SSNS110 – Extraction of a three-dimensions function of reinforcement represented by a membrane

Summarized:

The purpose of this test is to validate the modelization of the decoherence of a three-dimensions function of reinforcement. This one is represented by a membrane, connected to surrounding volume by a model of interface. One compares this modelization with a modelization of reference in which the steel bars are modelled in 3D.

1 Problem of reference

1.1 Geometry

One considers a reinforced concrete plate, comprising two perpendicular three-dimensions functions of reinforcement in its center. This plate is maintained at an end, and one applies a force to the section of the steel bars at the other end.

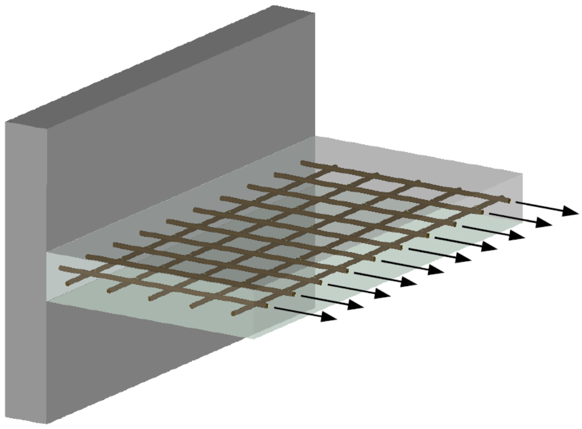


Figure 1: Extraction of a three-dimensions function of reinforcement out of a reinforced concrete plate.

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.

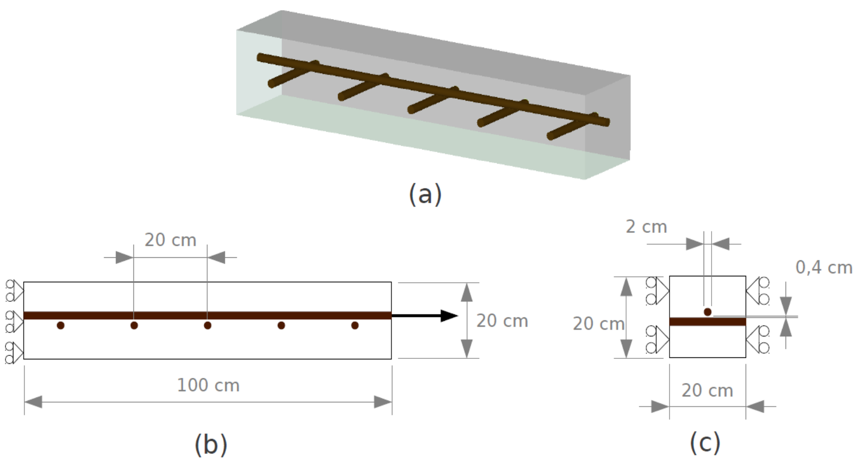
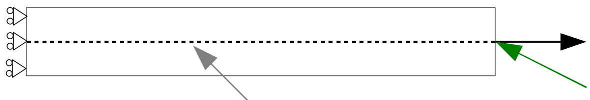


Figure 2: Dimensions of the section of plate modelled. (A) Seen general; (b) seen longitudinal; (c) cut of the modelled section.

One represents the two three-dimensions functions of reinforcement by a model of membrane connected to the volume of concrete by a model of interface. This makes it possible to limit the cost of computation much (see Figure3).



Membrane
BOUTFigur
e

3: Representation of the three-dimensions functions of reinforcement by a 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:

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

the Young modulus of steel is worth $E_A = 200 \text{ GPa}$, spacing between the steel bars $e = 20 \text{ cm}$ and the diameter of the bars $d = 2 \text{ cm}$.

The behavior of steel-concrete connection is of type `CZM_LAB_MIX`, with the following parameters:

Quantity	Value
σ_C	10 MPa
δ_C	1 mm
α	0.7
β	1

1.3 Boundary conditions and loadings

the conditions limits applied to the plate are indicated below, corresponding to the conditions limiting at the end of plate, the conditions of periodicity and the force exerted on reinforcements:

$$\begin{cases} u_Y = 0 \text{ sur A\_FOND et B\_FOND} \\ u_Z = 0 \text{ sur A\_FOND} \\ u_X = 0 \text{ sur A\_GAUC et B\_GAUC} \\ u_X = 0 \text{ sur A\_DROI et B\_DROI} \\ F_Y = -\dfrac{9810. T}{e} \text{ sur BOUT} \end{cases}$$

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 horizontal displacement of the steel measured at the end of plate, for two different levels of loading.

Component	quantity	Time	Reference solution
DEPL – END	DY	5	-140.367141312E-6
		10	-318.457920376E-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 uses a model called “models of grid with decoherence” to represent the three-dimensions function of reinforcement (cf reference 4). The structural mechanics behavior of the three-dimensions function is represented by a model of membrane, whose coefficients are calculated analytically:

$$M_{LLLL}=M_{TTTT}=E_A\frac{\pi d^2}{4e}$$

the other coefficients of stiffness of the membrane are all null. This model of membrane is thus equivalent to two models of grid of orthogonal directional sense.

In addition, this membrane is connected to surrounding volume by a model of interface of the type CZM_LAB_MIX , which authorizes the sliding of the membrane in the direction (Oy) . The parameters of this model of interface are the same ones as those indicated at paragraph 3 , except the critical stress which is written in the form:

$$\sigma_C=\frac{2\pi d}{e}\times 10\ \text{MPa}$$

3.2 Characteristic of the mesh

The mesh comprises 4 505 quadratic nodes, 2 543 tetrahedrons (TETRA10) to model the concrete, 162 quadratic pentahedrons degenerated (PENTA15) to represent the steel-concrete interface, and 162 quadratic triangles (TRIA6) to represent the three-dimensions function of reinforcement.

3.3 Quantities tested and results

One compares the horizontal displacement of the three-dimensions function of reinforcement at the end of plate with two times different with the three-dimensional modelization from reference. One doubles these tests of tests of NON-regression.

Component	identification	Standard	Time of reference	Value of reference	Tolerance
DEPL – END	DY	5	“AUTRE_ASTER”	-140.36714E-6	2 %
		5	“NON_REGRESSION”	-137.99653E-6	1.E-6
		10	“AUTRE_ASTER”	-318.45792E-6	2 %
		10	“NON_REGRESSION”	-314.93105E-6	1.E-6

4 Modelization B

4.1 Characteristic of the modelization

the characteristics of the modelization are the same ones as the model A.

4.2 Caractéristiques of the mesh

The mesh comprises 5 488 quadratic nodes, 868 hexahedrons (HEXA20) to model the concrete, 62 quadratic hexahedrons degenerated (HEXA20) to represent the steel-concrete interface, and 62 quadratic quadrangles (QUAD8) to represent the three-dimensions function of reinforcement.

4.3 Quantities tested and results

One compares the horizontal displacement of the three-dimensions function of reinforcement at the end of plate with two times different with the three-dimensional modelization from reference. One doubles these tests of tests of NON-regression.

Component	identification	Standard	Time of reference	Value of reference	Tolerance
DEPL – END	DY	5	"AUTRE_ASTER"	-140.36714E-6	2 %
		5	"NON_REGRESSION"	-138.00190E-6	1.E-6
		10	"AUTRE_ASTER"	-318.45792E-6	2 %
		10	"NON_REGRESSION"	-314.93776E-6	1.E-6

5 Summary of the results

This test validates the principle of the representation of the three-dimensions functions of reinforcement by a model of membrane connected to surrounding volume by a model of interface. This validation rests on a comparison with a model 3D of reference, supplemented by several tests of NON-regression.