SDNS106 – Transitory answer of a reinforced concrete flagstone: models GLRC_DAMAGE and GLRC_DM

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 $e=0.1\,\mathrm{m}$ and of trapezoidal form.

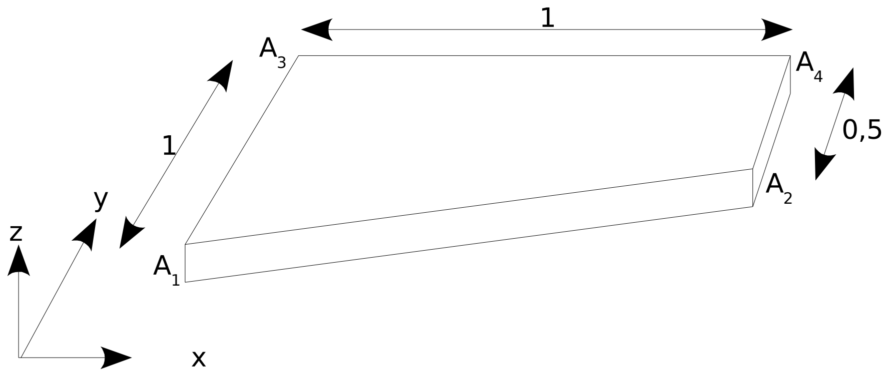

Figure 1.1-a: Studied geometry

The characteristics of the concrete section reinforced are:

- Higher tablecloth: section per following linear meter x and y $=5.65\,10^{-4}\,m^2/ml$; offsetting compared to the following average layer x and y : $+0.0475\,m$ (either 95% thickness),
- Lower tablecloth: section per following linear meter x and y $=5.65\,10^{-4}\,m^2/ml$; offsetting compared to the following average layer x and y : $-0.0475\,m$ (either 95% 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 offsetting compared to the average layer; 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.

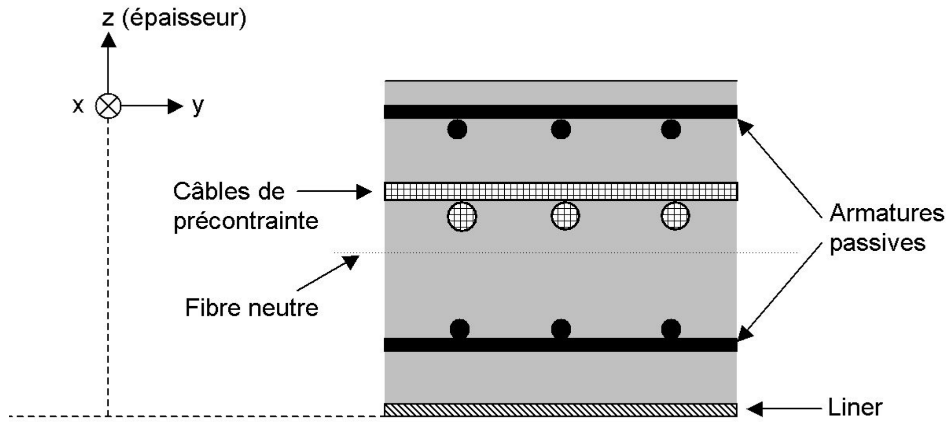

Figure 1.1-b: Section of the reinforced concrete plate

1.2 Properties of materials

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

Material	Young modulus MPa	Poisson's ratio	Density kg/m^3	Slope of work hardening	Yield stress in traction MPa	Yield stress in compression MPa
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
$Gamma$	0
$QP1$	0.15
$QP2$	0.15
C_N	$87.3\,MPa$
C_M	$14.8\,MPa$

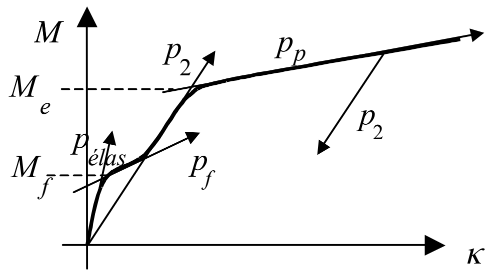

Figure 1.2-a: Curve moment – curve of the behavior of a reinforced concrete plate in inflection.

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

Parameters	Values
$E^m_{éq}$	$30000\,MPa$
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 $A1$ 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 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.

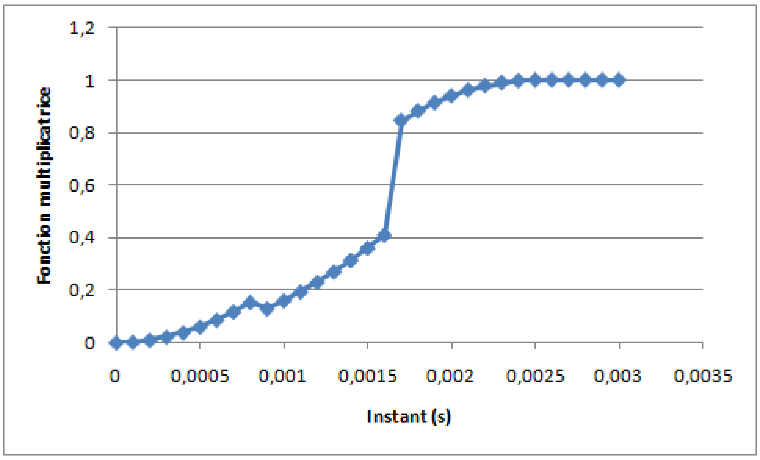

Figure 1.3-a: Multiplying function of the loading for modelings B and C

1.4 Initial conditions

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

2 Reference solution

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

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

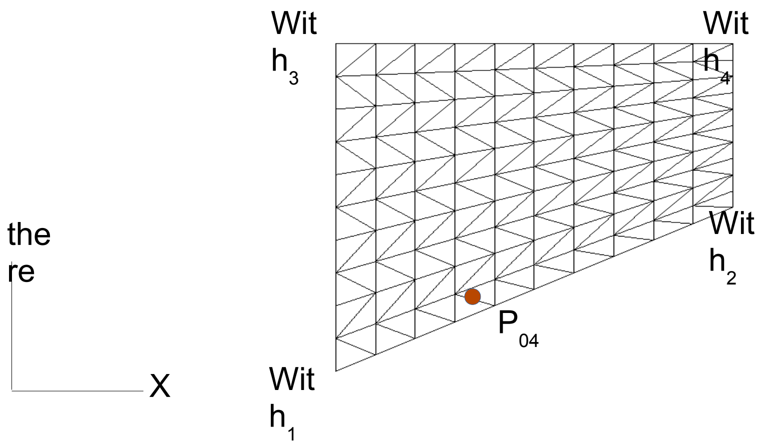

Figure 3.1-a : Grid of modeling A

Modeling: **DKTG**

Boundary conditions:

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

Temporal integration:

- Diagram: `DIFF_CENT`, formulation: `ACCELERATION`,
- Pas de time: $2.10^{-6}s$.

3.2 Characteristics of the grid

Many nodes: 121, Many meshs: 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 $t=2\,10^{-5}s$	'SOURCE_EXTERNE'	$-1,74913\,10^{-4}m$	$0,15$
Acceleration according to z with $t=2\,10^{-5}s$	'SOURCE_EXTERNE'	$-7,99968\,10^{5}m.s^{-2}$	10^{-4}
Following displacement z with $t=1\,10^{-3}s$	'SOURCE_EXTERNE'	$-4,4933\,10^{-1}m$	$0,03$
Speed according to z with $t=1\,10^{-3}s$	'SOURCE_EXTERNE'	$-8,24761\,10^{2}m.s^{-1}$	$0,1$
Elastic energy with node 2 of mesh 1 with $t=2\,10^{-6}s$	'SOURCE_EXTERNE'	$1,46067\,10^{-1}J$	10^{-5}

4 Modeling B

4.1 Characteristics of modeling

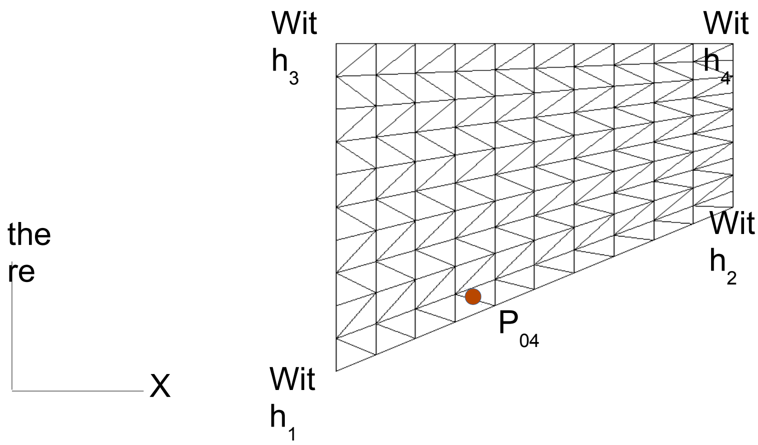

Figure 4.1-a : Grid of modeling A

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

5 Modeling C

5.1 Characteristics of modeling

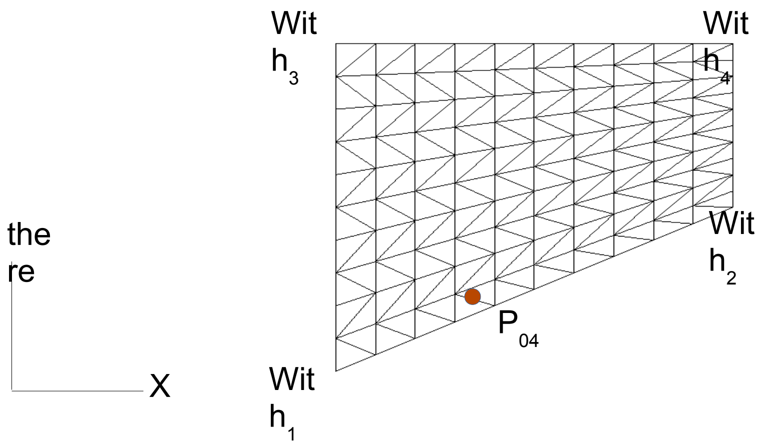

Figure 5.1-a : Grid of modeling A

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

6 Summary of the results

Got results with *Code_Aster* are close to those obtained with EUROPLEXUS. This modeling thus validates the utilisatione of GLRC_DAMAGE with *Code_Aster*.