SSLS139 – Bending of a plate with simplified representation of reinforcements

Summarized:

The purpose of this test is to validate the representation of three-dimensions functions of reinforcement by a model of grid or membrane homogenized in a reinforced concrete structure. One thus considers a classical problem of bending of plate, and one compares the solution obtained with a three-dimensional solution of reference.

1 Problem of reference

1.1 Geometry

One considers a reinforced concrete plate, comprising three-dimensions functions of reinforcement on the sides lower and higher. This plate is embedded at an end, and is subjected to one moment at the other end.

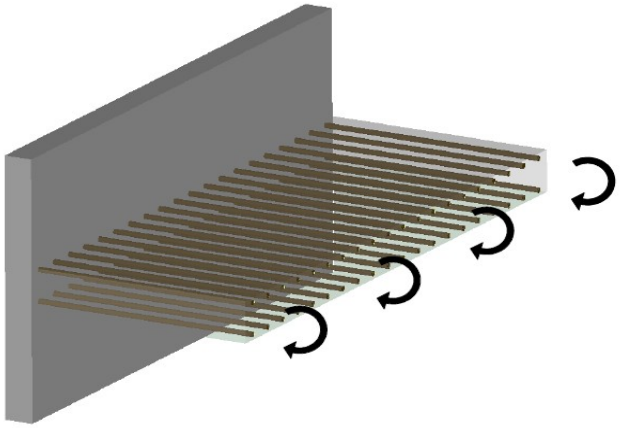


Figure 1: Classical problem of bending of a reinforced concrete plate.

To limit the cost of computation, one models only one section of plate, with the edges of which conditions of periodicity are imposed. Dimensions of the plate and reinforcements are indicated on Figure2.

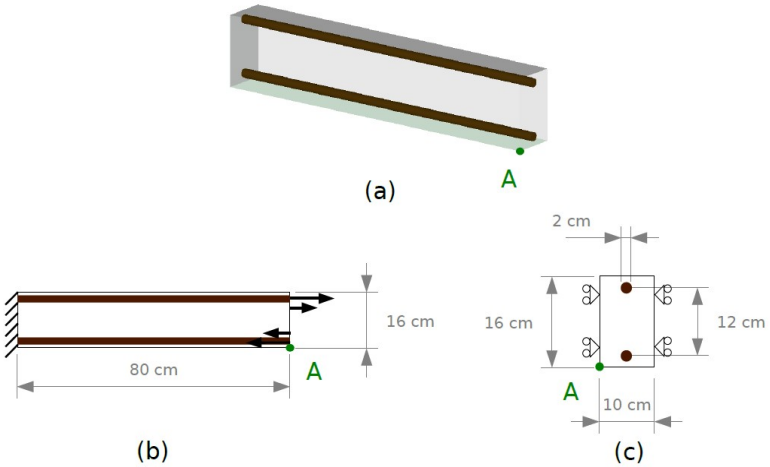
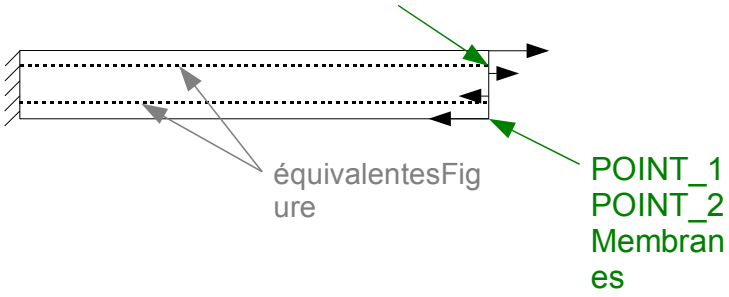


Figure 2: Dimensions of the section of plate modelled. (A) Seen general; (b) seen longitudinal; (c) cut of the modelled section.

One represents the three-dimensions functions of reinforcement by a model of grid or equivalent membrane, which makes it possible to limit the cost of computation much (see Figure3. Points `POINT_1` and `POINT_2` are used for the postprocessing of the results.



3: Representation of the three-dimensions functions of reinforcement by a model of grid or equivalent membrane

1.2 Properties of the materials

the concrete has an isotropic homogeneous elastic behavior, characterized by the Poisson's ratio and Young modulus indicated below:

$$\begin{cases} E_B = 30 \text{ GPa} \\ \nu_B = 0.22 \end{cases}$$

steel also presents an isotropic homogeneous elastic behavior, characterized by the coefficients:

$$\begin{cases} E_A = 200 \text{ GPa} \\ \nu_A = 0.3 \end{cases}$$

1.3 Boundary conditions and loadings

the conditions limits applied to the plate are indicated below, corresponding respectively to the conditions of fixed support, the conditions of periodicity and the time exerted at the end of plate:

$$\begin{cases} \boldsymbol{u} = \mathbf{0} \text{ sur ENCAST} \\ u_Y = 0 \text{ sur BORDS} \\ F_X = 937500 \dfrac{Z - 0.08}{0.08} \text{ sur BOUT} \end{cases}$$

2 Reference solution

2.1 Method of calculating

This problem does not admit an exact analytical solution. The reference solution is thus obtained by a fine three-dimensional modelization, detailed in the reference 4.

2.2 Quantities and results of reference

One specifies below the vertical displacement measured at the end of plate in the modelization of reference.

Component	quantity	Reference solution
DEPL - POINT_1	DZ	-87.1E-6

2.3 bibliographical References

[1] DAVID Mr. , Approach multi-scale of the structural mechanics behavior of reinforced concrete structures – Application to the containments of the nuclear thermal power stations . Thesis of doctorate

3 Modelization A

3.1 Characteristic of the modelization

One represents the three-dimensions functions of reinforcement on the sides lower and higher by a model of equivalent membrane. The coefficients of stiffness of this membrane are calculated by a method of homogenization detailed in the reference 4. The value of these coefficients is specified in the table below:

Parameter	Value (Pa.m) formulates
M_{LLLL}	E8 formulates
M_{LLTT}	E7 formulates
M_{TTTT}	E8 formulates
M_{LTLT}	E7 These

coefficients are expressed in the total reference (nautical angles of rotation of the null reference). Characteristics

3.2 of the mesh The mesh

contains 12 712 quadratic nodes, 8 018 tetrahedrons (TETRA10) and 500 quadratic triangles (TRIA6) to represent the three-dimensions functions of reinforcement. Quantities

3.3 tested and results One

tests vertical displacement at the end of plate, as well as the strain and the stress in the membrane at the end of plate. Standard

Component	identification	of reference Value of reference	Tolerance	DEPL
- POINT_1 DZ	"AUTRE_ASTER	" -87.1	E-6 0.3%	"NON_REGRESSION
		" -87.31232	E-6 1.	E-6 EPSI_NOEU
- POINT_2 EXX	"NON_REGRESSION	" 6.202664	E-6 1.	E-6 SIEF_NOEU
- POINT_2 NXX	"NON_REGRESSION	" 3374.971	1.	E-6 Modelization

4 B Characteristic

4.1 of the modelization One

represents the three-dimensions functions of reinforcement on the sides lower and higher by a model of grid. Characteristics

4.2 of the mesh The mesh

is the same one as that of modelization A. Grandeurs

4.3 tested and results One

tests vertical displacement at the end of plate, as well as the strain and the stress in the grid at the end of plate. Standard

Component	identification	of reference Value of reference	Tolerance	DEPL
- POINT_1 DZ	"AUTRE_ASTER	" -87.1	E-6 4%	"NON_REGRESSION
		" -83.962898	E-6 1.	E-6 EPSI_NOEU
- POINT_2 EPXX	"NON_REGRESSION	" 6.2297586	E-6 1.	E-6 SIEF_NOEU
- POINT_2 SIXX	"NON_REGRESSION	" 1.2459517	E+6 1.	E-6 Summary

5 of the results This

test validates the principle of the representation of the three-dimensions functions of reinforcement by a model of grid or homogenized membrane. This validation rests on a comparison with a model 3D of reference, supplemented by several tests of NON-regression. The model

of homogenized membrane gives excellent results in elastic mode, but he asks the preliminary identification of the coefficients of stiffness of the membrane via elementary computations of homogenization. This makes its use delicate in an industrial context. The model

of grid gives acceptable results although a little less precise. It is on the other hand much simpler to use.