# SSLS129 – Sinusoidal corrugated plate subjected to loadings linear forces

**Abstract**

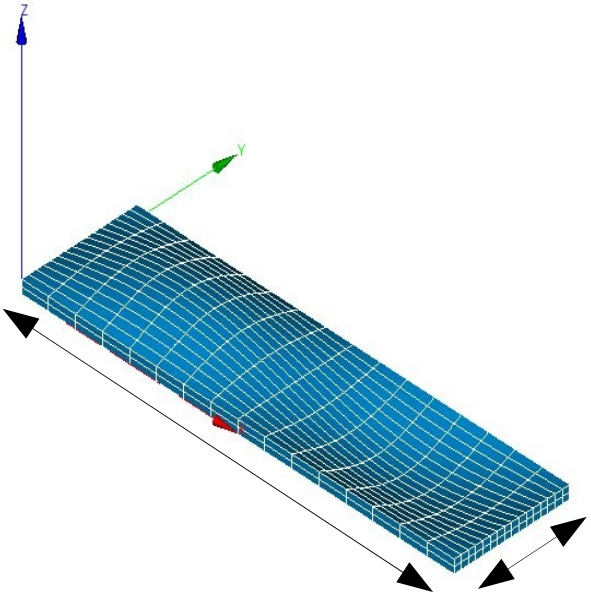
This test makes it possible to validate the taking into account of loading linear.

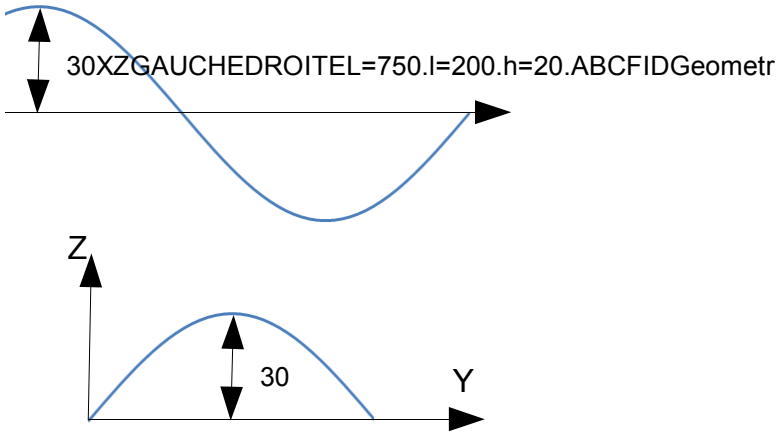
The three validated modelizations are the following ones:

- Modelization a: 3D,
- Modelization b: COQUE_3D,
- Modelization C : SHB.

# 1 Problem of reference

## 1.1






| Point | $X\,(mm)$ | $Y\,(mm)$ | $Z\,(mm)$ |
|---|---|---|---|
| $A$ | 0 | 0 | 0.750 |
| $B$ | | 0 | 10.750.200 |
| $C$ | | | 10 |
| $D$ | 0.200 | | 0 |
| $F$ | 0 | 0 | 20 |
| $I$ | 0.200 | | 20 |

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

## 1.2 Materials properties

the material has an isotropic elastic behavior:

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

## 1.3 Boundary conditions and loadings

Boundary conditions:

- Fixed support on with dimensions $GAUCHE$

the Modelization 3D, SHB : 3 cases of surface loadings on with dimensions one $DROITE$ :

- $fx = 0.5\,N/mm^2$
- $fy = 0.5\,N/mm^2$
- $fz = -0.5\,N/mm^2$

Modelization COQUE_3D ; 2 cases of linear loadings on with dimensions one $DROITE$

- $fx = 10.N/mm$
- $fz = -10.N/mm$

# 2 Reference solution

## 2.1 Reference solution

the reference solution is:

- "ANALYTIQUE" for the resulting forces and moment,
- "NON_REGRESSION" for displacements and the forced (modelization A)
- "AUTRE_ASTER" for displacements and the forced (modelizations B and C). The results got with the modelization A are used as reference solution.

Computations of the forces and resulting moments

- linear Loading case $fx$

$$R_x = \int_s f_x ds = f_x . h . l = 2\,000\,N$$
$$M_y = \int_s f_x z\, ds = \frac{(f_x . h^2)}{2} l = 20\,000\ N.mm$$
$$M_z = \int_s f_x y\, ds = \frac{(f_x . l^2)}{2} h = 200\,000\ N.mm$$

- formula Loading case $fy$

$$R_y = \int_s f_y ds = f_y . h . l = 2\,000\,N$$
$$M_x = \int_s f_y z\, ds = \frac{(f_y . h^2)}{2} l = 20\,000\ N.mm$$
$$M_z = \int_s f_y L\, ds = f_y . h . l . L = 1\,500\,000\ N.mm$$

- formula Loading case $fz$

$$R_z = \int_s f_z ds = f_z . h . l = 2\,000\,N$$
$$M_x = \int_s f_z y\, ds = \frac{(f_z . l^2)}{2} h = 200\,000\ N.mm$$
$$M_y = \int_s f_z L\, ds = f_z . h . l . L = 1\,500\,000\ N.mm$$

## 2.2 Variables reference

- resulting Forces: $RESULT\_X$, $RESULT\_Y$, $RESULT\_Z$
- resulting Moments: $MOMENT\_X$, $MOMENT\_Y$, $MOMENT\_Z$
- Displacements: $DX$, $DY$, $DZ$
- Forced: $SIXX$

## 2.3 Results of linear

•reference Loading case $fx$

| Standard | | | Identification of reference | Value of reference |
|---|---|---|---|---|
| Not | GROUP_MA | Components | | |
| $A$ | GAUCHE | $RESULT\_X$ | "ANALYTIQUE" | -2.000. N |
| | RIGHT | $RESULT\_X$ | "ANALYTIQUE" | 2.000. N |
| | GAUCHE | $MOMENT\_Y$ | "ANALYTIQUE" | -20.000. N.mm GAUCHE |
| | "ANALYTIQUE | $MOMENT\_Z$ | " -200 | 000. Standard N.mm |

| Identification | | of reference Value of reference | Not |
|---|---|---|---|
| formula $A$ | $SIXX$ | " 1.067538 | MPa Not |
| "NON_REGRESSION $B$ | $DX$ | " 5.676675 | E-3 mm Not |
| "NON_REGRESSION $C$ | $DX$ | " 5.837494 | E-3 mm Pointformule |
| $D$ | $SIXX$ | " 1.030237 | MPa Not |
| "NON_REGRESSION $F$ | $SIXX$ | " 1.435778 | MPa Not |
| "NON_REGRESSION $I$ | $SIXX$ | " 1.472049 | MPa linear |

•Loading case formulates $fy$

| Identification | | | of reference Value of reference | Not |
|---|---|---|---|---|
| GROUP_MA | Components | formulates | | |
| $A$ | formulates | $RESULT\_Y$ | " -2.000 | . N RIGHT |
| | formula | $RESULT\_Y$ | " 2.000 | . N GAUCHE |
| | formulates | $MOMENT\_X$ | " 20.000 | . N.mm GAUCHE formulates |
| | | $MOMENT\_Z$ | " -1.50 E6 | N.mm Identification |

| Standard of | Value of reference | Not formula |
|---|---|---|

| reference | | | |
|---|---|---|---|
| formulates $A$ | $SIXX$ | " 4.55542676 | MPa Not "NON_REGRESSION |
| $B$ | $DY$ | " 0.15476384 | mm Pointformule |
| formulates $C$ | $DY$ | " 0.15475096 | mm Not formula |
| formulates $D$ | $SIXX$ | " -4.43905267 | MPa Not "NON_REGRESSION |
| $F$ | $SIXX$ | " 26.8162393 | MPa Not "NON_REGRESSION |
| $I$ | $SIXX$ | " -26.9483395 | MPa linear |

•Loading case formulates Standard $fz$

| Identification of reference | | | Value of reference | Not GROUP_MA |
|---|---|---|---|---|
| Components | | formulates GAUCHE | | |
| $A$ | "ANALYTIQUE | $RESULT\_Z$ | " 2.000. N RIGHT | formula |
| | "ANALYTIQUE | $RESULT\_Z$ | " -2.000. N GAUCHE | formulates |
| | "ANALYTIQUE | $MOMENT\_X$ | " 200.000. N.mm | GAUCHE formulates |
| | "ANALYTIQUE | $MOMENT\_Y$ | E6 N.mm Identification | Standard |

| of reference | | Value of reference | Not formula formulates |
|---|---|---|---|
| " $A$ | $SIXX$ | -132.297834 MPa Not | "NON_REGRESSION |
| " $B$ | $DZ$ | -6.2097302 mm Not | "NON_REGRESSION |
| " $C$ | $DZ$ | -6.2082328 mm Not | "NON_REGRESSION |
| " $D$ | $SIXX$ | -131.564485 Mpa Not | "NON_REGRESSION |
| " $F$ | $SIXX$ | 37.0401177 MPa Not | "NON_REGRESSION |
| " $I$ | $SIXX$ | 36.1921083 MPa Uncertainty | on |

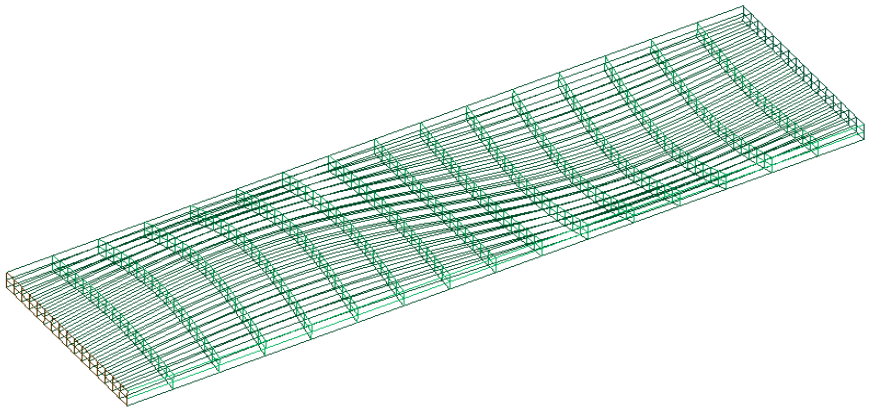
## 2.4 the solution analytical and

numerical Solutions. Modelization A Characteristic

# 3

## 3.1 of the modelization One uses a modelization

3D. Characteristics



## 3.2 of the mesh Many nodes

•: 3.077 Number of meshes
•and types: 512 HEXA20 surface Loading case

## 3.3 Results

•formulate Standard $fx$

| of reference | | | Value of reference | Tolerance (%) Not | GROUP_MA Components |
|---|---|---|---|---|---|
| | GAUCHE | “ANALYTIQUE | | | |
| $A$ | ″ -2.000 | $RESULT\_X$ | . N 10-6 LINE | “ANALYTIQUE | |
| | ″ 2.000 | $RESULT\_X$ | . N 10-6 GAUCHE | “ANALYTIQUE | |
| | ″ -20 | $MOMENT\_Y$ | 000. N.mm 10-6 GAUCHE | “ANALYTIQUE | ″ |
| | -200 000 | $MOMENT\_Z$ | . Standard N.mm 10-6 | Identification | of |

| reference Value of reference | | Tolerance | (%) Not formula | formulates |
|---|---|---|---|---|
| “NON_REGRESSION $A$ | $SIXX$ | MPa 10-6 Point | “NON_REGRESSION | ″ |
| 5.676675 $B$ | $DX$ | E-3 mm 10-6 Point | “NON_REGRESSION | ″ |
| 5.837494 $C$ | $DX$ | E-3 mm 10-6 Point | “NON_REGRESSION | ″ |

| | | | | |
|---|---|---|---|---|
| 1.030237 *D* | *SIXX* | MPa 10-6 Point | “NON_REGRESSION | " |
| 1.435778 *F* | *SIXX* | MPa 10-6 Point | “NON_REGRESSION | " |
| 1.472049 *I* | *SIXX* | MPa 10-6 Loading case | surface | |

•formulates Standard $fy$

| reference Value of reference | | | Tolerance | (%) Not GROUP_MA | Components |
|---|---|---|---|---|---|
| GAUCHE | "ANALYTIQUE | " -2 | | | |
| $A$ | 000. N | $RESULT\_Y$ | 10-6 LINE " | ANALYTIQUE | " 2.000 |
| | . N 10 | $RESULT\_Y$ | - 6 GAUCHE "ANALYTIQUE | | " 20 |
| | 000. N.mm | $MOMENT\_X$ | 10-6 GAUCHE " | ANALYTIQUE" -1.50 | |
| | E6 N.mm 10 | $MOMENT\_Z$ | - 6 Standard | Identification of reference | |

| Value of reference | | Tolerance | (%) Not formula | formulates "NON_REGRESSION |
|---|---|---|---|---|
| $A$ | $SIXX$ | 10-6 Point "NON_REGRESSION | " | 0.15476384 |
| mm $B$ | $DY$ | 10-6 Point "NON_REGRESSION | " 0.15475096 | |
| mm $C$ | $DY$ | 10-6 Point "NON_REGRESSION | " | -4.43905267 |
| $D$ | $SIXX$ | MPa 10-6 Point " | NON_REGRESSION" | 26.8162393 |
| MPa $F$ | $SIXX$ | 10-6 Point "NON_REGRESSION | " | -26.9483395 |
| $I$ | $SIXX$ | MPa 10-6 Loading case | surfaciqueformule | |

•Standard Identification of $fz$

| Value of reference | | | Tolerance | (%) Not GROUP_MA | Components GAUCHE |
|---|---|---|---|---|---|
| " | ANALYTIQUE | " 2.000. N | | | |
| $A$ | 10-6 LINE | $RESULT\_Z$ | "ANALYTIQUE | " -2.000 | . N |
| | 10-6 GAUCHE | $RESULT\_Z$ | "ANALYTIQUE | " 200 | 000 |
| | N.mm 10-6 | $MOMENT\_X$ | GAUCHE "ANALYTIQUE | " -1.50 E | 6 N.mm 10 |
| | - 6 Standard | $MOMENT\_Y$ | Identification | of reference | |

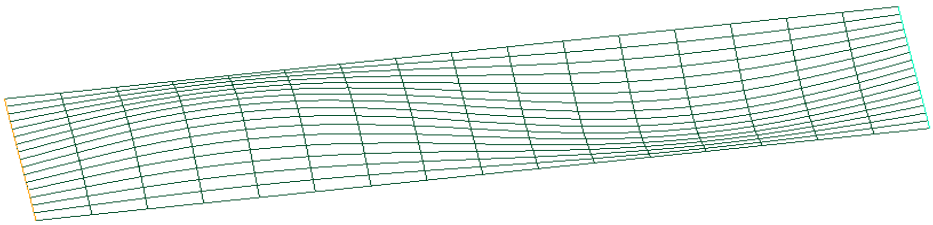
| Value of reference | | Tolerance (% | ) Not formula formulates | "NON_REGRESSION |
|---|---|---|---|---|
| " | $SIXX$ | - 6 Point | " -6.2097302 | |

| | | | | |
|---|---|---|---|---|
| -132.297 834 *A* | | "NON_REGRESSION | | |
| mm 10-6 *B* | *DZ* | Point "NON_REGRESSION | " -6.2082328 | mm |
| 10-6 *C* | *DZ* | Point "NON_REGRESSION | " -131.564485 | |
| Mpa 14 *D* | *SIXX* | Point "NON_REGRESSION | " 37.0401177 | |
| MPa 10 - *F* | *SIXX* | 6 Point "NON_REGRESSION | " 36.1921083 | |
| MPa 14 *I* | *SIXX* | Modelization B Characteristic | | of |

# 4 the modelization

## 4.1 One uses a modelization COQUE_3D

. Characteristics of the mesh Many



## 4.2 nodes: 1.089 Number of meshes

•and types: 256 QUADS
•9 linear Loading case Results

## 4.3 formulate Standard

•Identification of reference *fx*

| Value of reference | | | Tolerance (% | ) Not GROUP_MA Components | GAUCHE “ |
|---|---|---|---|---|---|
| ANALY TIQUE | ” -2 | 000. N 10-7 | | | |
| *A* | LINE | *RESULT _ X* | “ANALYTIQUE” | 2.000. N 10 | - 7 Standard |
| | | *RESULT _ X* | Identificati on of | reference | |

| Value of reference | | Tolerance (% | ) Not formula formulates | “AUTRE_AS TER |
|---|---|---|---|---|
| ” 2.503316 4 *A* | *NXX* | “AUTRE_ASTER | ” 5.676675E-3 | mm |
| 5 Pointform ule *B* | *DX* | formulates | “AUTRE_ASTER | ” |
| 5.837494 E-3 *C* | *DX* | formulates | “AUTRE_ASTER | ” |
| 2.502285 5 *D* | *NXX* | linear | formulates | Standard |

•Identification of reference *fz*

| Value of reference | | | Tolerance (% | ) Not GROUP_MA Components | GAUCHE “ |
|---|---|---|---|---|---|
| ANALY TIQUE | ” 2.000 | . N 10-7 LINE | | | |
| *A* | “ | *RESULT _ Z* | ANALYTIQUE” -2.000 | . N | 10-7 |

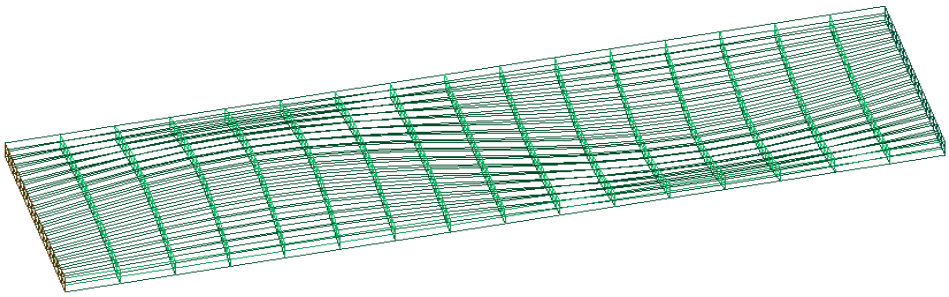
| | | | | | |
|---|---|---|---|---|---|
| | Standard | *RESULT _ Z* | Identificati on | of reference | |

| Value of reference | | Tolerance (% | ) Not formula formulates | "AUTRE_AS TER |
|---|---|---|---|---|
| " -9.52577 2 *A* | *NXX* | "AUTRE_ASTER | " -6.2097302 mm | |
| 2.5 Not *B* | *DZ* | "AUTRE_ASTER | " -6.2082328 | mm 2.5 |
| Not *C* | *DZ* | formula "AUTRE_ASTER | " -9.537275 | |
| N/mm *D* | *NXX* | C Characteristic | | of |

# 5 the modelization

## 5.1 One uses a modelization SHB.

Characteristics of the mesh Many



## 5.2 nodes: 867 Number of meshes

•and types: 512 HEXA
•8 surface Loading case Results

## 5.3 formulate Standard

•Identification of reference *fx*

| Value of reference | | | Tolerance (% | ) Not GROUP_MA Components | formulates |
|---|---|---|---|---|---|
| GAUC HE | formulat es | "ANALYTIQUE" | | | |
| *A* | N 10-6 | *RESULT _ X* | formulates "ANALYTIQUE | " 2 | 000. |
| | N 10-6 | *RESULT _ X* | "ANALYTIQUE | " -20.000 | |
| | . N.mm 10 - | *MOMENT _ Y* | formulate "ANALYTIQUE | " -200 | 000. |
| | Standard N.mm | *MOMENT _ Z* | Identificati on of | reference Value of reference | |

| | | Tolerance (%) Not | formula formulates “AUTRE_ASTER | ” 5.676675 |
|---|---|---|---|---|
| E-3 $B$ | $DX$ | formulates “AUTRE_ASTER | ” 5.837494 | |
| E-3 $C$ | $DX$ | Loading cases | formulates Standard | |

•Identification of reference $fy$

| | | | Tolerance (%) Not | GROUP_MA Components | formulates GAUCHE |
|---|---|---|---|---|---|
| formulates | "ANALYTIQUE | " -2.000 | | | |
| $A$ | - 6 RIGHT | $RESULT\_Y$ | "ANALYTIQUE | " 2.000. | N 10-6 |
| | GAUCHE | $RESULT\_Y$ | "ANALYTIQUE" | 20.000. | N.mm 7x10 |
| | - 6 GAUCHE | $MOMENT\_X$ | "ANALYTIQUE | " -1.50 E6 | N.mm $^{3x10-}$ |
| | 5 Identification | $MOMENT\_Z$ | Standard of reference | Value of reference | |

| Tolerance | | (%) Not "AUTRE_ASTER | " 0.15476384 | mm 1.5 Not "AUTRE_ASTER |
|---|---|---|---|---|
| $B$ | $DY$ | " 0.15475096 | mm 1.5 Standard | |
| Loading case $C$ | $DY$ | | surfaciqueformule | |

•Identification of reference Value of reference $fz$

| Tolerance | | | (%) Not GROUP_MA | Components formulates | GAUCHE formulates |
|---|---|---|---|---|---|
| "ANALYTIQUE | " | 2.000. N 9x | | | |
| $A$ | formulates | $RESULT\_Z$ | " -2 | 000. N 9x | 10-4 $^{GAUCHE}$ |
| | formulates | $RESULT\_Z$ | " 200.000 | . N.mm 10 | - 3 GAUCHE |
| | formulate | $MOMENT\_X$ | " -1.50 | E6 N.mm 10-3 Identification | |
| | | $MOMENT\_Y$ | reference | Value of reference | |

| Tolerance | | (%) Not "AUTRE_ASTER | " -6.2097302 mm 1. | Not "AUTRE_ASTER |
|---|---|---|---|---|
| " -6.2082328 $B$ | $DZ$ | mm 1. | | |
| $C$ | $DZ$ | | | |