SSLS135 - Reinforcement of a square tank according to the method of Capra and Maury

Summary:

This test relates to the study of the square tank used like example in the descriptive document of the method of Capra and Maury. The goal is to calculate densities of reinforcement longitudinal and transverse for elements Plates or Hull.

Warning: The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

Copyright 2020 EDF R&D - Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)
1 Problem of reference

1.1 Geometry

One considers a square concrete tank of dimensions $L \times l \times h = 10\,m \times 10\,m \times 5\,m$ (of average layer with average layer) and thickness $0.4\,m$.

1.2 Properties of material

Isotropic linear elastic material:

- Young modulus: $E = 3.10^4\,MPa$,
- Poisson's ratio: $\nu = 0.15$,
- Density: $\mu = 2500\,kg/m^3$.

1.3 Boundary conditions and loadings

The density of stiffness of ground applied under the tank is of $50\,kN/m^3$.

The integral of this density on the basis of the tank is thus $510^6\,kN/m$.

This quantity is then distributed on the nodes of the base.

The loading is made up:
- actual weight of the tank
- water drive of the tank filled (constant push on the bottom and gradual on the edges)
- of an overload distributed on contour on the top of the tank ($20\,kN/m$)
2 Reference solution

2.1 Method of calculating

The densities of longitudinal steels are calculated according to the method of Capra and Maury, for the directions $X$ and $Y$ of each element and according to the 2 faces, $I$ (Lower) and $S$ (Higher), defined by their position according to the normal $Z$ elementary. The transverse density of steel is also calculated as described in the article entitled "automatic Calculation of the optimal reinforcement of the plates or reinforced concrete hulls" by Alain CAPRA and Jean-Francis MAURY.

2.2 Results of reference

The various results are published in the article of Capra and Maury in the form of graphs (for a quarter of model only) are:
- deformation of the tank,
- iso-moments $M_{xx}$ and $M_{yy}$,
- densities of reinforcement in the directions $X$ and $Y$ as a superior and an inferior.

Below the extract of the article for the deformation and the moments $M_x$, $M_y$.
Below the extract of the article for the densities of reinforcement. For a better legibility, colors were associated with the various values of density of reinforcement.
### 2.3 Bibliographical references


---

**Warning:** The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

**Copyright 2020 EDF R&D - Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)**
3 Modeling A

3.1 Characteristics of modeling

A modeling is used DKT. Only one quarter of the tank is modelled.

3.2 Characteristics of the grid

The elements are quadrangles. Elements DKT are directed in order to have their outgoing normal.

3.3 Other parameters of calculation

The acceleration of gravity is of $9.81 \text{ m/s}^2$.

The distance between the axis of steels and the surface of an element (coating) is of $0.04 \text{ m}$.

The coefficient of equivalence is of $15.0$.

The acceptable maximum constraint of steel is of $2.8 \times 10^8 \text{ Pa}$.

The acceptable maximum constraint of the concrete is of $3.5 \times 10^7 \text{ Pa}$.

Calculation is carried out with the Absolute limit of Service (ELS).

The pivots are worth respectively $PIVA=1.0 \times 10^3$ and $PIVB=3.5 \times 10^{-3}$.

3.4 Sizes tested and results

The values tested correspond to the maximum of the densities of reinforcement on the various components $DNSXI$, $DNSXS$, $DNSYI$, $DNSYS$

To facilitate the reading, the results were converted into $\text{cm}^2/\text{m}$.

<table>
<thead>
<tr>
<th>Not</th>
<th>density</th>
<th>Type of reference</th>
<th>Value of reference</th>
<th>Computed value</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX</td>
<td>DNSXI</td>
<td>'SOURCE_EXTERNE'</td>
<td>14</td>
<td>14.1</td>
<td>2</td>
</tr>
<tr>
<td>MAX</td>
<td>DNSXS</td>
<td>'SOURCE_EXTERNE'</td>
<td>9</td>
<td>10.4</td>
<td>4</td>
</tr>
<tr>
<td>MAX</td>
<td>DNSYI</td>
<td>'SOURCE_EXTERNE'</td>
<td>7</td>
<td>16.6</td>
<td>10</td>
</tr>
<tr>
<td>MAX</td>
<td>DNSYS</td>
<td>'SOURCE_EXTERNE'</td>
<td>6</td>
<td>10.4</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Not</th>
<th>density</th>
<th>Type of reference</th>
<th>Value of reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>M748</td>
<td>DNSXI</td>
<td>'NON_REGRESSION'</td>
<td>0.00130323479922</td>
</tr>
<tr>
<td>M748</td>
<td>DNSXS</td>
<td>'NON_REGRESSION'</td>
<td>0.0</td>
</tr>
<tr>
<td>M748</td>
<td>DNSYI</td>
<td>'NON_REGRESSION'</td>
<td>4.23403596532-05</td>
</tr>
<tr>
<td>M748</td>
<td>DNSYS</td>
<td>'NON_REGRESSION'</td>
<td>0.0</td>
</tr>
<tr>
<td>Identification</td>
<td>Component</td>
<td>Type of Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------</td>
<td>------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>UT01_ELEM - Maximum</td>
<td>X 1</td>
<td>'NON_REGRESSION'</td>
<td>-</td>
</tr>
<tr>
<td>UT01_ELEM - Minimum</td>
<td>X 1</td>
<td>'NON_REGRESSION'</td>
<td>-</td>
</tr>
<tr>
<td>ferMax - Maximum</td>
<td>X 1</td>
<td>'AUTRE_ASTER'</td>
<td>0.00165857792205</td>
</tr>
<tr>
<td>ferMax - Minimum</td>
<td>X 1</td>
<td>'AUTRE_ASTER'</td>
<td>0.000101286161289</td>
</tr>
</tbody>
</table>
4 Summary of the results

This test makes it possible to highlight the validity of calculations of density of reinforcement with the ELS. The got results are indeed very close to those appearing in the reference document of the authors of the method. The validation is however limited by the absence of precise data of certain parameters used (value of coating, working stress for the concrete, coefficient of equivalence) and small quantity of useable results provided by the publication of origin.