SSNP161 – Biaxial tests of Kupfer

Summary:
Kupfer [1] is interested to characterize the performances of the concrete under biaxial loadings. Two of these tests are modelled in this case test in order to compare the experimental data with the results got with the Mazars model. Behaviours in bi--compression and shearing are studied in this case test.

1 Problem of reference

1.1 Geometry and boundary conditions

DanS these tests, a plate of concrete ($200\times200\times50\ mm$) is subjected to a loading where the report of the principal constraints σ_2/σ_1 is fixed ($\sigma_3=0$). These tests are modelled in two dimensions under the condition of plane constraints ($\sigma_{zz}=0$) using an element quadrangle with 4 nodes (QUAD4).

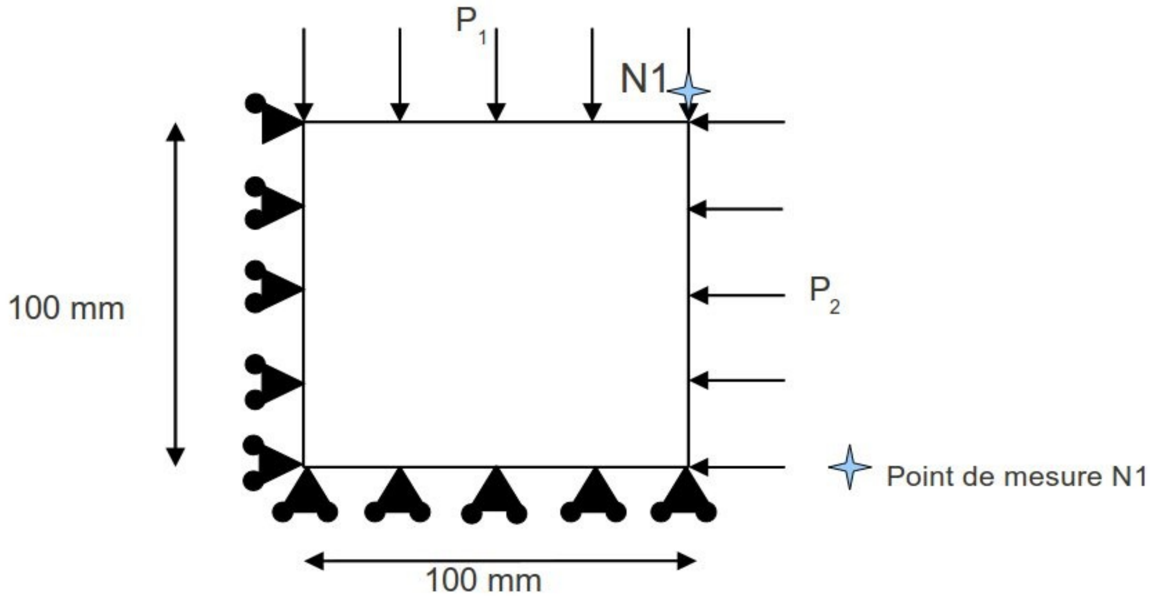

Figure 1.1-a : Modeling 2D and boundary conditions of the biaxial tests

Only one quarter of the concrete plate is modelled. Thus, conditions of symmetry are imposed:

- Following displacements y are blocked on the lower edge.
- Following displacements x are blocked on the left edge.

Two pressures are imposed on the free edges: P_1 and P_2. The report between the loads, and implicitly on the principal constraints, is noted ω :

$$\sigma_2=\omega\sigma_1 \quad \text{(Eq.1)}$$

These pressures follow one linear law of evolution.

Moment	0	1
P_1 (MPa)	0	30
P_2 (MPa)	0	30ω

Table 1.1-1: Evolution of the pressures

1.2 Properties of material

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

Elastic behavior:

$$E=34\ 000\ MPa,\ \ \nu=0.19$$

Damaging behavior:

$$\varepsilon_{d0}=1.1.10^{-3};\ Ac=1.25\ ;\ At=1.0\ ;\ Bc=1965\ ;\ Bt=9\ 000\ ;\ k=0.7$$

These parameters materials induce a limit in compression f_c about $33\,MPa$.

1.3 Initial conditions

Nothing

2 Reference solution

2.1 Comparison of the tests and simulations

NRous we are focused on two values of report $\omega=\sigma_2/\sigma_1$ correspondent with a test of bi--compression ($\omega=0.52$) and with a test of traction and compression ($\omega=-0.052$). The following figure presents the various got results:

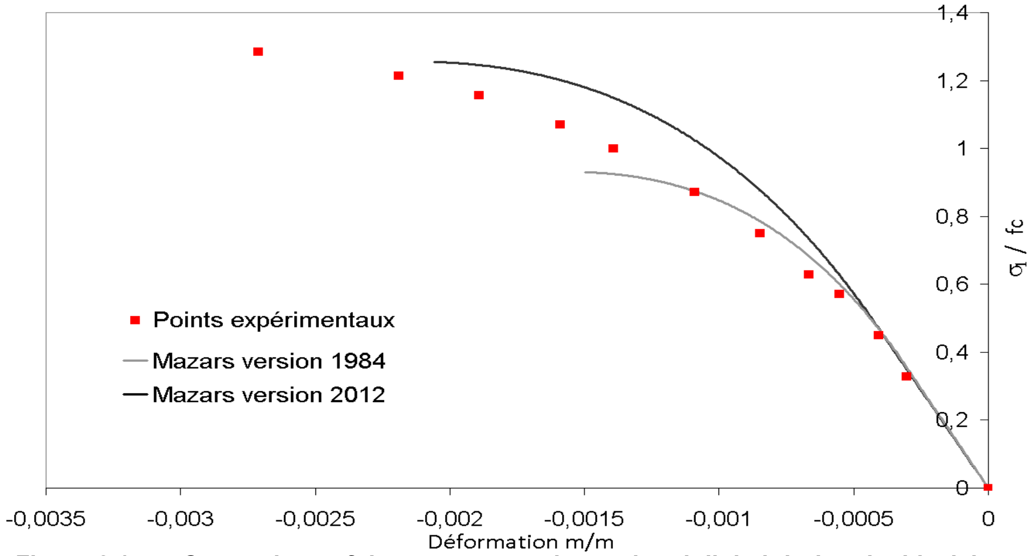

Figure 2.1-a : Comparison of the curves experimental and digital during the biaxial test ($\omega=0.52$)

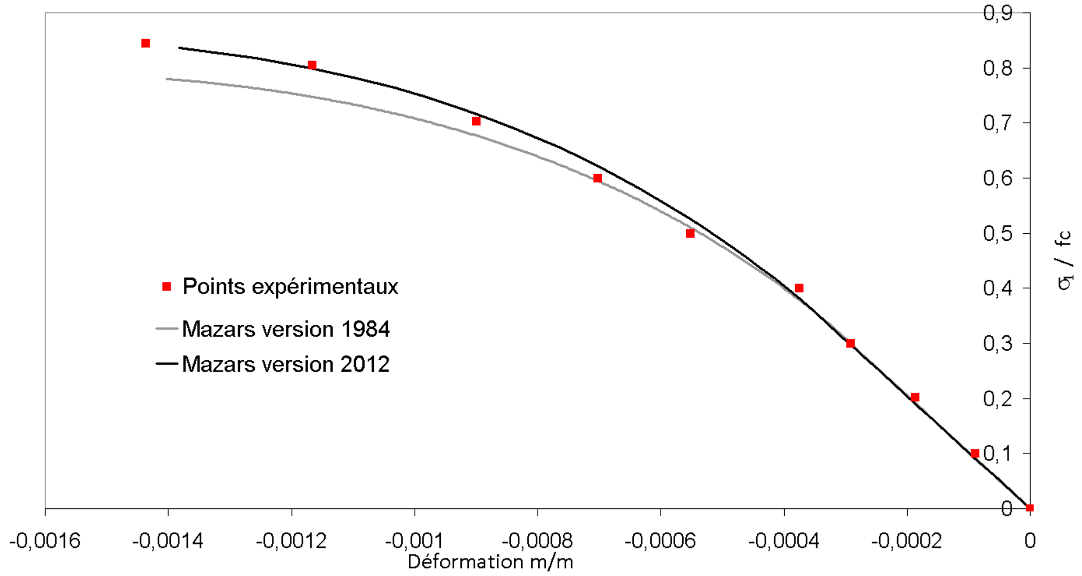

Figure 2.1-b : Comparison of the curves experimental and digital during the biaxial test $\omega=0.52$

Let us specify that simulations are controlled in force. So it is not possible to model the phase of rise in temperature. For the report $\omega=0.52$, not taken it into account of the model of the evolution of the Poisson's ratio in bi--compression does not allow to find the long-term deformations. However, the digital results are close to the experimental points at the beginning of simulation. Moreover, the model of Mazars makes it possible to find forced it with experimental rupture (the last point experimental corresponds to the rupture of the sample). Then, for ω = -0,052, it model provides results very close to the test.

Notice : To the stabilized version 11.2 of *Code_Aster* , the Mazars model followed the equations defined in the thesis of Mazars of 1984 [2]. Recently, a reformulation was proposed in order to fill certain gaps of the model of 1984 with knowing the description of the behavior of the concrete in bi--compression and pure shearing. This version of 2012 was implemented starting from the STA 11.3. It is possible to compare the answer the different one version Mazars model in order to highlight the improvements of the version 2012. It appears well that the model of Mazars of 1984 underestimates resistance in bi--compression. Then, for $\omega=-0.052$, the differences between the results coming from the two models are weak . Let us recall that the improvements of the model of 2012 relate to in particular behaviour in bi--compression and pure shearing. Consequently, this result is logical. The curve obtained starting from the model of Mazars of 2012 remains closer to the experimental points all the same.

2.2 Bibliographical references

[1] H. Kupfer, H.K. Hilsdorf, H. Rüsch, “ *Biaxial Behavior of Concrete under Stress”,* ACI Newspaper, Vol. 66, No 66-62, 1969, pp. 656-666.

[2] J. Mazars, “ *With micro description of and macroscale ramming of concrete structure”,* Engineering Fractures Mechanics, Vol25, 1986, p729-737.

[3] J. Mazars, F. Hamon, “ *With new strategy to formulate has 3D ramming model for concrete under monotonic, cyclic and severe loadings”, Engineering Structures, 2012, Under review*

3 Modeling A

3.1 Characteristics of modeling

A modeling is used `C_PLAN`. LE report of the principal constraints σ_2/σ_1 is fixed at 0.52 .

3.2 Characteristics of the grid

The grid contains 1 element of the type `QUAD4`.

3.3 Sizes tested and results

We test the strains and stresses with the node $N1$ Figure 1.1-a.

Identification	Increment	Type of reference	Value of reference	Tolerance
Constraint σ yy	7	'ANALYTICAL'	$-10842857\ Pa$	5%
Deformation ε yy	7	'ANALYTICAL'	$-3{,}00E\text{-}004$	5%
Constraint σ yy	69	'ANALYTICAL'	$-42428571\ Pa$	5%

Table 3.3-1: Summary of `TEST_RESU`

3.4 Remarks

The first two points of measurement make it possible to compare the slope at the origin of the stress-strain curve. The last point corresponds to the constraint with rupture.

4 Modeling B

4.1 Characteristics of modeling

A modeling is used C_PLAN. LE report of the principal constraints σ_2/σ_1 is fixed at -0.052.

4.2 Characteristics of the grid

The grid contains 1 element of the type QUAD4.

4.3 Sizes tested and results

We test the strains and stresses with the node $N1$ Figure 1.1-a.

Identification	Increment	Type of reference	Value of reference	Tolerance
Constraint σ_{yy}	6	'ANALYTICAL'	$-3589800\,Pa$	5%
Deformation ε_{yy}	6	'ANALYTICAL'	$-1{,}05E\text{-}004$	5%
Constraint σ_{yy}	46	'ANALYTICAL'	$-27899998\,Pa$	5%

Table 4.3-1: Summary of TEST_RESU

4.4 Remarks

The first two points of measurement make it possible to compare the slope at the origin of the stress-strain curve. The last point corresponds to the constraint with rupture.

5 Summary of the results

The version of the model of MAZARS of 2012 makes it possible to find the constraint with experimental rupture with an error lower than 5%.

Note: the profit compared to the model of 1984 is especially visible in bi--compression i.e. for the report $\omega=0.52$. On the other hand, the strain at failure is far away from the test because this model does not take into account the evolution of the Poisson's ratio in bi--compression.