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

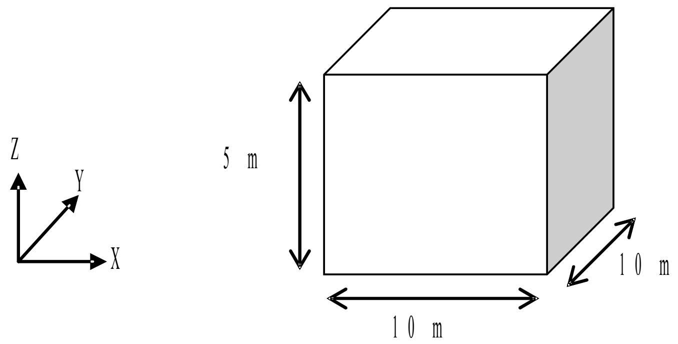
Summarized:

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 Shell.

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 average with average average) and of thickness $0.4\,m$.



1.2 Properties of the isotropic

material 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 soil stiffness applied under the tank is of $50\,kN/m^3$.

The integral of this density on the basis of the tank is thus $5\,10^6\,kN/m$.
This quantity is then distributed on the nodes of the base.

The loading is made up:
- inertia loading of the tank
- of the water drive of the tank filled (constant push on the bottom and gradual on edges)
- with 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 sides, I (Lower) and S (Higher), defined by their position according to the elementary Z norm. The transverse density of steel is also calculated as described in the article entitled “automatic Computation of optimal reinforcement of the plates or reinforced concrete shells” 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:

- deformed shape of the tank,
- Iso-moments Mxx and Myy ,
- densities of reinforcement in the directions X and Y as a superior and an inferior.

Below the extract of the article for the deformed shape and the moments Mx My .

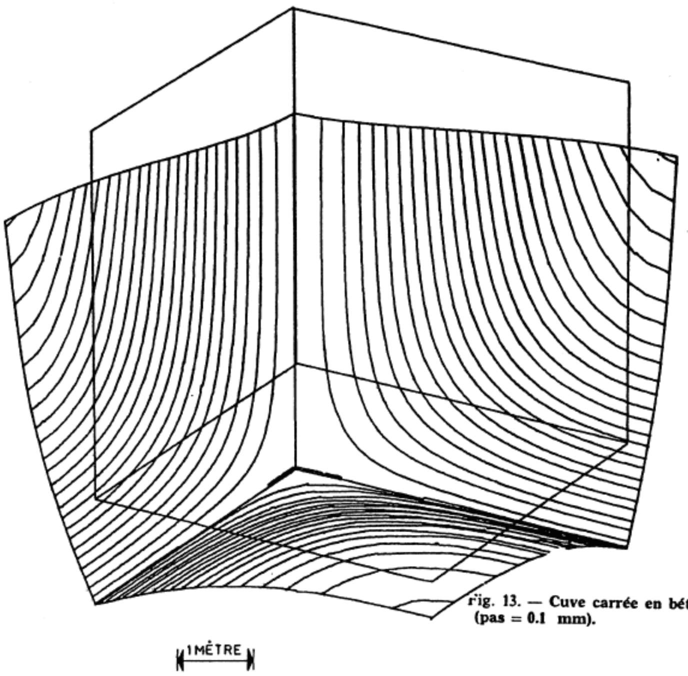


Fig. 13. — Cuve carrée en béton armé. Déformée (pas = 0.1 mm).

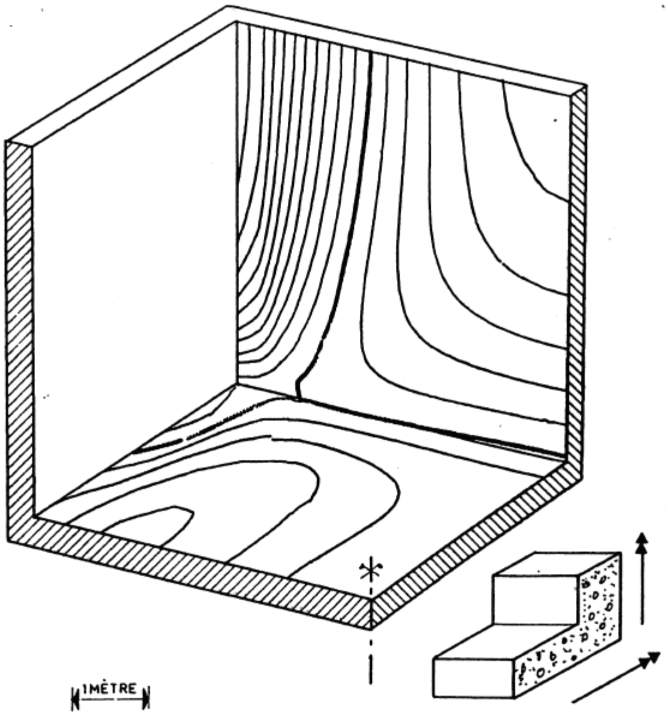


Fig. 14. — Cuve carrée en béton armé. Tracé des iso-moments M_{XX} (pas : 10^4 Nm par mètre).

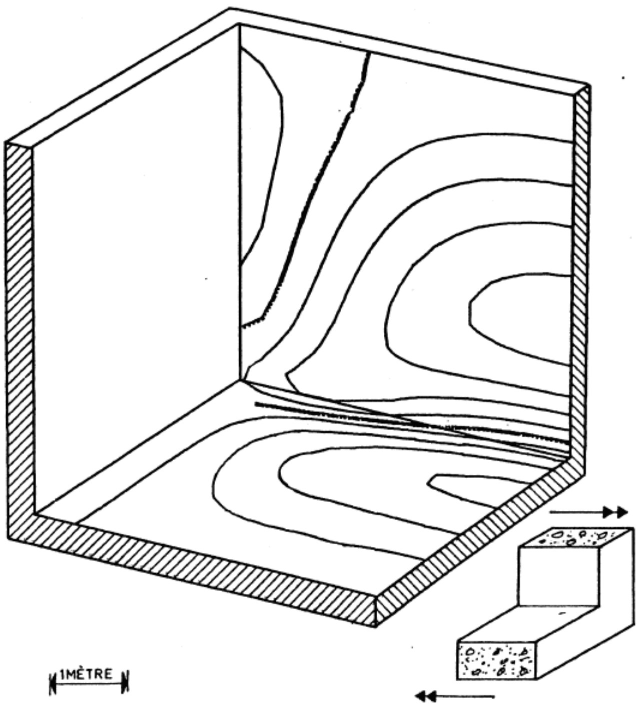


Fig. 15. — Cuve carrée en béton armé. Tracé des iso-moments M_{YY} (pas : 10^4 Nm par mètre).

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.

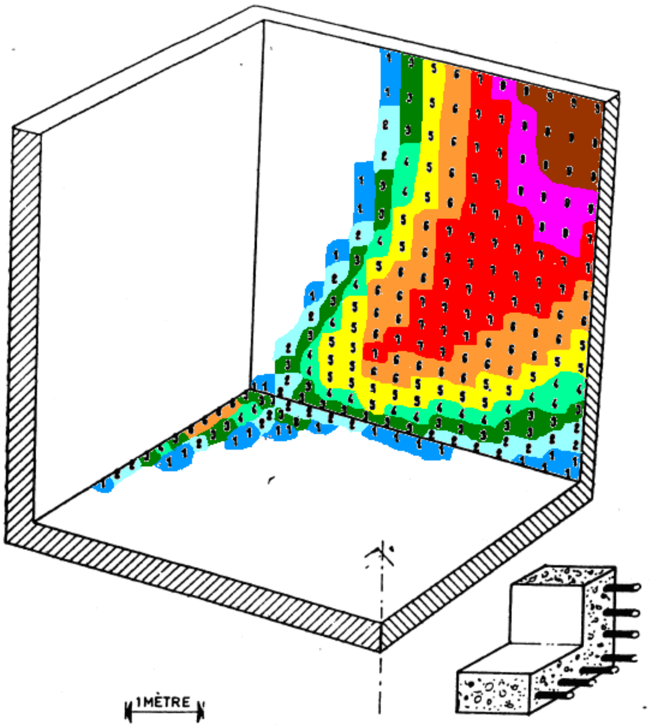


Fig. 16. — Cuve carrée en béton armé. Carte de ferraillage des aciers X extérieurs (en cm² par mètre).

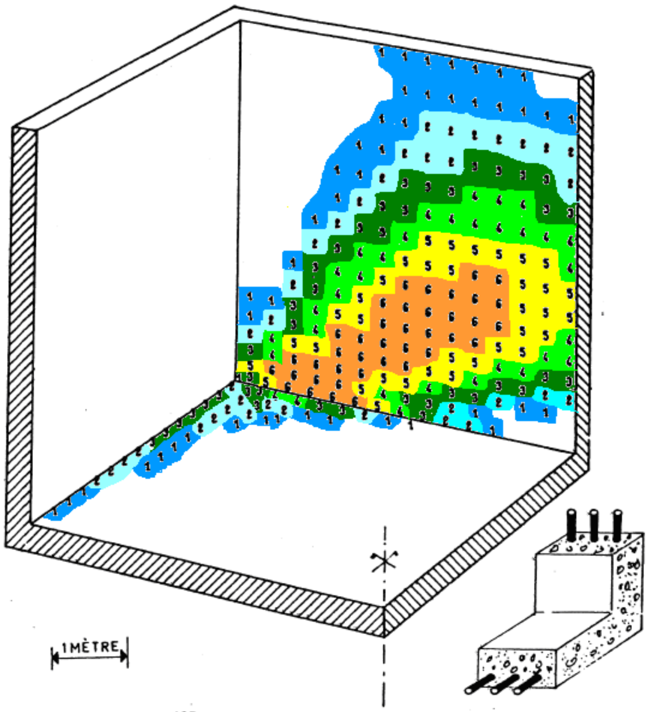


Fig. 17. — Cuve carrée en béton armé. Carte de ferraillage des aciers Y extérieurs (en cm² par mètre).

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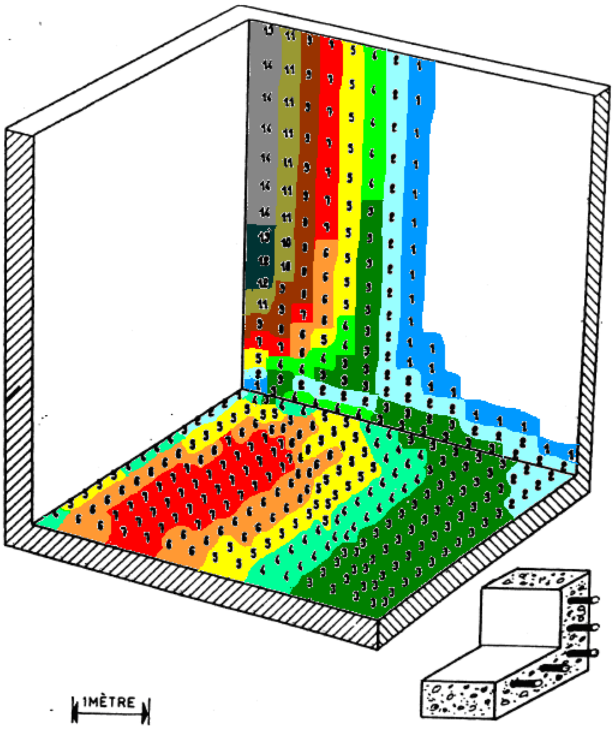

Fig. 18. — Cuve carrée en béton armé. Carte de ferraillage des aciers X intérieurs (en cm² par mètre).

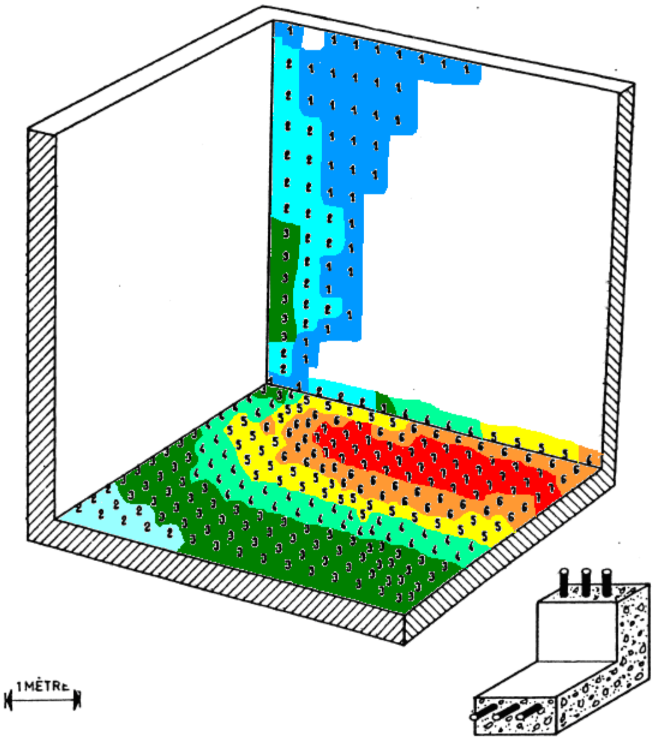

Fig. 19. — Cuve carrée en béton armé. Carte de ferraillage des aciers Y intérieurs (en cm² par mètre).

2.3 Bibliographical references

[1] Yearly of the Technical Institute of the Building industry and Public works N° 367 December 1978 – Series: Computer applications – Article entitled “automatic Computation of the optimal reinforcement of the plates or reinforced concrete shells” by Alain CAPRA and Jean-Francis MAURY.

3 Modelization A

3.1 Characteristic of the modelization

One uses a modelization DKT.

3.2 Characteristics of the mesh

the elements are quadrangles. The length of maximum edge is of 0.5. Elements DKT are directed towards X positive, respectively worms Y positive, respectively worms Z positive for the elements perpendicular to X, respectively with Y and respectively with Z. Moreover, for the elements of the base, horizontal, the elementary axis X is identical to the total axis X. For the other elements, vertical, the elementary axis Y is identical to the total axis Z.

3.3 Other parameters of computation

the acceleration of gravity is of $9.81\,m/s^2$.
The distance between the axis of steels and the surface of an element (coating) is of $0.04\,m$.
The coefficient of equivalence is of 15.0.
The acceptable maximum stress of steel is of $2.3\,10^8\,Pa$.
The acceptable maximum stress of the concrete is of $3.5\,10^7\,Pa$.
The computation is realized with the Absolute limit of Service (ELS).
The pivots are worth respectively $PIVA=1.0\,10^3$ and $PIVB=3.5\,10^{-3}$

3.4 Quantities tested and results

the values tested correspond to a certain number of elements "characteristic" of the model.
To facilitate the reading, the results were converted into cm^2/m and the values observers in the publication of reference were readjusted on the coordinate system used in the model Aster.

The analysis is led on the quarter of the tank presented in the publication (quarter of the model). 10 items were discussed:

Base tank
- BC : center
- BSO : south-west
- BSE : south-east
- BNO : the North-West
- BNE : the North-East

Veil "is" tank
- VC : center
- VBN : low north
- VBS : low-south
- VHN : high-north
- VHS : standard

high-south	Not	density of reference	Value of reference (in cm^2/m)
BC	DNSXI	"EXTERNAL"	0
BC	"	EXTERNAL" DNSXS	6
BC	"	EXTERNAL" DNSYI	0
BC	"	EXTERNAL" DNSYS	5
"	EXTERNAL	" BSO DNSXI	0
"	EXTERNAL	" BSO DNSXS	3
"	EXTERNAL	" BSO DNSYI	0
"	EXTERNAL	" BSO DNSYS	3
"	EXTERNAL	" BSE DNSXI	0
"	EXTERNAL	" BSE DNSXS	6
"	EXTERNAL	" BSE DNSYI	1
"	EXTERNAL	" BSE DNSYS	2
"	EXTERNAL	" BNO DNSXI	1
"	EXTERNAL	" BNO DNSXS	2
"	EXTERNAL	" BNO DNSYI	0
"	EXTERNAL	" BNO DNSYS	4
"	EXTERNAL	" BNE DNSXI	3
"	EXTERNAL	" BNE DNSXS	1
"	EXTERNAL	" BNE DNSYI	2
"	EXTERNAL	" BNE DNSYS	2
VC	"	EXTERNAL" DNSXI	1
VC	"	EXTERNAL" DNSXS	6
VC	"	EXTERNAL" DNSYI	0
VC	"	EXTERNAL" DNSYS	4
"	EXTERNAL	" VBN DNSXI	2
"	EXTERNAL	" VBN DNSXS	1
"	EXTERNAL	" VBN DNSYI	2
"	EXTERNAL	" VBN DNSYS	3
"	EXTERNAL	" VBS DNSXI	1
"	EXTERNAL	" VBS DNSXS	1
"	EXTERNAL	" VBS DNSYI	0
"	EXTERNAL	" VBS DNSYS	0
"	EXTERNAL	" VHN DNSXI	15
"	EXTERNAL	" VHN DNSXS	0
"	EXTERNAL	" VHN DNSYI	1
"	EXTERNAL	" VHN DNSYS	0
"	EXTERNAL	" VHS DNSXI	0
"	EXTERNAL	" VHS DNSXS	9
"	EXTERNAL	" VHS DNSYI	0
"	EXTERNAL	" VHS DNSYS	0

4 Summary of the results

This test makes it possible to highlight the validity of computations of density of reinforcement. 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 for example) and the small quantity of results exploitable provided by the publication of origin.