

## SDNS108 – Dynamic response of a reinforced concrete flagstone supported on 4 with dimensions subjected to a concentrated loading

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### Summary:

This test represents the calculation of a reinforced concrete flagstone, in inflection, subjected to a concentrated loading. It makes it possible to validate modeling Q4GG (thick hull) using model total material GLRC\_DAMAGE by comparing it with a similar calculation with code EUROPLEXUS. The flagstone is simply supported on the four with dimensions ones.

Two modelings are carried out:

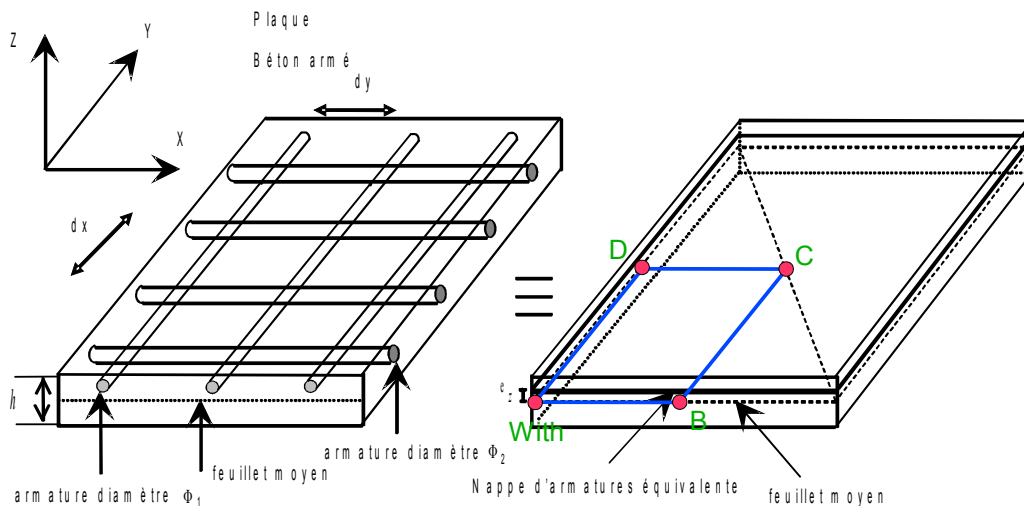
- 1) Modeling A makes it possible to test the model Q4GG with QUAD4,
- 2) Modeling B makes it possible to test the model Q4GG with TRIA3,
- 3) Modeling C allows to test the model Q4GG with a criterion of plasticity defined by the user .

## 1 Problem of reference

### 1.1 Geometry

Square flagstone, length  $l=1.8\text{ m}$ , thickness  $h=0.12\text{ m}$ , in simple support on the four edges. The reinforcement of inflection is parallel to the edges; it is identical on each of the two faces and in each of the two directions ( $dx$ ,  $dy$  being spacings of irons in the directions  $x$  and  $y$ ). The coating of the longitudinal irons closest to the faces is of  $22\text{ mm}$ . The coating of irons compared to the side edges of the flagstone of  $2\text{ cm}$  is neglected. The table hereafter recapitulates the data of reinforcement. Geometrical percentage of steel  $\mu$  is given for a face in a direction.

Diameter of the reinforcements	Spacing	Section steel/section of the concrete	distance roasts/average surface of the flagstone
$\Phi=0,01\text{ m}$	$dx=dy=0,1\text{ m}$	$\mu=0,65$	$e_s=\pm 0,038\text{ m}$



One notes  $a_x = \frac{A_x}{d_x}$  and  $a_y = \frac{A_y}{d_y}$  rates of reinforcement (here:  $a_x = a_y = 7,854 \cdot 10^{-4}$ ),  $A_x$  ( $A_y$ ) being the surface of the section of an iron bar in the direction  $x$  ( $y$ );  $e_s$  is the distance from the tablecloths on the average surface.

For reasons of symmetry one models a quarter ( $ABCD$ ) flagstone.

### 1.2 Material properties

The mechanical properties of steels are the following ones:

Young modulus $E_a$	Poisson's ratio	Yield stress with 0.2% $\sigma_y$	Slope of work hardening
210000 MPa	0.3	500 MPa	0. MPa

Those of the concrete are the following ones:

Young modulus $E_b$	Poisson's ratio	Resistance in compression $\sigma_c$	Resistance in traction $\sigma_t$
35700 MPa	0.22	52,5 MPa	4,4 MPa



For modeling C, one enters manually the moments limit plastic :

MP1X = 1200 Nm/m  
MP1Y = 1200 Nm/m  
MP2X = -1200 Nm/m  
MP2Y = -1200 Nm/m

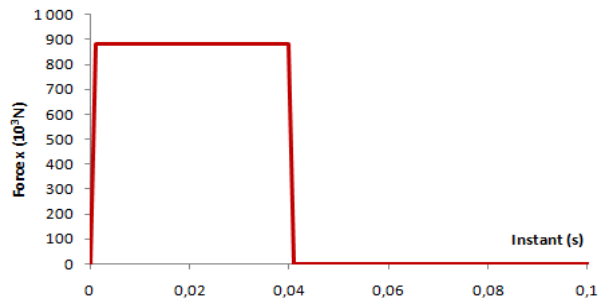
## 1.3 Boundary conditions and loadings

The boundary conditions are the following ones:

- Simply supported on with dimensions ones  $AD$  and  $BC$  :  $DZ=0$
- Symmetry on with dimensions ones
  - $BC$  :  $DX=DRY=0$
  - $CD$  :  $DY=DRX=0$

The evolution of the loading, applied to the center of the plate, is presented below.

Moment (S)	$Fz(N)$
0.0	0.0
0,001	8.8E5
0,040	8.8E5
0,041	0.0
1.0	0.0



## 1.4 Initial conditions

The plate is initially at rest in a virgin state.

## 2 Reference solution

### 2.1 Method of calculating used for the reference solution

The results of reference were got with Europlexus.

The grids used by Europlexus and Code\_Aster are the same ones.

### 2.2 Results of reference

The results of reference correspond to following displacement  $Z$  point  $C$  located at the center of the plate. The appointed moment corresponds to the moment when the displacement obtained with Europlexus is maximum. For modelings A and B, the values obtained by Europlexus are:

Moment ( $s$ )	Size	Localization	Europlexus	
			Element	Displacement ( $m$ )
0,0093436	Following displacement $Z$	Center of the plate	Q4GS	-0.04890906 m
0,0091250	Following displacement $Z$	Center of the plate	T3GS	-0.04574386 m

For modeling C, one has

Moment ( $s$ )	Size	Localization	Europlexus	
			Element	Displacement ( $m$ )
0,0096593	Following displacement $Z$	Center of the plate	Q4GS	-0.05870762 m

### 2.3 Uncertainty on the solution

Digital solution.

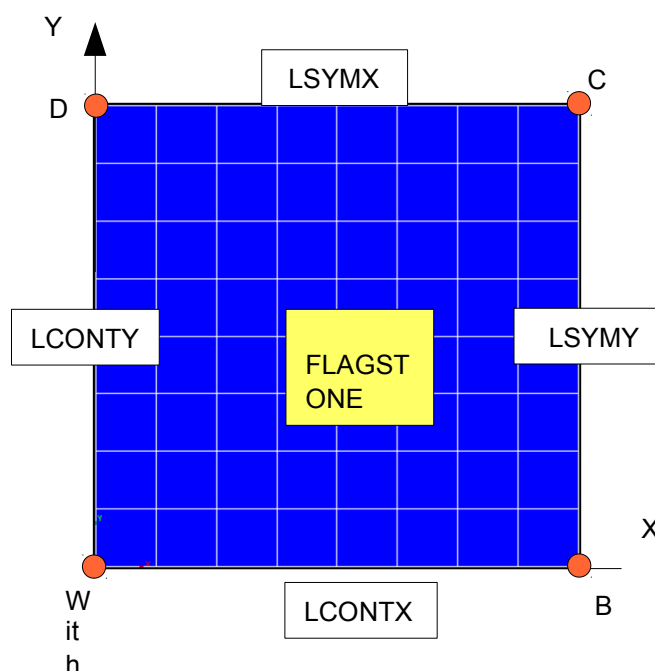
### 2.4 Bibliographical references

- [1] [R3.07.09]: "Element of thick plate T3G"
- [2] [U2.02.01]: " Note of use of the voluminal elements plates, hulls and hulls SHB "

## 3 Modeling A

### 3.1 Characteristics of modeling

Modeling Q4GG



### 3.2 Characteristics of the grid

Many nodes: 81  
Number of meshes and type: 64 QUAD4

### 3.3 Sizes tested and results

Moment (S)	SIZE	COMPONENT	GROUP_NO	Type of Reference	Reference	Tolerance (%)
0,0093436	DEPL	DZ	Point_C	'SOURCE_EXTERNE'	-0.04890906 m	5.0

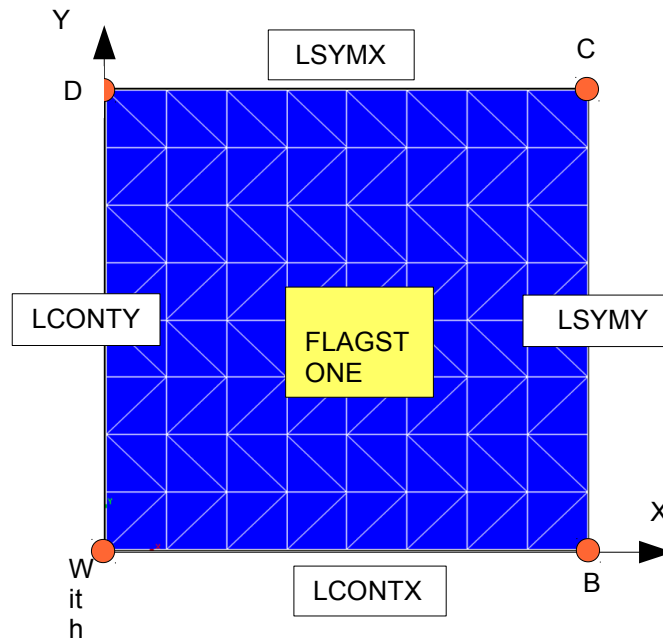
### 3.4 Remarks

Calculations were carried out with a diagram of temporal integration explicit of centered differences type finished.

## 4 Modeling B

### 4.1 Characteristics of modeling

Modeling Q4GG



### 4.2 Characteristics of the grid

Many nodes: 91

Number of meshes and type: 128 TRIA3

### 4.3 Sizes tested and results

Moment (S)	SIZE	COMPONENT	GROUP_NO	Type of Reference	Reference	Tolerance (%)
0,0091250	DEPL	DZ	Point_C	'SOURCE_EXTERNE'	-0.04574386 m	1.5

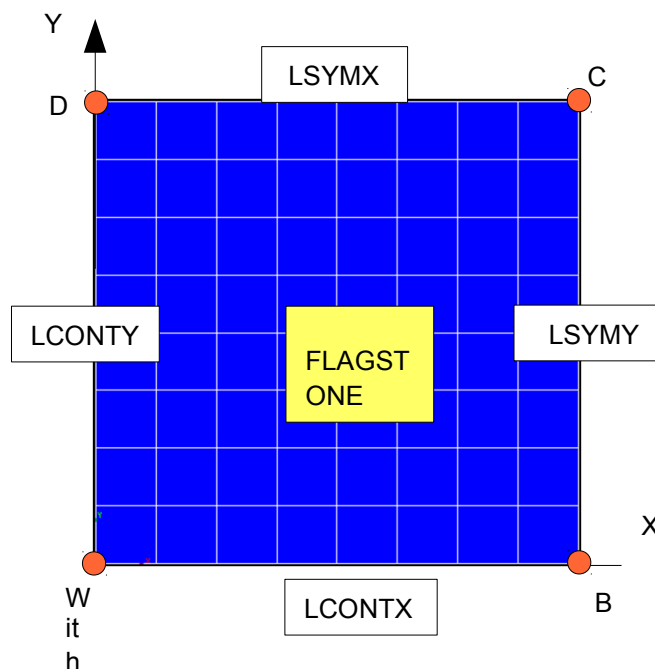
### 4.4 Remarks

Calculations were carried out with a diagram of temporal integration explicit of centered differences type finished.

## 5 Modeling C

### 5.1 Characteristics of modeling

Modeling Q4GG



### 5.2 Characteristics of the grid

Many nodes: 81  
Number of meshes and type: 64 QUAD4

### 5.3 Sizes tested and results

Moment (S)	SIZE	COMPONENT	GROUP_NO	Type of Reference	Reference	Tolerance (%)
0,0096593	DEPL	DZ	Point_C	'SOURCE_EXTERNE'	-0.05870762 m	20.0

### 5.4 Remarks

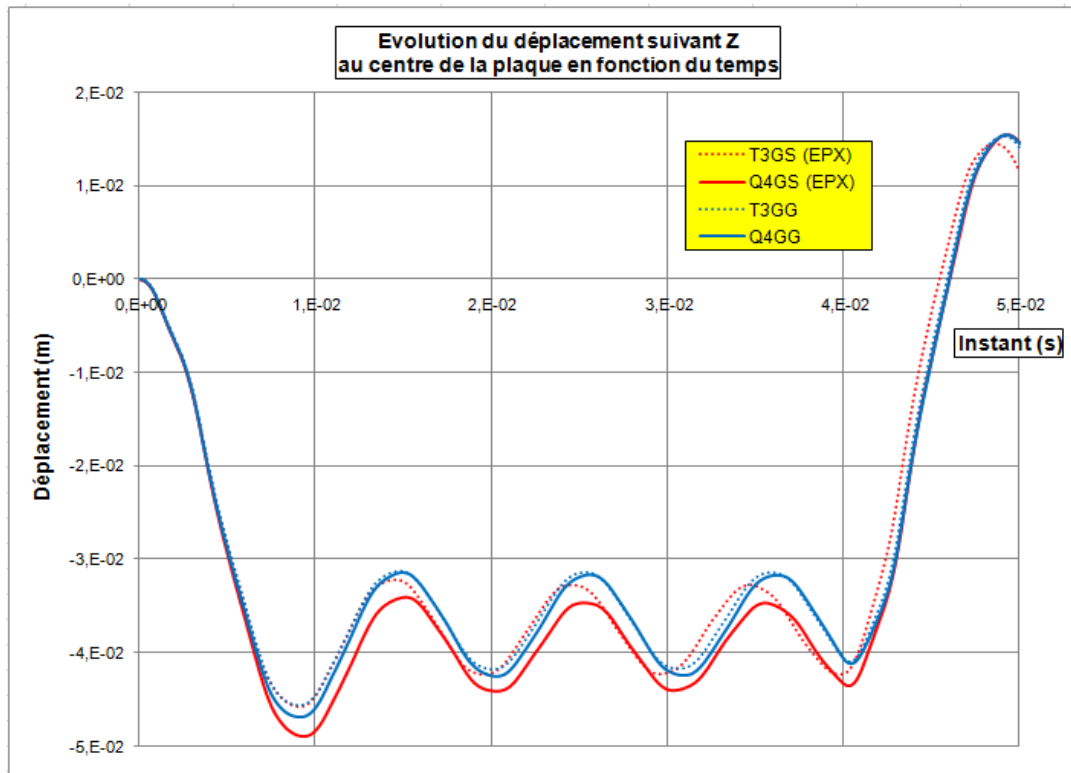
Calculations were carried out with a diagram of temporal integration explicit of centered differences type finished.



## 6 Summary of the results

The got results are satisfactory for modelings A and B.

On the figure below, we traced the evolution of displacement in the center of the plate according to time. This answer is compared with that obtained with Europlexus (EPX).



Got results for modeling C show an important variation on the amplitudes between the results got with Europlexus and Code\_Aster. The limit use of manually defined plastic moments must be made with precaution.