

## SSLS129 – Sinusoidal corrugated plate subjected to loadings linear forces

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### Summary

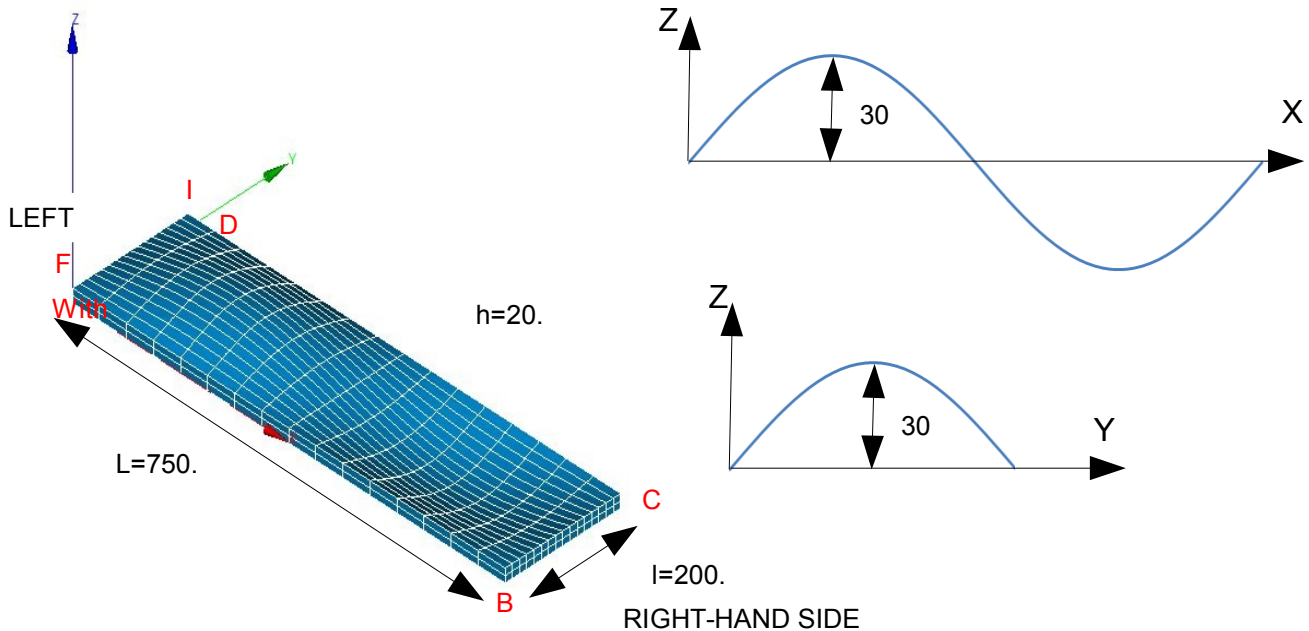
This test makes it possible to validate the taking into account of loading linear.

Three validated modelings are the following ones:

- Modeling A : 3D ,
- Modeling B : COQUE\_3D ,
- Modeling C : SHB .

## 1 Problem of reference

### 1.1 Geometr



Not	$X$ (mm)	$Y$ (mm)	$Z$ (mm)
A	0	0	0
B	750	0	10
C	750	200	10
D	0	200	0
F	0	0	20
I	0	200	20

The dimension  $z$  plate is defined by the following equation:  $z = 30 \sin(2\pi x/L) \sin(\pi y/I)$

### 1.2 Properties materials

The material has an isotropic elastic behavior:

- Young modulus:  $E = 204\,000 \text{ MPa}$
- Poisson's ratio:  $\nu = 0.3$

### 1.3 Boundary conditions and loadings

Boundary conditions:

- Embedding on with dimensions one *GAUCHE*

Modeling 3D, SHB : 3 cases of surface loadings on with dimensions one *DROITE* :

- $f_x = 0.5 \text{ N/mm}^2$
- $f_y = 0.5 \text{ N/mm}^2$

- $f_z = -0.5 \text{ N/mm}^2$

Modeling COQUE\_3D ; 2 cases of linear loadings on with dimensions one *DROITE*

- $f_x = 10. \text{ N/mm}$
- $f_z = -10. \text{ N/mm}$

## 2 Reference solution

### 2.1 Reference solution

The reference solution is:

- "ANALYTICAL" for Efforts and moment resulting,
- "NON\_REGRESSION" for displacements and the constraints (modeling A)
- "AUTRE\_ASTER" for displacements and the constraints (modelings B and C). The results got with modeling A are used as reference solution.

Calculations of the efforts and resulting moments

- Linear loading case  $f_x$

$$R_x = \int_s f_x ds = f_x \cdot h \cdot l = 2000 \text{ N}$$

$$M_y = \int_s f_x z ds = \frac{(f_x \cdot h^2)}{2} l = 20000 \text{ N.mm}$$

$$M_z = \int_s f_x y ds = \frac{(f_x \cdot l^2)}{2} h = 200000 \text{ N.mm}$$

- Linear loading case  $f_y$

$$R_y = \int_s f_y ds = f_y \cdot h \cdot l = 2000 \text{ N}$$

$$M_x = \int_s f_y z ds = \frac{(f_y \cdot h^2)}{2} l = 20000 \text{ N.mm}$$

$$M_z = \int_s f_y L ds = f_y \cdot h \cdot l \cdot L = 1500000 \text{ N.mm}$$

- Linear loading case  $f_z$

$$R_z = \int_s f_z ds = f_z \cdot h \cdot l = 2000 \text{ N}$$

$$M_x = \int_s f_z y ds = \frac{(f_z \cdot l^2)}{2} h = 200000 \text{ N.mm}$$

$$M_y = \int_s f_z L ds = f_z \cdot h \cdot l \cdot L = 1500000 \text{ N.mm}$$

### 2.2 Reference variables

- Resulting efforts: *RESULT\_X*, *RESULT\_Y*, *RESULT\_Z*
- Resulting moments: *MOMENT\_X*, *MOMENT\_Y*, *MOMENT\_Z*
- Displacements: *DX*, *DY*, *DZ*
- Constraints: *SIXX*

## 2.3 Results of reference

- Linear loading case  $f_x$

Not	Identification		Type of reference	Value of reference
	GROUP_MA	Components		
A	LEFT	<i>RESULT_X</i>	'ANALYTICAL'	-2,000. NR
	RIGHT-HAND SIDE	<i>RESULT_X</i>	'ANALYTICAL'	2,000. NR
	LEFT	<i>MOMENT_Y</i>	'ANALYTICAL'	-20,000. N.mm
	LEFT	<i>MOMENT_Z</i>	'ANALYTICAL'	-200 000. N.mm

Not	Identification	Type of reference	Value of reference
A	<i>SIXX</i>	'NON_REGRESSION'	1.067538 MPa
B	<i>DX</i>	'NON_REGRESSION'	5.676675E-3 mm
C	<i>DX</i>	'NON_REGRESSION'	5.837494E-3 mm
D	<i>SIXX</i>	'NON_REGRESSION'	1.030237 MPa
F	<i>SIXX</i>	'NON_REGRESSION'	1.435778 MPa
I	<i>SIXX</i>	'NON_REGRESSION'	1.472049 MPa

- Linear loading case  $f_y$

Not	Identification		Type of reference	Value of reference
	GROUP_MA	Components		
A	LEFT	<i>RESULT_Y</i>	'ANALYTICAL'	-2,000. NR
	RIGHT-HAND SIDE	<i>RESULT_Y</i>	'ANALYTICAL'	2,000. NR
	LEFT	<i>MOMENT_X</i>	'ANALYTICAL'	20,000. N.mm
	LEFT	<i>MOMENT_Z</i>	'ANALYTICAL'	-1.50 E6 N.mm

Not	Identification	Type of reference	Value of reference
A	<i>SIXX</i>	'NON_REGRESSION'	4.55542676 MPa
B	<i>DY</i>	'NON_REGRESSION'	0.15476384 mm
C	<i>DY</i>	'NON_REGRESSION'	0.15475096 mm
D	<i>SIXX</i>	'NON_REGRESSION'	-4.43905267 MPa
F	<i>SIXX</i>	'NON_REGRESSION'	26.8162393 MPa
I	<i>SIXX</i>	'NON_REGRESSION'	-26.9483395 MPa

- Linear loading case  $f_z$

Identification			Type of reference	Value of reference
Not	GROUP_MA	Components		
A	LEFT	RESULT_Z	'ANALYTICAL'	2,000. NR
	RIGHT-HAND SIDE	RESULT_Z	'ANALYTICAL'	-2,000. NR
	LEFT	MOMENT_X	'ANALYTICAL'	200,000. N.mm
	LEFT	MOMENT_Y	'ANALYTICAL'	-1.50 E6 N.mm

Identification		Type of reference	Value of reference
Not A	SIXX	'NON_REGRESSION'	-132.297834 MPa
Not B	DZ	'NON_REGRESSION'	-6.2097302 mm
Not C	DZ	'NON_REGRESSION'	-6.2082328 mm
Not D	SIXX	'NON_REGRESSION'	-131.564485 Mpa
Not F	SIXX	'NON_REGRESSION'	37.0401177 MPa
Not I	SIXX	'NON_REGRESSION'	36.1921083 MPa

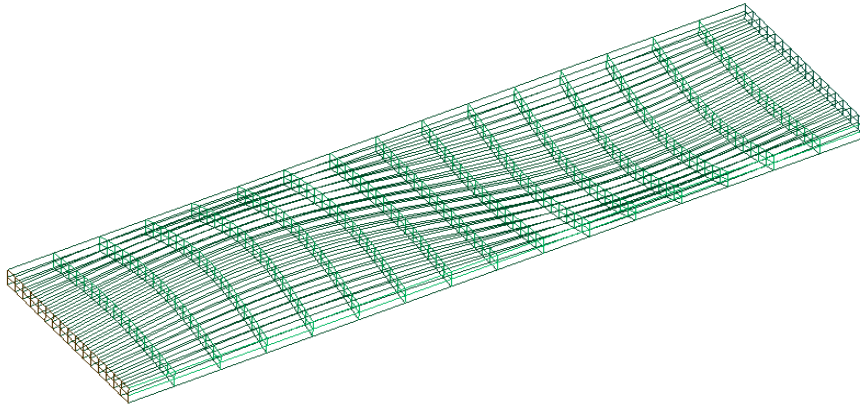
## 2.4 Uncertainty on the solution

Analytical and digital solutions.

## 3 Modeling A

### 3.1 Characteristics of modeling

A modeling is used 3D.



### 3.2 Characteristics of the grid

- Many nodes: 3,077
- Many meshes and types: 512 HEXA20

### 3.3 Results

- Surface loading case  $f_x$

Identification			Type of reference	Value of reference	Tolerance (%)
Not	GROUP_MA	Components			
A	LEFT	RESULT_X	'ANALYTICAL'	-2,000. NR	10 <sup>-6</sup>
	RIGHT-HAND SIDE	RESULT_X	'ANALYTICAL'	2,000. NR	10 <sup>-6</sup>
	LEFT	MOMENT_Y	'ANALYTICAL'	-20,000. N.mm	10 <sup>-6</sup>
	LEFT	MOMENT_Z	'ANALYTICAL'	-200 000. N.mm	10 <sup>-6</sup>

Identification		Type of reference	Value of reference	Tolerance (%)
Not A	SIXX	'NON_REGRESSION'	1.067538 MPa	10 <sup>-6</sup>
Not B	DX	'NON_REGRESSION'	5.676675E-3 mm	10 <sup>-6</sup>
Not C	DX	'NON_REGRESSION'	5.837494E-3 mm	10 <sup>-6</sup>
Not D	SIXX	'NON_REGRESSION'	1.030237 MPa	10 <sup>-6</sup>
Not F	SIXX	'NON_REGRESSION'	1.435778 MPa	10 <sup>-6</sup>
Not I	SIXX	'NON_REGRESSION'	1.472049 MPa	10 <sup>-6</sup>

- Surface loading case  $f_y$

Identification			Type of reference	Value of reference	Tolerance (%)
Not	GROUP_MA	Components			
A	LEFT	RESULT_Y	'ANALYTICAL'	-2,000. NR	10 <sup>-6</sup>
	RIGHT-HAND SIDE	RESULT_Y	'ANALYTICAL'	2,000. NR	10 <sup>-6</sup>
	LEFT	MOMENT_X	'ANALYTICAL'	20,000. N.mm	10 <sup>-6</sup>
	LEFT	MOMENT_Z	'ANALYTICAL'	-1.50 E6 N.mm	10 <sup>-6</sup>

Identification		Type of reference	Value of reference	Tolerance (%)
Not A	SIXX	'NON_REGRESSION'	4.55542676 MPa	10 <sup>-6</sup>
Not B	DY	'NON_REGRESSION'	0.15476384 mm	10 <sup>-6</sup>
Not C	DY	'NON_REGRESSION'	0.15475096 mm	10 <sup>-6</sup>
Not D	SIXX	'NON_REGRESSION'	-4.43905267 MPa	10 <sup>-6</sup>
Not F	SIXX	'NON_REGRESSION'	26.8162393 MPa	10 <sup>-6</sup>
Not I	SIXX	'NON_REGRESSION'	-26.9483395 MPa	10 <sup>-6</sup>

- Surface loading case  $f_z$

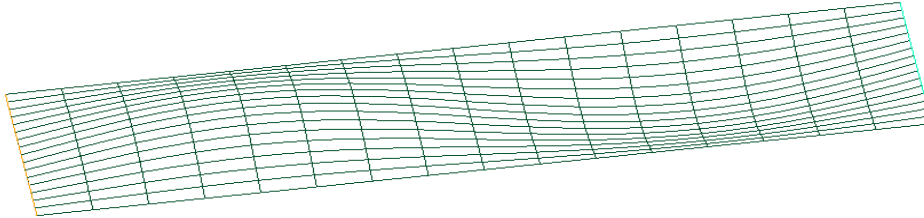
Identification			Type of reference	Value of reference	Tolerance (%)
Not	GROUP_MA	Components			
A	LEFT	RESULT_Z	'ANALYTICAL'	2,000. NR	10 <sup>-6</sup>
	RIGHT-HAND SIDE	RESULT_Z	'ANALYTICAL'	-2,000. NR	10 <sup>-6</sup>
	LEFT	MOMENT_X	'ANALYTICAL'	200,000. N.mm	10 <sup>-6</sup>
	LEFT	MOMENT_Y	'ANALYTICAL'	-1.50 E6 N.mm	10 <sup>-6</sup>

Identification		Type of reference	Value of reference	Tolerance (%)
Not A	SIXX	'NON_REGRESSION'	-132.297834 MPa	10 <sup>-6</sup>
Not B	DZ	'NON_REGRESSION'	-6.2097302 mm	10 <sup>-6</sup>
Not C	DZ	'NON_REGRESSION'	-6.2082328 mm	10 <sup>-6</sup>
Not D	SIXX	'NON_REGRESSION'	-131.564485 Mpa	14
Not F	SIXX	'NON_REGRESSION'	37.0401177 MPa	10 <sup>-6</sup>
Not I	SIXX	'NON_REGRESSION'	36.1921083 MPa	14

## 4 Modeling B

### 4.1 Characteristics of modeling

A modeling is used COQUE\_3D .



### 4.2 Characteristics of the grid

- Many nodes: 1,089
- Many meshes and types: 256 QUAD9

### 4.3 Results

- Linear loading case  $f_x$

Identification			Type of reference	Value of reference	Tolerance (%)
Not	GROUP_MA	Components			
A	LEFT	RESULT_X	'ANALYTICAL'	-2,000. NR	10 <sup>-7</sup>
	RIGHT-HAND SIDE	RESULT_X	'ANALYTICAL'	2,000. NR	10 <sup>-7</sup>

Identification		Type of reference	Value of reference	Tolerance (%)
Not A	NXX	'AUTRE_ASTER'	2.5033164 N/mm	5
Not B	DX	'AUTRE_ASTER'	5.676675E-3 mm	5
Not C	DX	'AUTRE_ASTER'	5.837494E-3 mm	5
Not D	NXX	'AUTRE_ASTER'	2.5022855 N/mm	5

- Linear loading case  $f_z$

Identification			Type of reference	Value of reference	Tolerance (%)
Not	GROUP_MA	Components			
A	LEFT	RESULT_Z	'ANALYTICAL'	2,000. NR	10 <sup>-7</sup>
	RIGHT-HAND SIDE	RESULT_Z	'ANALYTICAL'	-2,000. NR	10 <sup>-7</sup>

Identification		Type of reference	Value of reference	Tolerance (%)
Not A	NXX	'AUTRE_ASTER'	-9.525772 N/mm	9

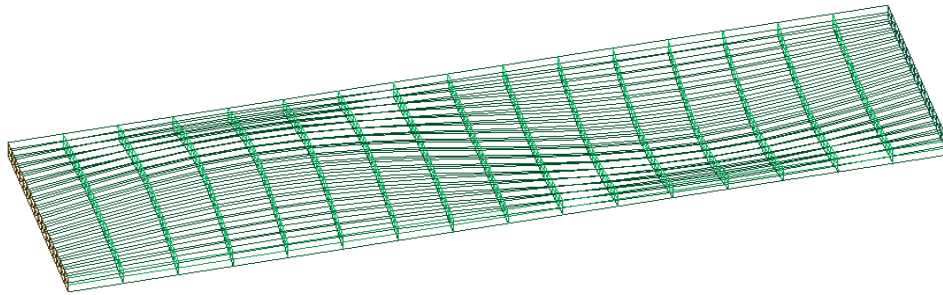


Not <i>B</i>	<i>DZ</i>	'AUTRE_ASTER'	-6.2097302 mm	2.5
Not <i>C</i>	<i>DZ</i>	'AUTRE_ASTER'	-6.2082328 mm	2.5
Not <i>D</i>	<i>NXX</i>	'AUTRE_ASTER'	-9.537275 N/mm	10

## 5 Modeling C

### 5.1 Characteristics of modeling

A modeling SHB is used.



### 5.2 Characteristics of the grid

- Many nodes: 867
- Many meshes and types: 512 HEXA8

### 5.3 Results

- Surface loading case  $f_x$

Identification			Type of reference	Value of reference	Tolerance (%)
Not	GROUP_MA	Components			
<i>A</i>	LEFT	<i>RESULT_X</i>	'ANALYTICAL'	-2,000. NR	10 <sup>-6</sup>
	RIGHT-HAND SIDE	<i>RESULT_X</i>	'ANALYTICAL'	2,000. NR	10 <sup>-6</sup>
	LEFT	<i>MOMENT_Y</i>	'ANALYTICAL'	-20,000. N.mm	10 <sup>-6</sup>
	LEFT	<i>MOMENT_Z</i>	'ANALYTICAL'	-200 000. N.mm	10 <sup>-6</sup>

Identification		Type of reference	Value of reference	Tolerance (%)
Not <i>B</i>	<i>DX</i>	'AUTRE_ASTER'	5.676675E-3 mm	1.
Not <i>C</i>	<i>DX</i>	'AUTRE_ASTER'	5.837494E-3 mm	1.6

- Surface loading case  $f_y$

Identification			Type of reference	Value of reference	Tolerance (%)
Not	GROUP_MA	Components			
A	LEFT	RESULT_Y	'ANALYTICAL'	-2,000. NR	5x10 <sup>-6</sup>
	RIGHT-HAND SIDE	RESULT_Y	'ANALYTICAL'	2,000. NR	10 <sup>-6</sup>
	LEFT	MOMENT_X	'ANALYTICAL'	20,000. N.mm	7x10 <sup>-6</sup>
	LEFT	MOMENT_Z	'ANALYTICAL'	-1.50 E6 N.mm	3x10 <sup>-5</sup>

Identification		Type of reference	Value of reference	Tolerance (%)
Not B	DY	'AUTRE_ASTER'	0.15476384 mm	1.5
Not C	DY	'AUTRE_ASTER'	0.15475096 mm	1.5

- Surface loading case  $f_z$

Identification			Type of reference	Value of reference	Tolerance (%)
Not	GROUP_MA	Components			
A	LEFT	RESULT_Z	'ANALYTICAL'	2,000. NR	9x10 <sup>-4</sup>
	RIGHT-HAND SIDE	RESULT_Z	'ANALYTICAL'	-2,000. NR	9x10 <sup>-4</sup>
	LEFT	MOMENT_X	'ANALYTICAL'	200,000. N.mm	10 <sup>-3</sup>
	LEFT	MOMENT_Y	'ANALYTICAL'	-1.50 E6 N.mm	10 <sup>-3</sup>

Identification		Type of reference	Value of reference	Tolerance (%)
Not B	DZ	'AUTRE_ASTER'	-6.2097302 mm	1.
Not C	DZ	'AUTRE_ASTER'	-6.2082328 mm	1.

Results got with the SHB in concord with the analytical values and with calculations with HEXA20 and COQUE\_3D.