SSNS110 – Extraction of a tablecloth of reinforcement represented by a membrane

Summary:

The objective of this test is to validate the modeling of the decoherence of a tablecloth of reinforcement. This one is represented by a membrane, connected to surrounding volume by a law of interface. One compares this modeling with a modeling 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 tablecloths of reinforcement in her centre. This plate is maintained at an end, and one applies a force to the section of the steel bars at the other end.

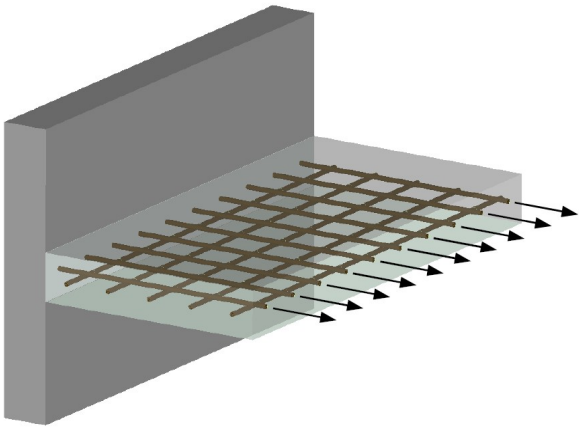

Figure 1: Extraction of a tablecloth of reinforcement out of a reinforced concrete plate.

To limit the cost of calculation, one models only one section of plate, at the edges of which conditions of periodicity are imposed. Dimensions of the plate and the reinforcements are indicated on the Figure 2.

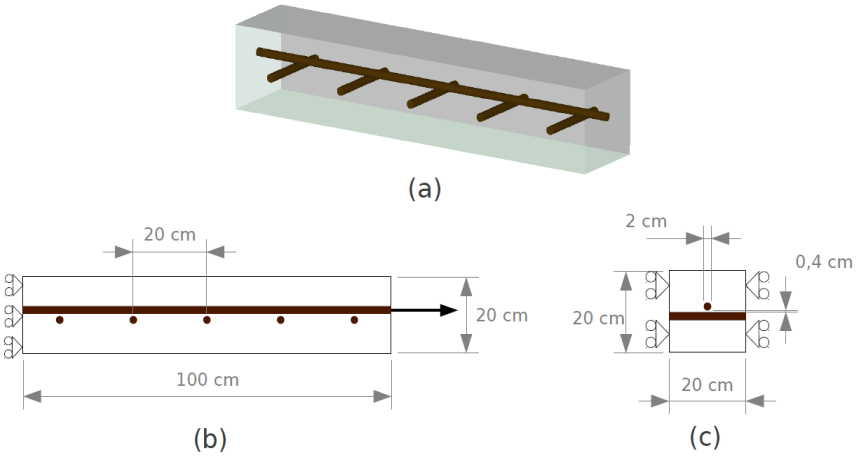

Figure 2: Dimensions of the section of plate modelled. (A) Seen general; (b) seen longitudinal; (c) crosses modelled section.

One represents the two tablecloths of reinforcement by a model of membrane connected to the volume of concrete by a law of interface. This makes it possible to limit the cost of calculation much (see Figure 3).

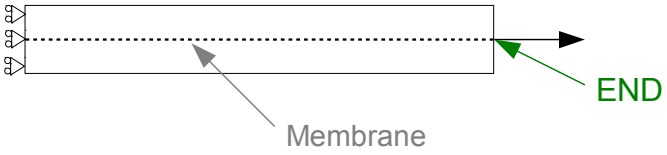

Figure 3: Representation of the tablecloths of reinforcement by a membrane

1.2 Properties of materials

The concrete has an isotropic homogeneous elastic behavior, characterized by Young the modulus and Poisson's ratio 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 enters the steel bars $e = 20 \text{ cm}$ and the diameter of the bars $d = 2 \text{ cm}$.

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

Size	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 the 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 modeling, detailed in the reference [1].

2.2 Sizes 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.

Size	Component	Moment	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 mechanical behavior of the reinforced concrete structures – Application to the containment systems of the nuclear power plants . Doctorate

3 Modeling A

3.1 Characteristics of modeling

One uses a model called “model of grid with decoherence” to represent the tablecloth of reinforcement (cf reference [1]). The mechanical behavior of the tablecloth 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 rigidity of the membrane are all worthless. This model of membrane is thus equivalent to two models of grid of orthogonal orientation.

In addition, this membrane is connected to surrounding volume by a law of interface of the type CZM_LAB_MIX , which authorizes the slip of the membrane in the direction (Oy) . The parameters of this law of interface are the same ones as those indicated at the paragraph 1.2 , except the constraint criticizes which is written in the form:

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

3.2 Characteristics of the grid

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

3.3 Sizes tested and results

One compares the horizontal displacement of the tablecloth of reinforcement at the end of plate with two moments different with three-dimensional modeling from reference. One doubles these tests of tests of not-regression.

Identification	Component	Moment	Type 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 Modeling B

4.1 Characteristics of modeling

The characteristics of modeling are the same ones as model A.

4.2 Characteristics of the grid

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

4.3 Sizes tested and results

One compares the horizontal displacement of the tablecloth of reinforcement at the end of plate with two moments different with three-dimensional modeling from reference. One doubles these tests of tests of not-regression.

Identification	Component	Moment	Type 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 tablecloths of reinforcement by a model of membrane connected to surrounding volume by a law of interface. This validation rests on a comparison with a model 3D of reference, supplemented by several tests of not-regression.