M
annual of Validation
V6.03 booklet: Nonlinear statics of the systems plans
Document: V6.03.113
Division

School
Thickness
1) $(\Delta\varepsilon_{xx}, \Delta\varepsilon_{yy}, \Delta\varepsilon_{xy}) = (1, -\nu, 0)$
2) $(\Delta\varepsilon_{xx}, \Delta\varepsilon_{yy}, \Delta\varepsilon_{xy}) = (1, 1.5, 1)$
$\varepsilon_{xx} = 0.0015$

- xx
- ε
- OX
- yy
- ε
- OY
- ε_{xy}
- OY

P4
P8
P3
P7
P2
P6
Dy = 2.

School
2D

Bibliographical references

Element

Features tested

The law of behavior MAZARS local version in 3D.

1.1 3.3

1.2

Results of modeling A

Element

1.3 4.3

1.4

Features tested

The law of behavior of Mazars in delocalized.

2 Results of modeling B

0.05%
0.002%

SSNP113 - Rotation of the principal constraints (law of MAZARS)

Summary:

This case test of mechanics is inspired by work of Willam [bib1] and was used in benchmark EDFR & D "Model three-dimensional of non-linear behaviors of the material concrete in cracking" [bib2] to evaluate the models of behavior dedicated to the concrete. It is characterized by a specific way of loading which creates a continuous rotation of the principal constraints. It is used here to test the establishment of the model of Mazars in its local version (modeling 3D) and in its delocalized version (modeling 3D_GRAD_EPSI). The validation is carried out by comparison with the results got with code CASTEM2000 with the LGCNSN (School Power station of Nantes).

3 Problem of reference

3.1 Geometry and boundary conditions

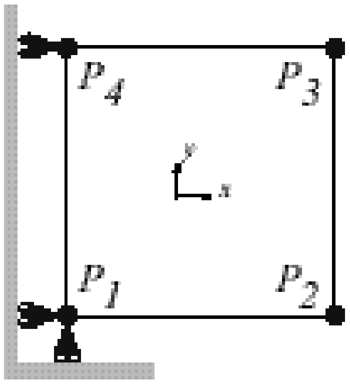

Figure 1.1-a: Geometry and boundary conditions

Length of the edges:	$a=0.56\,m$
Thickness :	$0.1\,m$

The loading is such as one obtains a homogeneous state of plane forced constraint and type even if modeling in Code_Aster was carried out in `3D`. The loading is imposed in the form of displacements imposed in two stages:

3) direction $(\Delta\varepsilon_{xx},\Delta\varepsilon_{yy},\Delta\varepsilon_{xy})=(1,-\nu,0)$ until the maximum constraint (initiation of the lenitive phase)
4) direction $(\Delta\varepsilon_{xx},\Delta\varepsilon_{yy},\Delta\varepsilon_{xy})=(1,1.5,1)$ until $\varepsilon_{xx}=0.0015$

9) ε_{xx}: displacement on the side delimited by the side P_2 - P_3 in the direction OX
10) ε_{yy}: displacement on the side delimited by the side P_3 - P_4 in the direction OY
11) ε_{xy} : displacement on the side delimited by the side P_2 - P_3 in the direction OY

That is to say $P5P6P7P8$ the plan of the cube in $z=0.1$.
Practically, the following conditions are imposed

- during all the loading: $P1P4P8P5: dx=0$
  $P1 : dy=dz=0$
  $P5 : dy=0$
- during phase 1: $P2, P6: dy=0$
  $P2P3P7P6: dx=1$
  $P3P4P8P7: dy=-0.2$
- during phase 2: $P2P3P7P6: dx=1$
  $P4, P8: dy=1.5$
  $P3, P7: dy=3.5$
  $P2, P6: dy=2.$

3.2 Properties of material

For the model of Mazars, the following parameters were used:

Elastic behavior:

$$E=32\,000\,MPa\,,\nu=0.2$$

Damaging behavior:

$$\varepsilon_{d0}=9.375.10^{-4};\ Ac=1.15\ ;\ At=0.8\ ;\ Bc=1391.3\ ;\ Bt=10\ 000\ ;\ k=0.7$$

4 Reference solution

It is about a comparison code-code. The reference used is the code Castem2000 (version 2001). The results were got by the LGCNSN (School Power station of Nantes) with the same parameters materials and the same discretization in time. Contrary to the calculation carried out with *Code_Aster*, Castem calculation was carried out in $2D$ under the assumption of plane constraints.

The delocalized version of the model of Mazars was tested with a worthless characteristic length in order to check that one finds the same results as with the local version.

2.1 Bibliographical references

1) Willam K., Pramono E. and Sture S. - Fundamental exits of smeared ace models, Proc. of the Int. Conf. one fractures and concrete and rock'n'roll, Huston Texas, 1987, pp 17-19

2) CR-99-232, concrete tests Evaluation one models of non-linear behaviour of cracking using three dimensional modelling, Benchmark EDF/Division R & D – S. Ghavamian

5 Modeling A

5.1 Characteristics of modeling

Modeling `3D`
Element `MECA_HEXA8`

5.2 Characteristics of the grid

Many nodes: 8
Number of meshs and type: 1 `HEXA8`

5.3 Sizes tested and results

One compared to 3 pas de different times (at the end of stage 1, during the phase of growth of the damage and at the end of the loading) strains, stresses as well as the value of the damage.

Identification		Reference	*Aster*	% difference
N°10	ε_{xx}	$9{,}375\ 10^{-5}$	$9{,}375\ 10^{-5}$	$5.8\ 10^{-14}$
	σ_{xx}	$3.00\ 10^{6}$	$3.00\ 10^{6}$	$4.7\ 10^{-14}$
	ε_{yy}	$-1{,}875\ 10^{-5}$	$-1{,}875\ 10^{-5}$	$9.0\ 10^{-14}$
	σ_{yy}	0.	$-2.83\ 10^{-10}$	$-2.83\ 10^{-10}$
	ε_{xy}	0.	0.	-
	σ_{xy}	0.	0.	-
	D	0.	$2.22\ 10^{-16}$	$2.22\ 10^{-16}$

Identification		Reference	*Aster*	% difference
N°25	ε_{xx}	$1.64\ 10^{-4}$	$1.64\ 10^{-4}$	0,065
	σ_{xx}	$2.04\ 10^{6}$	$2.04\ 10^{6}$	-0,048
	ε_{yy}	$8.67\ 10^{-5}$	$8.68\ 10^{-5}$	0,099
	σ_{yy}	$1.35\ 10^{6}$	$1.3 5\ 10^{6}$	-0,016
	ε_{xy}	$7.03\ 10^{-5}$	$7.04\ 10^{-5}$	0,081
	σ_{xy}	$6.34\ 10^{5}$	$6. 33\ 10^{5}$	-0,016
	D	0.66211	0.66238	0,040

Identification		Reference	Aster	% difference
N°310	ε_{xx}	$1.50\ 10^{-3}$	$1.50\ 10^{-3}$	0.06
	σ_{xx}	$3.69\ 10^{5}$	$3.69\ 10^{5}$	-0,002
	ε_{yy}	$2.09\ 10^{-3}$	$2.09\ 10^{-3}$	0,064
	σ_{yy}	$4.59\ 10^{5}$	$4. 59\ 10^{5}$	$5.22\ 10^{-4}$
	ε_{xy}	$1.41\ 10^{-3}$	$1.41\ 10^{-3}$	0,063
	σ_{xy}	$2.16\ 10^{5}$	$2. 16\ 10^{5}$	$6.85\ 10^{-4}$
	D	0.99423	0.99424	$8.07\ 10^{-4}$

6 Modeling B

6.1 Characteristics of modeling

The use of the delocalized version of the model of Mazars passes by the use of modeling `3D_GRAD_EPSI` and the use of quadratic elements implies.
The test is carried out with a worthless characteristic length.

Modeling: `3D_GRAD_EPSI`
Element : `MGCA_HEXA20`

6.2 Characteristics of the grid

Many nodes: 20
Number of meshs and type: 1 `HEXA20`

6.3 Sizes tested and results

One compared to 3 pas de different times (at the end of stage 1, during the phase of growth of the damage and at the end of the loading) strains, stresses as well as the value of the damage.

Identification		Reference	*Aster*	% difference
N°10	ε_{xx}	$9{,}375\ 10^{-5}$	$9{,}375\ 10^{-5}$	$2.02\ 10^{-13}$
	σ_{xx}	$3.00\ 10^{6}$	$3.00\ 10^{6}$	$-2.33\ 10^{-13}$
	ε_{yy}	$-1{,}875\ 10^{-5}$	$-1{,}875\ 10^{-5}$	$5.42\ 10^{-14}$
	σ_{yy}	0.	$5.98\ 10^{-10}$	$5.98\ 10^{-10}$
	ε_{xy}	0.	$6.88\ 10^{-21}$	$6.88\ 10^{-21}$
	σ_{xy}	0.	0.	-
	D	0.	$3.88\ 10^{-15}$	$3.88\ 10^{-15}$

Identification		Reference	*Aster*	% difference
N°25	ε_{xx}	$1.64\ 10^{-4}$	$1.64\ 10^{-4}$	0,038
	σ_{xx}	$2.04\ 10^{6}$	$2.04\ 10^{6}$	$-1.89\ 10^{-4}$
	ε_{yy}	$8.67\ 10^{-5}$	$8.67\ 10^{-5}$	0,022
	σ_{yy}	$1.35\ 10^{6}$	$1.3\,5\ 10^{6}$	$-3.39\ 10^{-4}$
	ε_{xy}	$7.03\ 10^{-5}$	$7.03\ 10^{-5}$	0,018
	σ_{xy}	$6.34\ 10^{5}$	$6.34\ 10^{5}$	$1.4\ 10^{-5}$
	D	0.66211	0.66211	$-1.88\ 10^{-4}$

Identification		Reference	*Aster*	% difference
N°310	ε_{xx}	$1.50\ 10^{-3}$	$1.50\ 10^{-3}$	$2.02\ 10^{-13}$
	σ_{xx}	$3.69\ 10^{5}$	$3.69\ 10^{5}$	$9.02\ 10^{-5}$
	ε_{yy}	$2.09\ 10^{-3}$	$2.09\ 10^{-3}$	$-2.39\ 10^{-4}$
	σ_{yy}	$4.59\ 10^{5}$	$4.\ 59\ 10^{5}$	$-8.66\ 10^{-5}$
	ε_{xy}	$1.41\ 10^{-3}$	$1.41\ 10^{-3}$	$1.23\ 10^{-13}$
	σ_{xy}	$2.16\ 10^{5}$	$2.16\ 10^{5}$	$7.66\ 10^{-5}$
	D	0.99423	0.99423	$4.42\ 10^{-4}$

7 Summary of the results

With very weak variations about 0.05% to the maximum on the constraints in the non-linear phase and about 0.002% after complete damage on a test where the loadings are not radial, one can consider as the establishment of the model of Mazars as well in local version as not-local, is faithful to the original model.