = 0.$
$DRX = DRY = DRZ = 0.$
the node $A2$ is blocked according to the following degrees of freedom: $DX = DY = 0.$

One applies the nodal forces $FZ = -1000\,N$ to the node $A3$, and one applies the distributed loading (key word FORCE_COQUE) to meshes $m1$, $m2$ and $m3$:

$FX = 200\,N$ $FX = -500.\,N/m^2$ $FZ = -500.\,N/m^2$ $MX = 100.\,N/m$ $MY = 40.\,N/m$

The selected loading utilizes requests out of membrane and bending.

2 Reference solution

2.1 Method of calculating used for the reference solution

The computation with the double-layered material (command DEFI_COMPOSITE) is used as reference. The non regression one compared to the results got by this first computation is checked. The two plates of the second modelization are offset compared to the average plane of the double-layered one.

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 generalized with the node $A1$. In addition, the 4 smaller frequencies of structure are calculated.

2.2.2 Modelization C and D

They are made up by the values of the field of displacement DX, DY, DZ, DRX, DRY at the point $A3$ and the point $A4$.

One compares also the forces generalized with the node $A1$.

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 modelizations C and D , uncertainties are null since it is about the same computation carried out by two different ways.

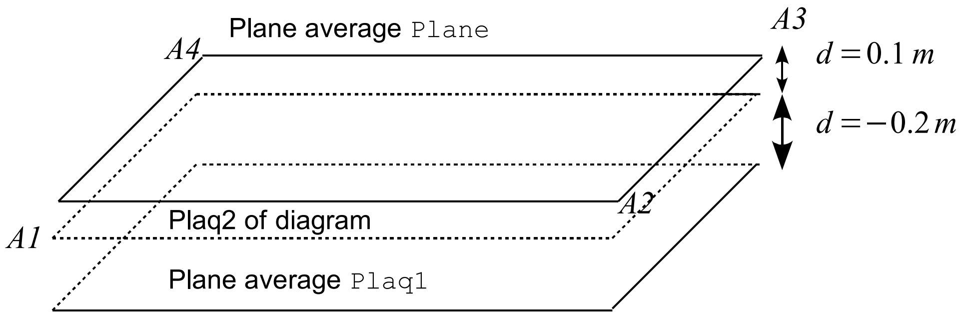
2.4 Bibliographical references

1) [R3.07.03]: Shell elements DKT, DST, DKQ, DSQ and Q4G.
2) [R3.07.06]: Processing of the eccentring for shell elements DKT, DST, DKQ, DSQ and Q4G.

3 Modelization A

3.1 Characteristic of the modelization

The model consists of two plates corresponding to the average plane of each of the two layers of the model of reference. To represent these two plates, one leaves the mesh of the plane of diagram which one offsets distances $0.1\,m$ and $-0.2\,m$.



the elements used are shell elements DKT.

3.2 Characteristics of the mesh

Coordinated of the nodes:

Node	X	Y	Z
$A1=N65$	0.	0.	0.
$A2=N66$	10.	0.	0.
$A3=N1$	10.	5.	0.
$A4=N51$	0.5	.	0.

- 94 nodes; GROUP_MA: $L14=A1A4$, $L12=A2A3$
- 100 meshes DKT (TRIA3).

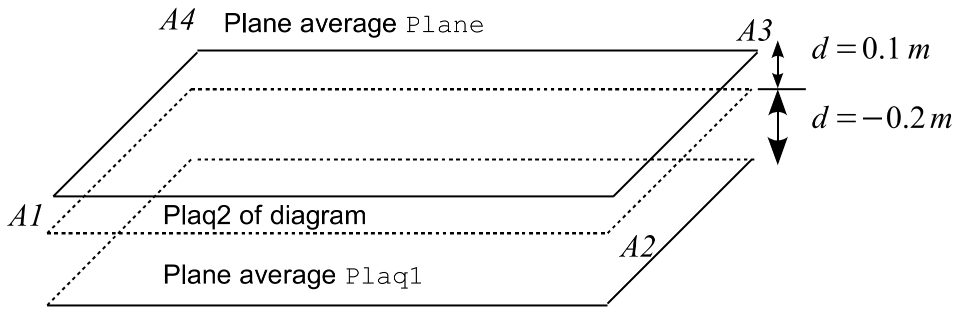
3.3 Quantities tested and Standard

Identification		results of reference	Reference	Tolerance $(\%)$
Displacement				
DZ ($A3$)		"ANALYTIQUE"	-9.259259 10^{-5}	0.5
Eigenfrequencies				
Frequency 1st mode		"NON_REGRESSION"	13.67	0.1
Frequency 2nd mode		"NON_REGRESSION"	64.86	0.1
Frequency 3rd mode		"NON_REGRESSION"	84.47	0.1
Frequency 4th mode		"NON_REGRESSION"	101.16	0.1
generalized Forces				
MXX	$N66$	"ANALYTIQUE"	5000.	0.1
QX	$N66$	"ANALYTIQUE"	– 500.	0.1

4 Modelization B

4.1 Characteristic of the modelization

The model consists of two plates corresponding to the average plane of each of the two layers of the model of reference. To represent these two plates, one leaves the mesh of the plane of diagram which one offsets distances $0.1\,m$ and $-0.2\,m$.



the elements used are shell elements DKQ.

4.2 Characteristics of the mesh

Coordinated of the nodes:

Node	X	Y	Z
$A1$	0.	0.	0.
$A2$	10.	0.	0.
$A3$	10.	5.	0.
$A4$	0.5	.	0.

* 67 nodes
* 50 meshes DKQ (QUAD4)

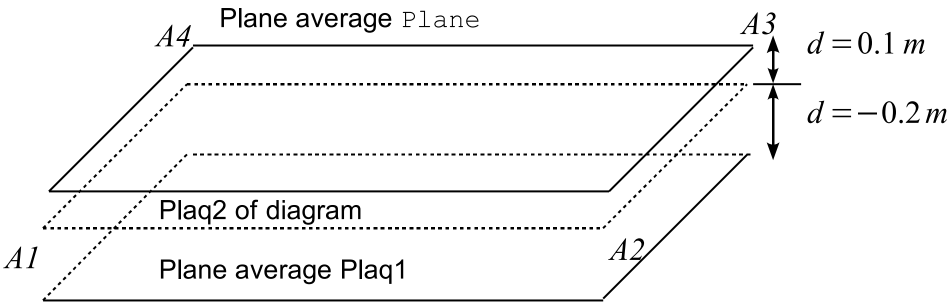
4.3 Quantities tested and Standard

Identification	results of Reference	Reference	Tolerance $(\%)$
Displacement			
DZ ($A3$)	"ANALYTIQUE"	-9.259259 10^{-5}	0.5
Eigenfrequencies			
Frequency 1st mode	"NON_REGRESSION"	13.7	0.1
Frequency 2nd mode	"NON_REGRESSION"	66.65	0.1
Frequency 3rd mode	"NON_REGRESSION"	85.49	0.1
Frequency 4th mode	"NON_REGRESSION"	100.1	0.1
generalized Forces			
MXX $N60$	"ANALYTIQUE"	5000.	0.1
QX $N60$	"ANALYTIQUE"	– 500.	0.1

5 Modelization C

5.1 Characteristic of the modelization

The model consists of two plates corresponding to the average plane of each of the two layers of the model of reference. To represent these two plates, one leaves the mesh of the plane of diagram which one offsets distances $0.1\,m$ and $-0.2\,m$.



the elements used are shell elements DST.

5.2 Characteristics of the mesh

Coordinated of the nodes:

Node	X	Y	Z
$A1=N1$	0.	0.	0.
$A2=N11$	10.	0.	0.
$A3=N65$	10.	5.	0.
$A4=N66$	0.5	.	0.

- 66 Nodes
- 100 meshes DST (TRIA3)

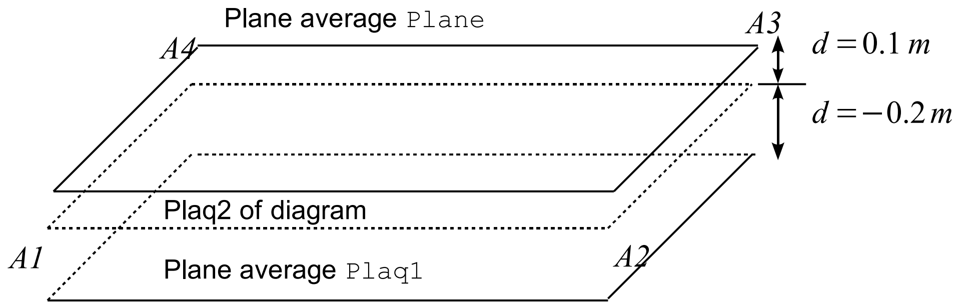
5.3 Quantities tested and Standard

Identification	results of Reference	Reference	Tolerance $(\%)$
Displacement			
DX ($A4$)	"NON_REGRESSION"	$-1.939\ 10^{-6}$	0.1
DY ($A4$)	"NON_REGRESSION"	$-1.149\ 10^{-6}$	0.1
DZ ($A4$)	"NON_REGRESSION"	$-2.2091\ 10^{-4}$	0.6
DRX ($A4$)	"NON_REGRESSION"	$-6.09302\ 10^{-5}$	0.6
DRY ($A4$)	"NON_REGRESSION"	$1.297279\ 10^{-4}$	0.4
DX ($A3$)	"NON_REGRESSION"	$-2.4385\ 10^{-6}$	0.1
DY ($A3$)	"NON_REGRESSION"	$-2.3382\ 10^{-7}$	0.5
DZ ($A3$)	"NON_REGRESSION"	$-1.5864\ 10^{-3}$	0.4
DRX ($A3$)	"NON_REGRESSION"	$-1.2639\ 10^{-4}$	0.3
DRY ($A3$)	"NON_REGRESSION"	$1.4127\ 10^{-4}$	0.4
Eigenfrequencies			
Frequency 1st mode	"NON_REGRESSION"	1.512356	0.1
Frequency 2nd mode	"NON_REGRESSION"	6.373398	0.1
Frequency 3rd mode	"NON_REGRESSION"	1.25011 101.0.1	
Frequency 4th mode	"NON_REGRESSION"	2.546726 101.0.1	
generalized Forces			
NXX $A1$	"NON_REGRESSION"	9.85902 E+03	0.3
NYY $A1$	"NON_REGRESSION"	6.36055 E+03	0.5
NXY $A1$	"NON_REGRESSION"	2.07601 E+03	1.5
MXX $A1$	"NON_REGRESSION"	2.11639 E+04	0.5
MYY $A1$	"NON_REGRESSION"	1.49410 E+04	0.5
MXY $A1$	"NON_REGRESSION"	5.82623 E+03	0.65
QX $A1$	"NON_REGRESSION"	– 2.56538 E+03	0.6
QY $A1$	"NON_REGRESSION"	1.79286 E+03	1.5

6 Modelization D

6.1 Characteristic of the modelization

The model consist of two plates corresponding to the average plane of each of the two layers of the model of reference. To represent these two plates, one leaves the mesh of the plane of diagram which one offsets distances $0.1\,m$ and $-0.2\,m$.



the elements used are shell elements DSQ.

6.2 Characteristics of the mesh

Coordinated of the nodes:

Node	X	Y	Z
$A1=N1$	0.	0.	0.
$A2=N51$	10.	0.	0.
$A3=N65$	10.	5.	0.
$A4=N66$	0.5	.	0.

- 67 nodes
- 50 meshes DSQ (QUAD4)

6.3 Quantities tested and Standard

Identification	results of reference	*Reference*	Tolerance $(\%)$
Displacement			
DX ($A4$)	"NON_REGRESSION"	$-2.34539\ 10^{-6}$	0.1
DY ($A4$)	"NON_REGRESSION"	$-1.9694\ 10^{-6}$	0.1
DZ ($A4$)	"NON_REGRESSION"	$-2.2428\ 10^{-4}$	0.1
DRX ($A4$)	"NON_REGRESSION"	$-6.2983\ 10^{-5}$	0.1
DRY ($A4$)	"NON_REGRESSION"	1.5823 10-4	0.1
DX ($A3$)	"NON_REGRESSION"	$-3.0023\ 10^{-6}$	0.1
DY ($A3$)	"NON_REGRESSION"	$-4.6612\ 10^{-7}$	0.1
DZ ($A3$)	"NON_REGRESSION"	$-1.8842\ 10^{-3}$	0.1
DRX ($A3$)	"NON_REGRESSION"	$-1.2768\ 10^{-4}$	0.1
DRY ($A3$)	"NON_REGRESSION"	$1.7064\ 10^{-4}$	0.1
Eigenfrequencies			
Frequency 1st mode	"NON_REGRESSION"	1.4219	0.1
Frequency 2nd mode	"NON_REGRESSION"	5.2995	0.1
Frequency 3rd mode	"NON_REGRESSION"	1.215 101.0.1	
Frequency 4th mode	"NON_REGRESSION"	2.4385 101.0.1	
generalized Forces			
NXX $A1$	"NON_REGRESSION"	8.68372 E+03	0.1
NYY $A1$	"NON_REGRESSION"	– 4.10693 E+03	0.1
NXY $A1$	"NON_REGRESSION"	3.90190 E+02	0.1
MXX $A1$	"NON_REGRESSION"	3.47663 E+04	0.1
MYY $A1$	"NON_REGRESSION"	1.52451 E+04	0.1
MXY $A1$	"NON_REGRESSION"	6.34489 E+03	0.1
QX $A1$	"NON_REGRESSION"	– 1.70439 E+04	0.1
QY $A1$	"NON_REGRESSION"	– 9.82819 E+03	0.1

7 Summary of the results

With regard to displacements for modelizations DKT and DKQ, the results obtained with 2 offset shells differ from to the more 2% compared to the reference solution. For the other modelizations, one obtains to the maximum of the errors of 4% for the DST and 6% for the DSQ. For these two last modelizations, the error is more important because the computation of the transverse shears is not equivalent between double-layered and the two offset plates.

Indeed, the transverse shears are supposed to be constant in the thickness of each element DST or DSQ ; these transverse shears are average shears. One thus obtains a mean value for each plate offset, overall different from the average transverse shears on the double-layered plate.

This is marked even more for the forces, where the differences A remain lower than 5% for the modelizations DKT (and B) but reach 11% for the modelization C and 100% for modelization D.

One can thus note that for the DSQ, 2 computations (double-layered and full-course offset) are far from being equivalent. One preserves nevertheless this modelization precisely to display this difference.