SSLS132 – Plate comforts under loading of inflection

Summary

This quasi-static test enters within the framework of the validation of the elements GRILLE_EXCENTRE, GRILLE_MEMBRANE and MEMBRANE. A concrete plate (modelled by HULL possibly) is covered with two tablecloths of reinforcement on its faces higher and lower, each one offset of the same quantity. The loadings are of three types:

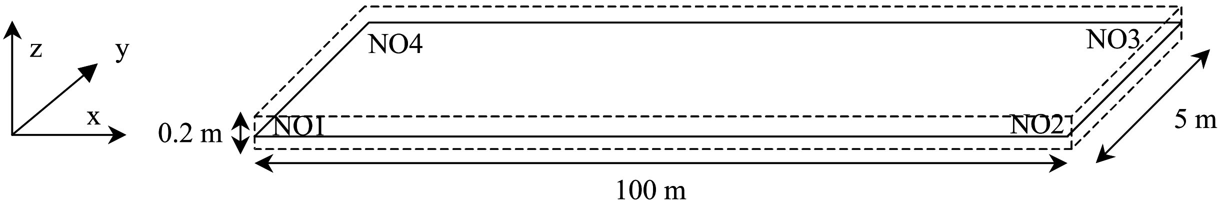
1) embedded edge and inflection of the plate
2) effect of gravity and the actual weight
3) predeformations in the two tablecloths of reinforcements to make compress the plate

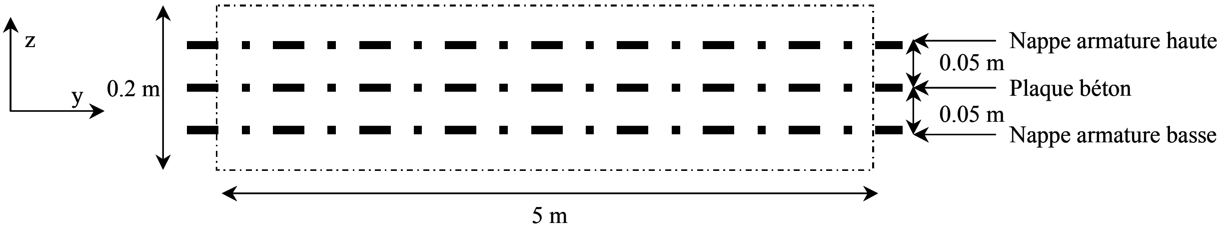
The results of simulation are compared with analytical solutions.

The interest of this test is to validate modeling GRILLE_EXCENTRE, GRILLE_MEMBRANE and MEMBRANE under loadings of inflection, of gravity and by imposing predeformations.
Modeling I test algorithm IMPLEX in elasticity.

1 Problem of reference

1.1 Geometry





The concrete console is modelled either in standard voluminal elements or by modeling HULL (DKT) . The tablecloths of reinforcement are respectively modelled by modelings of GRID (GRILLE_MEMBRANE when there is no offsetting or GRILLE_EXCENTRE when the reinforcements are offset).

1.2 Properties of materials

Concrete console: $E=3\text{E+}10\,Pa$, $\nu=0$, $\rho=2500\,kg/m^3$

Thickness of the console: $0.2\,m$; ANGL_REP = (0; 0)

Tablecloths of steel reinforcement: $E=2\text{E+}11\,Pa$, $\nu=0$, $\rho=7800\,kg/m^3$

Tablecloth of high reinforcement: section per linear meter = $0.2\,m^2/ml$; offsetting = $0.05\,m$; ANGL_REP = (0; 0)

Tablecloth of low reinforcement: section per linear meter = $0.2\,m^2/ml$; offsetting = $-0.05\,m$; ANGL_REP = (0; 0)

1.3 Boundary conditions and loadings

The boundary conditions and the loadings break up in the following way:

Modeling A and B :
Edge $NO1NO4$ ($B0X$) embedded
$DZ=1.0$ on the edge $NO2NO3$ ($B1X$) (inflection)

Modeling C, D and G:
Edge $B0X$ and $B1X$ embedded
Gravity

Modeling E, F and H;

Edge $B0X$ embedded
Predeformations EXX imposed on the two tablecloths of reinforcements, equal to 0.001 .

Modelings and the loadings considered are summarized in the following table:

Modelings	Inflection	Gravity	Predeformation
GRILLE_EXCENTRE	With and B	C	E and F
GRILLE_MEMBRANE		D	
MEMBRANE		G	H

Modeling I tests MEMBRANE and GRILLE_MEMBRANE simultaneously.

2 Reference solution

2.1 Flexbeam

One seeks to calculate the resultant F_Z efforts applying to a reinforced concrete plate (2 tablecloths of reinforcement) of dimension $L_1 \times L_2 \times e$ (L_1 is dimension according to the principal direction of the reinforcements), embedded on an edge and which one subjects to a displacement of inflection on the opposite edge (U_z).

The force is written:

$$F_z = K_Z U_z$$

with K_z rigidity according to z data by:

$$K_z = \frac{3(EI)_{tot}}{L_1^3}$$

with $(EI)_{tot}$ equal to

$$(EI)_{tot} = (EI)_{beton} + (EI)_{armatures}$$

where

$$(EI)_{armatures} = 2.E_{armat}.(s.L_2).e_{exc}^2$$

with E_{armat} the Young modulus of steel, s the section of the reinforcements per linear meter and e_{exc} the offsetting of the tablecloths of reinforcements compared to the average layer

$$(EI)_{beton} = E_{béton}.L_2.\frac{e^3}{12}$$

where $E_{béton}$ is the Young modulus of the concrete.

Knowing the vertical displacement imposed and by using the preceding formulas, it is possible to go back to the analytical value of the force.

2.2 Effect of gravity

One is interested now in a reinforced concrete plate embedded at his two ends and subjected to the effect of gravity.

One seeks to calculate the resultant of the vertical efforts associated F_z

$$F_z = F_{z,armat} + F_{z,beton}$$

where $F_{z,beton}$ and $F_{z,armat}$ are respectively the effects of gravity related on the concrete and the reinforcements.

$$F_{z,beton} = L_1.L_2.e.\rho_{beton}.g$$

with g the acceleration of gravity

$$F_{z,armat} = 2.s.L_2.L_1.\rho_{armat}.g$$

with ρ_{armat} density of the steel reinforcements, and s the section per linear meter.

By combining the preceding equations, it becomes possible to determine the value of the vertical force related to gravity and to deduce the vertical resultant from it from the reactions of support.

2.3 Predeformations

One seeks to calculate following average displacement Ux free edge of a reinforced concrete plate embedded at the other edge. One applies to the reinforcements a predeformation ε_{xx} .

By considering the homogeneous deformation and equalizes on the tablecloths of reinforcements and in the concrete, one writes simply:

$$U_x = \varepsilon_{xx}.L_x$$

with L_x the dimension of the plate in the direction x (equalizes with L_1 in this case)

One can thus determine the value of displacement sought.

3 Modeling A

3.1 Characteristics of modeling

One tests here a loading of inflection with elements GRILLE_EXCENTRE. The concrete console is with a grid with 1616 elements TRIA3

3.2 Results of modeling A

One tests the value of the reaction according to z on the embedded edge (BOX)

Value of reference (analytical solution) : $-3.299\text{E}3\,N$

Value provided by *Code_Aster* : $-3.3\text{E}3\,N$

Variation : 0.016%

4 Modeling B

Modeling identical to modeling A, with a grid of 500 elements QUAD4.

The results of modeling B are the same ones as those of modeling A.

5 Modeling C

5.1 Characteristics of modeling

One tests here a loading of gravity with elements GRILLE_EXCENTRE. The concrete console is with a grid with 500 elements QUAD4.

5.2 Results of modeling C

One tests the value of the reaction according to z on the embedded edges ($BOX+B1X$)

Value of reference (analytical solution) : $1.7756\text{E}+07\,N$

Value provided by *Code_Aster* : $1.7756\text{E}+07\,N$

Variation : 0.

6 Modeling D

One tests here a loading of gravity with elements GRILLE_MEMBRANE. The offsetting of the reinforcements is considered null. The grid is identical to that of modeling C.

The results of modeling D are the same ones as those of modeling C.

7 Modeling E

7.1 Characteristics of modeling

One tests here a loading of predeformation with elements GRILLE_EXCENTRE. The grid is identical to that of modeling A.

7.2 Results of modeling E

One tests the value of following average displacement x free edge $B1X$

Value of reference (analytical solution) : $0.1\,m$

Value provided by *Code_Aster* : $0.1\,m$

Variation : 0.

8 Modeling F

Modeling identical to modeling E, with a grid of 500 elements QUAD4.

The results of modeling F are the same ones as those of modeling E.

9 Modeling G

9.1 Characteristics of modeling

One tests here a loading of gravity with elements MEMBRANE. The grid is identical to that of modeling A.

9.2 Results of modeling G

One tests the value of the reaction according to z on the embedded edges ($BOX+B1X$)

Value of reference (analytical solution) : $1.7756\mathrm{E}+07\,N$

Value provided by *Code_Aster* : $1.7756\mathrm{E}+07\,N$

Variation : 0.

10 Modeling H

10.1 Characteristics of modeling

One tests here a loading of predeformation with elements MEMBRANE . The grid is identical to that of modeling A.

10.2 Results of modeling H

One tests the value of following average displacement x free edge $B1X$

Value of reference (analytical solution) : $0.1\,m$

Value provided by *Code_Aster* : $0.1\,m$

Variation : 0.

11 Modeling I

11.1 Characteristics of modeling

One tests here method IMPLEX in elasticity. A loading of inflection is combined with gravity. Elements MEMBRANE and GRILLE_MEMBRANE are tested simultaneously. The grid is voluminal with two tablecloths of two-dimensional meshs.

11.2 Results of modeling I

The value of the resultant is tested dz nodal force free edge $B1X$

Value of reference (elastic solution) is equal to the solution in IMPLEX

Variation : 0.

12 Conclusions

One valid by this CAS-test various modelings of the behavior of a plate comforts under loading of inflection, the effect of gravity and by imposing predeformations on the tablecloths of reinforcement. Modelings thus are validated GRILLE_EXCENTRE, GRILLE_MEMBRANE and MEMBRANE.

The results of simulations are in agreement with the values of the analytical solutions.