

## SDNS106 – Transitory answer of a reinforced concrete flagstone: models GLRC\_DAMAGE and GLRC\_DM

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### Summary:

This test validates the total models GLRC\_DAMAGE [R7.01.31] and GLRC\_DM [R7.01.32] applied to dynamics clarifies (DYNA\_NON\_LINE (SCHEMA\_TEMPS=DIFF\_CENT)). It is about a trapezoidal reinforced concrete plate, pressed on two opposite sides and requested in inflection by a pressure.

## 1 Problem of reference

### 1.1 Geometry

The geometry used in this case test is a concrete plate reinforced thickness  $e=0.1\text{ m}$  and of trapezoidal form.

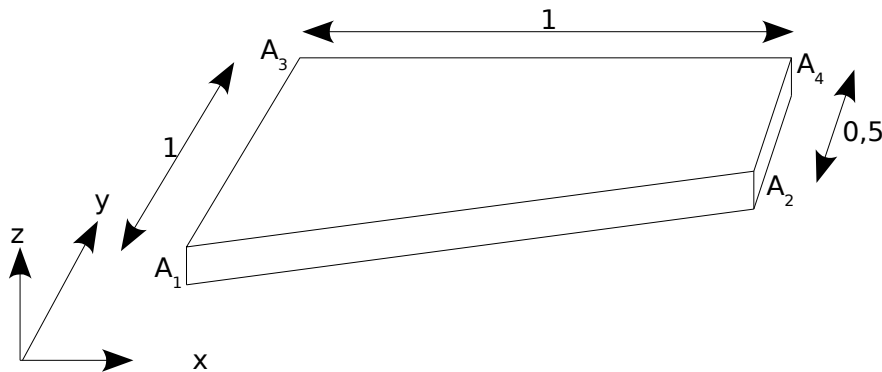


Figure 1.1-a: Studied geometry

The characteristics of the concrete section reinforced are:

- Higher tablecloth: section per following linear meter  $x$  and  $y = 5.65 \cdot 10^{-4} \text{ m}^2/\text{ml}$  ; offsetting compared to the following average layer  $x$  and  $y : +0.0475 \text{ m}$  (either 95% thickness),
- Lower tablecloth: section per following linear meter  $x$  and  $y = 5.65 \cdot 10^{-4} \text{ m}^2/\text{ml}$  ; offsetting compared to the following average layer  $x$  and  $y : -0.0475 \text{ m}$  (either 95% thickness),
- Cables of prestressed: section per following linear meter  $x=4.56 \cdot 10^{-3} \text{ m}^2/\text{ml}$  and  $y=1.32 \cdot 10^{-2} \text{ m}^2/\text{ml}$  ; no offsetting compared to the average layer; prestressed according to  $x$  and  $y = -3 \text{ MN}$ ,
- Liner: the thickness of the liner is of  $6 \text{ mm}$  and is positioned on the lower face.

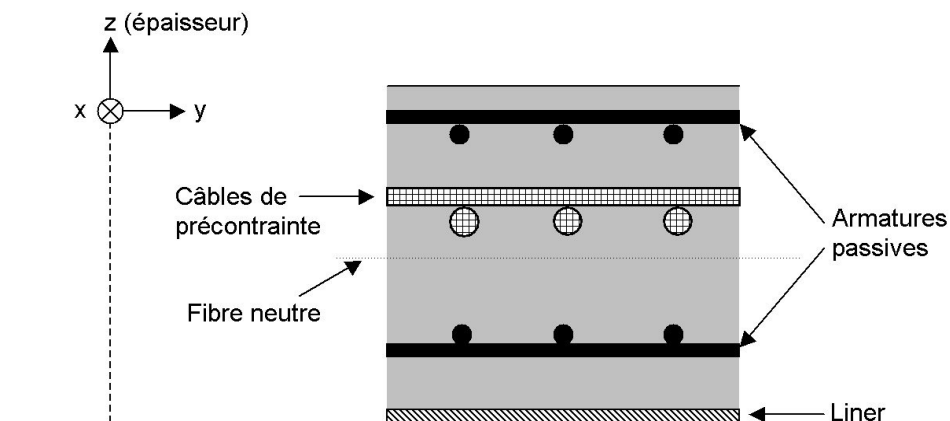


Figure 1.1-b: Section of the reinforced concrete plate

## 1.2 Properties of materials

Characteristics of various materials for modeling `GLRC_DAMAGE` are summarized in the table which follows.

Material	Young modulus <i>MPa</i>	Poisson's ratio	Density <i>kg/m<sup>3</sup></i>	Slope of work hardening	Yield stress in traction <i>MPa</i>	Yield stress in compression <i>MPa</i>
Concrete	30000.	0.2	2500	0	5	-35
Steel of the reinforcements	200000	-	-	0	3000	-3000
Steel of the liner and the cables of prestressing	200000	-	-	0	500	-500

To supplement the law of behavior `GLRC_DAMAGE`, it is necessary to define the globalized parameters of homogenized law.

Parameters	Values
<i>Gamma</i>	0
<i>QP1</i>	0.15
<i>QP2</i>	0.15
<i>C<sub>N</sub></i>	87.3 <i>MPa</i>
<i>C<sub>M</sub></i>	14.8 <i>MPa</i>

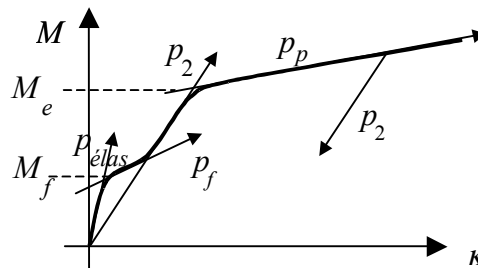


Figure 1.2-a: Curve moment – curve of the behavior of a reinforced concrete plate in inflection.

Characteristic materials for modeling `GLRC_DM` are summarized in the table which follows.

Parameters	Values
<i>E<sub>ég</sub><sup>m</sup></i>	30000 <i>MPa</i>
<i>v<sub>m</sub></i>	0.22
<i>E<sub>ég</sub><sup>f</sup></i>	73000 <i>MPa</i>
<i>v<sub>f</sub></i>	0.24
<i>γ<sub>mt</sub></i>	0.02
<i>γ<sub>f</sub></i>	0.05
<i>N<sub>D</sub></i>	470000 <i>N/m</i>
<i>M<sub>D</sub></i>	16000 <i>N</i>

## 1.3 Boundary conditions and loadings

On the corner  $AI$  plate, one embeds displacements  $u_x=u_y=u_z=0$ , as well as rotations  $\theta_x=\theta_y=\theta_z=0$ . Displacements are blocked according to  $x$  and  $z$  on the sides  $AIA3$  and  $A2A4$ . A pressure is applied to the whole of the flagstone in the direction  $(0.0,0.0,1,0)$  and is worth  $F_0=20.10^7 N$  for modeling A. For modelings B and C, one applies a nodal force to the whole of the flagstone  $1500 N$ . This force is applied in a progressive way while following the multiplying function represented to the figure which follows.

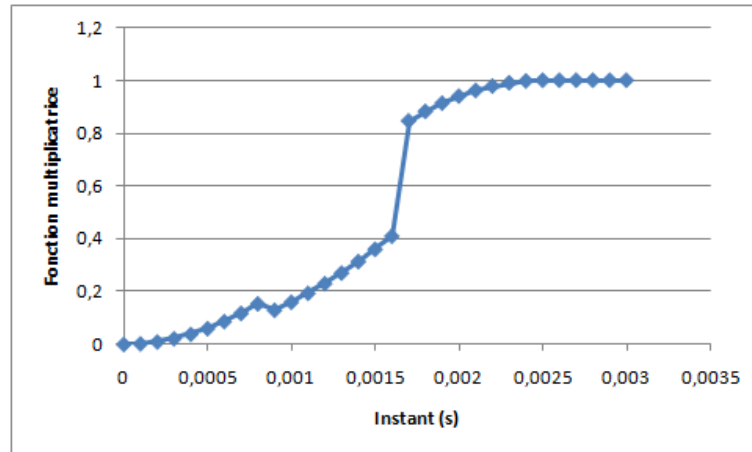


Figure 1.3-a: Multiplying function of the loading for modelings B and C

## 1.4 Initial conditions

WITH the initial state, displacements and speeds are worth zero everywhere.

## 2 Reference solution

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### 2.1 Method of calculating

The values of reference are obtained by comparison with EUROPLEXUS for modeling A. For modelings B and C, the values of reference are nonregression.

### 2.2 Sizes and results of reference

The results of reference for modeling A are recapitulated in the table which follows. The data are obtained at the point  $P_{04}$  (cf appears 3.1-a).

Sizes	Reference
Following displacement $z$ with $t=2 \cdot 10^{-5} s$	$-1,74913 \cdot 10^{-4} m$
Acceleration according to $z$ with $t=2 \cdot 10^{-5} s$	$-7,99968 \cdot 10^5 m.s^{-2}$
Following displacement $z$ with $t=1 \cdot 10^{-3} s$	$-4,4933 \cdot 10^{-1} m$
Speed according to $z$ with $t=1 \cdot 10^{-3} s$	$-8,24761 \cdot 10^2 m.s^{-1}$
Elastic energy with node 2 of mesh 1 with $t=2 \cdot 10^{-6} s$	$1,46067 \cdot 10^{-1} J$

### 2.3 Uncertainties on the solution

Comparisons with EUROPLEXUS for the temporal answers in displacement, reactions, and kinetic energy, for a sinusoidal loading

## 3 Modeling A

### 3.1 Characteristics of modeling

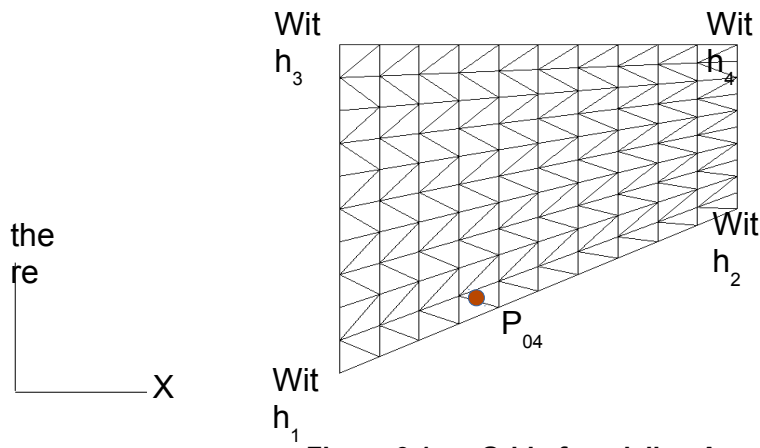


Figure 3.1-a : Grid of modeling A

Modeling: **DKTG**

Boundary conditions:

- Embedding in  $AI$ ,
- Simple support  $A3A1$  and  $A2A4$ , that is to say  $DZ=0$  and  $DX=0$ .

Temporal integration:

- Diagram: **DIFF\_CENT**, formulation: **ACCELERATION**,
- Pas de time:  $2 \cdot 10^{-6} s$ .

### 3.2 Characteristics of the grid

Many nodes: 121, Many meshes: elements **TRI3** : 200, elements **SEG2** : 40.

### 3.3 Sizes tested and results

One tests displacements, speed and acceleration of the point  $P04$  at various moments. One tests also elastic energy in two points of the structure.

Identification	Type of reference	Value of reference	Tolerance
Following displacement $z$ with $t=2 \cdot 10^{-5} s$	\SOURCE_EXTERNE`	$-1,74913 \cdot 10^{-4} m$	0,15
Acceleration according to $z$ with $t=2 \cdot 10^{-5} s$	\SOURCE_EXTERNE`	$-7,99968 \cdot 10^5 m.s^{-2}$	$10^{-4}$
Following displacement $z$ with $t=1 \cdot 10^{-3} s$	\SOURCE_EXTERNE`	$-4,4933 \cdot 10^{-1} m$	0,03
Speed according to $z$ with $t=1 \cdot 10^{-3} s$	\SOURCE_EXTERNE`	$-8,24761 \cdot 10^2 m.s^{-1}$	0,1
Elastic energy with node 2 of mesh 1 with $t=2 \cdot 10^{-6} s$	\SOURCE_EXTERNE`	$1,46067 \cdot 10^{-1} J$	$10^{-5}$

## 4 Modeling B

### 4.1 Characteristics of modeling

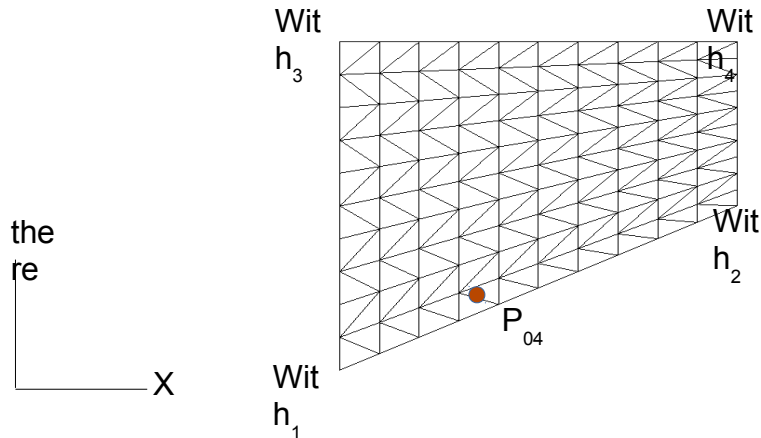


Figure 4.1-a : Grid of modeling A

Modeling: DKTG

Boundary conditions:

- Embedding in  $A1$ ,
- Simple support  $A3A1$  and  $A2A4$ , that is to say  $DZ=0$  and  $DX=0$ .

Temporal integration:

- Diagram: NEWMARK, formulation: DISPLACEMENT,
- Pas de time:  $1.10^{-4} s$ .

### 4.2 Characteristics of the grid

Many nodes: 121, Many meshes: elements QUAD4 : 100, elements SEG2 : 40.

### 4.3 Sizes tested and results

One tests displacements, speed and acceleration of the point  $P04$  at various moments.

Identification	Type of reference	Value of reference	Tolerance
Following displacement $z$ with $t=2.5 \cdot 10^{-3} s$	NOT REGRESSION	$-4.09238 \cdot 10^{-4} m$	$10^{-5}$
Speed according to $z$ with $t=2.5 \cdot 10^{-3} s$	NOT REGRESSION	$-0.4984907 m.s^{-1}$	$10^{-5}$
Acceleration according to $z$ with $t=2.5 \cdot 10^{-3} s$	NOT REGRESSION	$-56,1819 m.s^{-2}$	$10^{-5}$
Following displacement $z$ with $t=5 \cdot 10^{-3} s$	NOT REGRESSION	$-1.89876 \cdot 10^{-4} m$	$10^{-5}$
Speed according to $z$ with $t=5 \cdot 10^{-3} s$	NOT REGRESSION	$0.3652467 m.s^{-1}$	$10^{-5}$
Acceleration according to $z$ with $t=5 \cdot 10^{-3} s$	NOT REGRESSION	$-797.416 m.s^{-2}$	$10^{-5}$

## 5 Modeling C

### 5.1 Characteristics of modeling

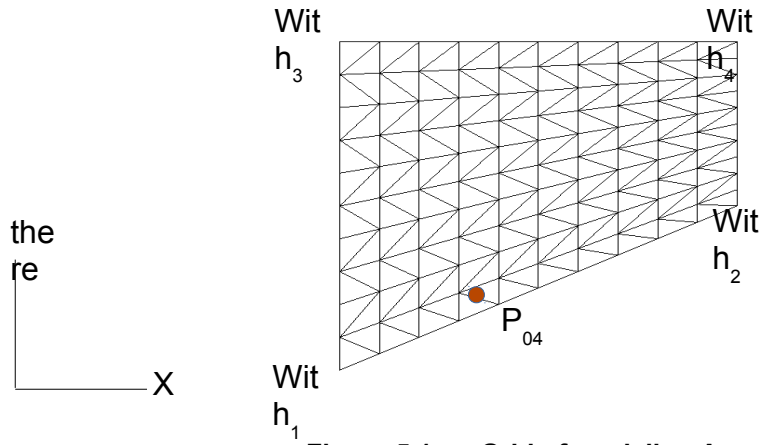


Figure 5.1-a : Grid of modeling A

Modeling: **DKTG**

Boundary conditions:

- Embedding in *A1*,
- Simple support *A3A1* and *A2A4*, that is to say  $DZ=0$  and  $DX=0$ .

Temporal integration:

- Diagram: **NEWMARK**, formulation: **DISPLACEMENT**,
- Pas de time:  $1.10^{-4}s$ .

### 5.2 Characteristics of the grid

Many nodes: 121, Many meshes: elements **TRI3** : 200, elements **SEG2** : 40.

### 5.3 Sizes tested and results

One tests displacements, speed and acceleration of the point *P04* at various moments. One tests also elastic energy in two points of the structure.

Identification	Type of reference	Value of reference	Tolerance
Following displacement $z$ with $t=2.5 \cdot 10^{-3}s$	NOT REGRESSION	$-3.71031 \cdot 10^{-4}m$	$10^{-5}$
Speed according to $z$ with $t=2.5 \cdot 10^{-3}s$	NOT REGRESSION	$-0.4496707 m.s^{-1}$	$10^{-5}$
Acceleration according to $z$ with $t=2.5 \cdot 10^{-3}s$	NOT REGRESSION	$-61,3004 m.s^{-2}$	$10^{-5}$
Following displacement $z$ with $t=5 \cdot 10^{-3}s$	NOT REGRESSION	$-1.56827 \cdot 10^{-4}m$	$10^{-5}$
Speed according to $z$ with $t=5 \cdot 10^{-3}s$	NOT REGRESSION	$-0.4552156 m.s^{-1}$	$10^{-5}$
Acceleration according to $z$ with $t=5 \cdot 10^{-3}s$	NOT REGRESSION	$73.0819 m.s^{-2}$	$10^{-5}$



## 6 Summary of the results

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Got results with *Code\_Aster* are close to those obtained with EUROPLEXUS. This modeling thus validates the utilisation of `GLRC_DAMAGE` with *Code\_Aster*.