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## SSLS134 - Reinforcement according to the method of Capra and Maury: analytical computation

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### Abstract:

This test relates to the analytical checking of the densities of reinforcement calculated using operator CALC\_FERRAILLAGE.

## 1 Problem of reference

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### 1.1 Geometry

One considers a square plate of with dimensions  $1 m$  and thickness  $0,2 m$  .

### 1.2 Properties of the material

Nothing.

### 1.3 Boundary conditions and loadings

There is no really mechanical computation.

One arranges oneself so that the field of forces in the plate corresponds to the one of the 4 following configurations:

- compression force of  $1\,000\,000 N$  exerted according to the axis  $X$  ,
- tensile force of  $1\,000\,000 N$  exerted along the axis  $X$  ,
- tensile force of  $1\,000\,000 N$  exerted along the axis  $Y$  ,
- bending moment of  $100\,000 Nm$  around the axis  $X$  .

### 1.4 Initial conditions

Nothing

### 1.5 Other parameters of computation

coatings (higher and lower) are fixed at  $4 cm$  .

Computations are carried out at the Ultimate Limiting State (  $ELU$  ) .

The yield stress of the steel of reinforcement is fixed at  $500 MPa$  .

## 2 Reference solution

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### 2.1 Method of calculating

the densities of longitudinal steels are calculated according to the method of Capra and Maury. Taking into account the directions of the forces, the "dimensioning" facet is obvious. The computation analytical thus summarizes itself with a computation of section allowing to determine the forces to which the 2 steel beds are subjected (higher and lower).

### 2.2 Quantities and results of reference

#### 2.2.1 Configuration 1

the plate is subjected to no tension. Reinforcement is thus null in all the directions.

#### 2.2.2 Configuration 2

the plate is subjected to a tractive effort of 1 000 000 N according to the axis X. It is about an entirely tended section in a symmetric way. Each bed of reinforcement thus takes again half of the force is 500 000 N.

The steel section is thus equal to 10 cm<sup>2</sup>/ml.

Theoretical reinforcement along the axis Y is null taking into account the absence of force in this direction.

#### 2.2.3 Configuration the 3

theoretical results are symmetric those of configuration 2.

#### 2.2.4 Configuration 4

the plate is subjected to one next bending moment Y (around the axis X) equal to 100 000 Nm. This bending moment corresponds to a tended top fiber.

The computation is carried out here according to the code of construction of the BAEL.

The reduced ultimate moment  $M_{ub}$  is equal to 0,186012.

The relative position of neutral fiber  $\alpha_u$  is equal to 0,259438.

The reduced lever arm  $\beta_u$  is equal to 0,8962.

The section of reinforcement is thus equal to 13,947 cm<sup>2</sup>/m (higher Y bed).

### 2.3 Uncertainties on the solution

None.

## 3 Modelization A

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### 3.1 Characteristic of the modelization

One uses a modelization DKT.

### 3.2 Characteristics of the mesh

The mesh contains 1 element of type QUAD4.

### 3.3 Quantities tested and results

| Standard | Configuration | Identification of reference | Value of reference | Tolerance |
|----------|---------------|-----------------------------|--------------------|-----------|
| 1        | DNSXI         | "ANALYTIQUE"                | 0                  | 0         |
| 1        | DNSXS         | "ANALYTIQUE"                | 0                  | 0         |
| 1        | DNSYI         | "ANALYTIQUE"                | 0                  | 0         |
| 1        | DNSYS         | "ANALYTIQUE"                | 0                  | 0         |
| 2        | DNSXI         | "ANALYTIQUE"                | 10                 | 0         |
| 2        | DNSXS         | "ANALYTIQUE"                | 10                 | 0         |
| 2        | DNSYI         | "ANALYTIQUE"                | 0                  | 0         |
| 3        | DNSYS         | "ANALYTIQUE"                | 0                  | 0         |
| 3        | DNSXI         | "ANALYTIQUE"                | 0                  | 0         |
| 3        | DNSXS         | "ANALYTIQUE"                | 0                  | 0         |
| 3        | DNSYI         | "ANALYTIQUE"                | 10                 | 0         |
| 3        | DNSYS         | "ANALYTIQUE"                | 10                 | 0         |
| 4        | DNSXI         | "ANALYTIQUE"                | 0                  | 0         |
| 4        | DNSXS         | "ANALYTIQUE"                | 0                  | 0         |
| 4        | DNSYI         | "ANALYTIQUE"                | 0                  | 0         |
| 4        | DNSYS         | "ANALYTIQUE"                | 13,947             | 0.001     |

## 4 Summary of the results

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This test make it possible to highlight the validity of computations of density of reinforcement on simple cases. The results got with the model are indeed in conformity with the given values in an analytical way.