SDNS106 – Transient response of a reinforced concrete slab: models GLRC_DAMAGE and GLRC_DM

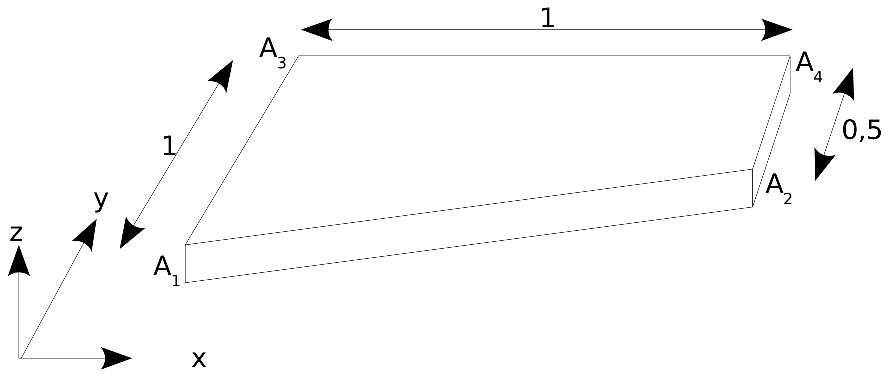
Summarized:

This test validates total models GLRC_DAMAGE [R7.01.31] and GLRC_DM [R7,01.32] applied to the explicit dynamics (DYNA_NON_LINE (SCHEMA_TEMPS=DIFF_CENT)). It is about a reinforced concrete plate trapezoidal, leaned on two opposite sides and requested in bending by a pressure.

1 Problem of reference

1.1 Geometry

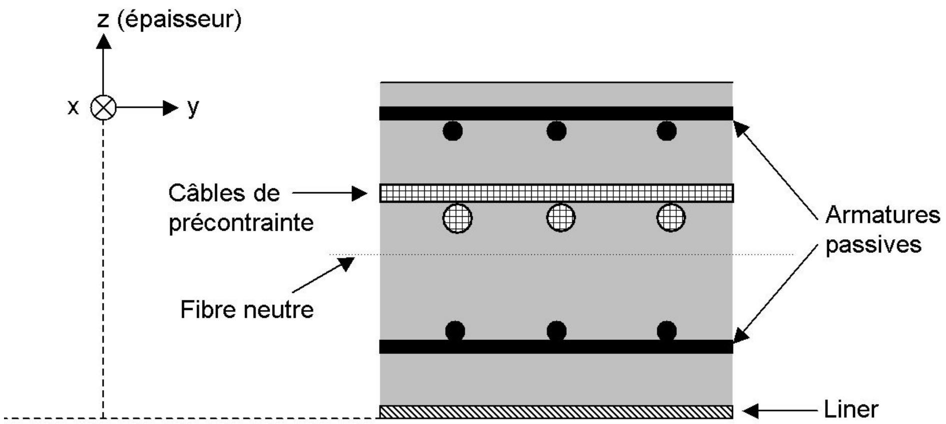
the geometry used in this case test is a concrete plate reinforced with thickness $e=0.1\,\mathrm{m}$ and trapezoidal form.



Appear 1.1-a: Studied geometry

the characteristics of the concrete section reinforced are:

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



Appear 1.1-b: Section of the reinforced concrete Properties plate

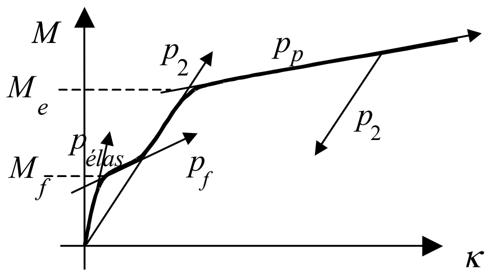
1.2 of the materials

the characteristics of the various materials for modelization GLRC_DAMAGE are summarized in the table which follows.

Material	Modulus Young MPa	Poisson's ratio	Density kg/m^3	Slope of hardening	Yield stress in tension MPa	Yield stress in compression MPa
Concrete	30000.	0.2	2500	0	5.-35	
Steel of reinforcements	200000	-	-	0	3000	-3000
Steel of the liner and the cables of prestressing	200000	-	-	0.500		-500

to supplement constitutive law GLRC_DAMAGE, it is necessary to define the globalized parameters of homogenized model.

Parameters	Values
$Gamma$	0
$QP1$	0.15
$QP2$	0.15
C_N	$87.3\,MPa$
C_M	$14.8\,MPa$



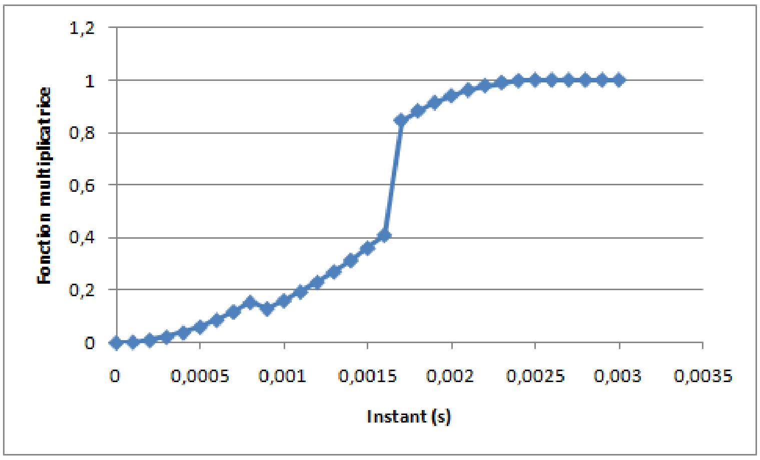
Appears 1.2-a: Curve moment – curvature of the behavior of a reinforced concrete plate in bending.

The characteristic materials for modelization GLRC_DM are summarized in the table which follows.

Parameters	Values
$E^m_{éq}$	$30000\,MPa$
ν_m	0.22
$E^f_{éq}$	$73000\,MPa$
ν_f	0.24
γ_{mt}	0.02
γ_f	0.05
N_D	$470000\,N/m$
M_D	$16000\,N$

1.3 Boundary conditions and loadings

On the corner $A1$ of the 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 $A1A3$ and $A2A4$. A pressure is applied to the group of slab in the direction $(0.0,0.0,1,0)$ and applies $F_0 = 20.10^7 N$ to modelization A. For the modelizations B and C, one applies a nodal force to the group of slab $1500 N$. This force is applied in a progressive way while following the multiplying function represented to the figure which follows.



Appear 1.3-a: Multiplying function of the loading for the modelizations B and C

1.4 Initial conditions

IN an initial state, displacements and the velocities are worth zero everywhere.

2 Reference solution

2.1 Méthode de calcul

the values of reference are obtained by comparisons with EUROPLEXUS for modelization A. For the modelizations B and C, the values of reference are the non regression ones.

2.2 Quantities and results of reference

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

Quantities	Reference
Displacement following z to $t=2\,10^{-5}s$	$-1{,}74913\,10^{-4}m$
Acceleration following z to $t=2\,10^{-5}s$	$-7{,}99968\,10^{5}\,m.s^{-2}$
following Displacement z at $t=1\,10^{-3}s$	$-4{,}4933\,10^{-1}\,m$
Velocity following z to $t=1\,10^{-3}s$	$-8{,}24761\,10^{2}\,m.s^{-1}$
Elastic strain energy to the node 2 of the mesh 1 to $t=2\,10^{-6}s$	$1{,}46067\,10^{-1}J$

2.3 Uncertainties on the solution

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

3 Modelization A

3.1 Characteristic of the modelization

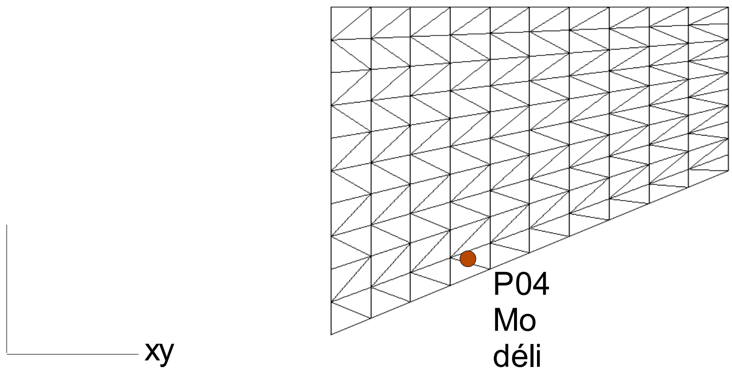


Figure 3.1-a : Mesh of the modelization A

: **DKTG**

Boundary conditions:

Fixed support in $A1$,
simple Bearing $A3A1$ and $A2A4$, are $DZ=0$ and $DX=0$.

Temporal integration:

Diagram: `DIFF_CENT`, formulation: `ACCELERATION`,
Time step: $2.10^{-6} s$.

3.2 Characteristics of the mesh

Many nodes: 121, Number of meshes: elements `TRI3` : 200, elements `SEG2` : 40.

3.3 Quantities tested and results

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

Standard	identification of reference	Value of reference	Tolerance
Displacement following z with $t=2\,10^{-5} s$	"AUTRE_ASTER"	$-1{,}74913\,10^{-4} m$	0,15
Acceleration following z with $t=2\,10^{-5} s$	"AUTRE_ASTER"	$-7{,}99968\,10^{5} m.s^{-2}$	10^{-4}
following Displacement z with $t=1\,10^{-3} s$	"AUTRE_ASTER"	$-4{,}4933\,10^{-1} m$	0,03
Velocity following z with $t=1\,10^{-3} s$	"AUTRE_ASTER"	$-8{,}24761\,10^{2} m.s^{-1}$	0,1
formulates Elastic strain energy with the node 2 1 with $t=2\,10^{-6} s$	"AUTRE_ASTER"	$1{,}46067\,10^{-1} J$	10^{-5}

4 Modelization B

4.1 Characteristic of the modelization

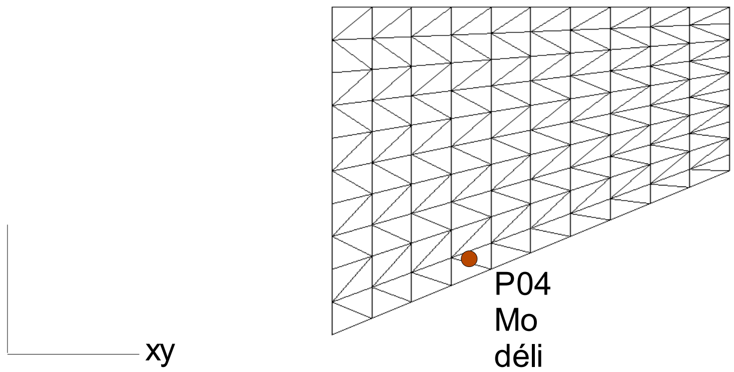


Figure 4.1-a : Mesh of the modelization A

: **DKTG**

Boundary conditions:

Fixed support in $A1$,
simple Bearing $A3A1$ and $A2A4$, that is to say $DZ=0$ and $DX=0$.

Temporal integration:

Diagram: `NEWMARK`, formulation: `DEPLACEMENT`,
Time step: $1.10^{-4}s$.

4.2 Characteristics of the mesh

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

4.3 Quantities tested and results

One tests displacements, velocity and acceleration of the point $P04$ at various times.

Standard	identification of reference	Value of reference	Tolerance
Displacement following z at $t=2.5\,10^{-3}s$	`Non regression`	$-4.09238\,10^{-4}m$	10^{-5}
Velocity according to z to $t=2.5\,10^{-3}s$	`formula`	$-0.4984907\,m.s^{-1}$	10^{-5}
Acceleration according to z with $t=2.5\,10^{-3}s$	`formula`	$-56,1819\,m.s^{-2}$	10^{-5}
following Displacement z with $t=5\,10^{-3}s$	`formula`	$-1.89876\,10^{-4}m$	10^{-5}
Velocity according to z with $t=5\,10^{-3}s$	`formula`	$0.3652467\,m.s^{-1}$	10^{-5}
formulates Acceleration z formula $t=5\,10^{-3}s$	`Non regression`	$-797.416\,m.s^{-2}$	10^{-5}

5 formula Modelization

5.1 Characteristic of the modelization

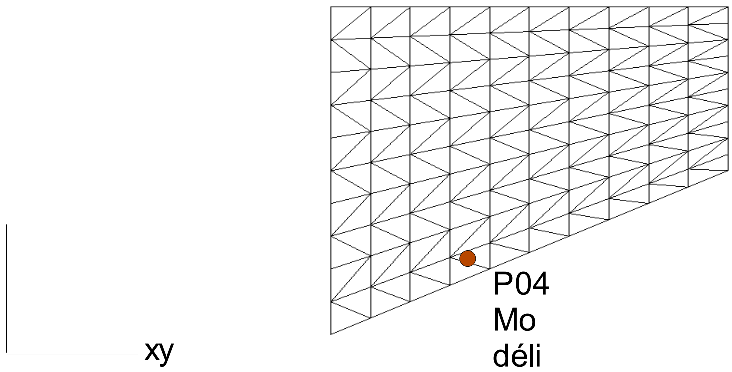


Figure 5.1-a : Mesh of the modelization A

: **DKTG**

Boundary conditions:

Fixed support in $A1$,
simple Bearing $A3A1$ and $A2A4$, that is to say $DZ=0$ and $DX=0$.

Temporal integration:

Diagram: `NEWMARK`, formulation: `DEPLACEMENT`,
`Time step:` $1.10^{-4}s$.

5.2 Characteristics of the mesh

Many nodes: 121, Number of meshes: elements `TRI3` : 200, elements `SEG2` : 40.

5.3 Quantities tested and results

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

Standard	identification of reference	Value of reference	Tolerance
following Displacement z with $t=2.5\,10^{-3}s$	`formula`	$-3.71031\,10^{-4}m$	10^{-5}
Velocity according to z with $t=2.5\,10^{-3}s$	`formula`	$-0.4496707\,m.s^{-1}$	10^{-5}
Acceleration according to z with $t=2.5\,10^{-3}s$	`formula`	$-61,3004\,m.s^{-2}$	10^{-5}
following Displacement z with $t=5\,10^{-3}s$	`formula`	$-1.56827\,10^{-4}m$	10^{-5}
Velocity according to z with $t=5\,10^{-3}s$	`formula`	$-0.4552156\,m.s^{-1}$	10^{-5}
Acceleration according to z with $t=5\,10^{-3}s$	`formula`	$73.0819\,m.s^{-2}$	10^{-5}

6 Summary of the results

the results got with *Code_Aster* are close to those obtained with EUROPLEXUS. This modelization thus validates the use of GLRC_DAMAGE with *Code_Aster*.