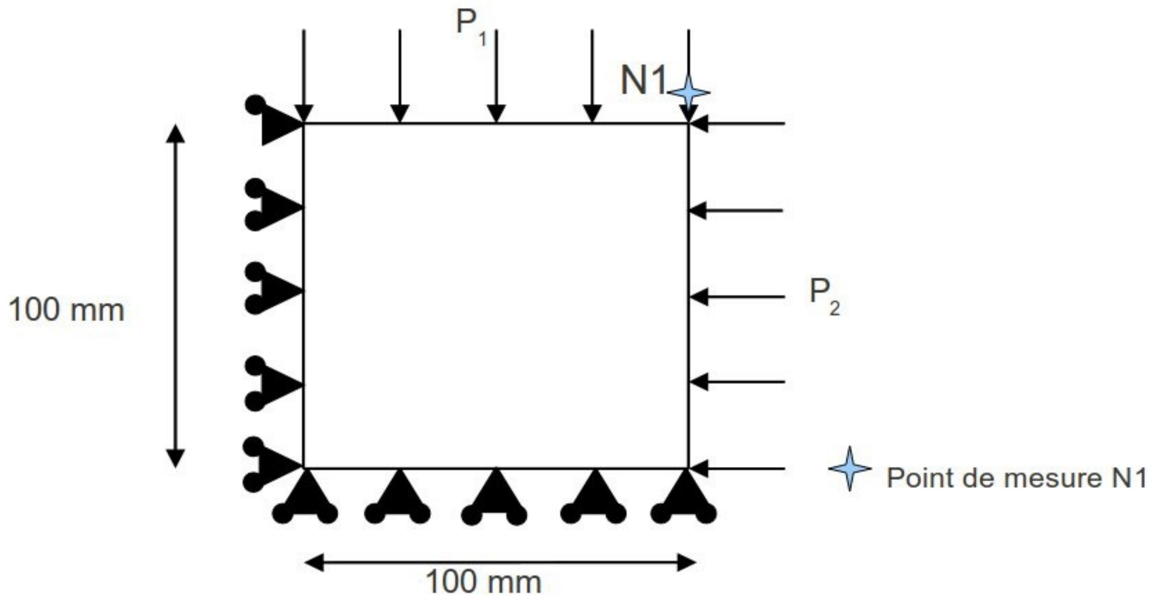
SSNP161 – Biaxial tests of Summarized

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

1 Problem of reference

1.1 Geometry and boundary conditions

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



Appear 1.1-a : Modelization 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 lower edge.
- Following displacements x are blocked on left edge.

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

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

These pressures follow a linear law of evolution.

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

Table 1.1-1: Evolution of the pressures

1.2 Properties of the material

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

Behavior elastic:

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

Behavior damaging:

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

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

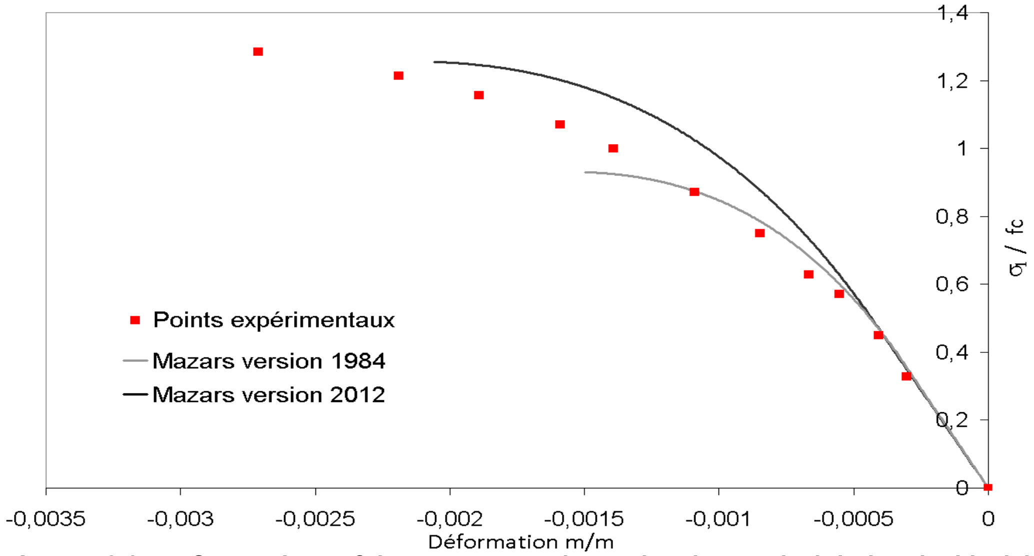
1.3 Initial conditions

Nothing

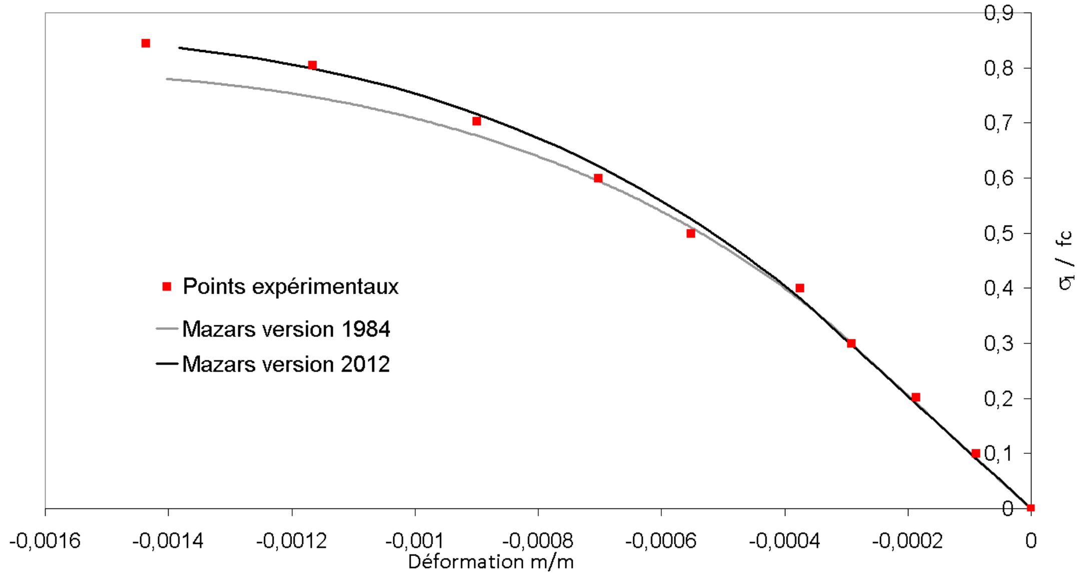
2 Reference solution

2.1 Comparison of the tests and simulations

We focused ourselves on two values of ratio $\omega=\sigma_2/\sigma_1$ corresponding to a test of bi--compression ($\omega=0.52$) and to a test of traction and compression ($\omega=-0.052$). The following figure presents the various got results:



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



Appears 2.1-b : Comparison of the curves experimental and numerical 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 ratio $\omega=0.52$, 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 strains. However, the numerical results are close to the experimental points at the beginning of simulation. Moreover, the model of

Mazars allows to find forced it with experimental fracture (the last experimental point corresponds to the fracture of the sample). Then, for ω = -0.052, the model provides results very close to the test.

Note: To the stabilized version 11.2 of *Code_Aster* , the model Mazars 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 shears. This version of 2012 was implemented from the STA 11.3. It is possible to compare the response of the different version of the Mazars model in order to highlight the improvements of the version 2012. It appears well that the model of Mazars of 1984 strength in bi--compression underestimates. 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 behavior in bi--compression and pure shears. 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, " *A micro description of and macroscale ramming of concrete structure",* Engineering Fractures Mechanics, Vol25, 1986, p729-737.

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

3 Modelization A

3.1 Characteristic of the modelization

One uses a modelization C_PLAN. The ratio of the principal stresses σ_2/σ_1 is fixed at 0.52 .

3.2 Characteristics of the mesh

The mesh contains 1 element of type QUAD4.

3.3 Quantities tested and results

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

Standard	identification	Increment of reference	Value of reference	Forced
Tolerance σ yy	7	"ANALYTIQUE"	$-10842857\,Pa$	5%
Strain ε yy	7	"ANALYTIQUE"	$-3{,}00\text{E-}004$	5%
Stress σ yy	69	"ANALYTIQUE"	$-42428571\,Pa$	5%

Table 3.3-1: Summary of the 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 stress with fracture.

4 Modelization B

4.1 Characteristic of the modelization

One uses a modelization C_PLAN. The ratio of the principal stresses σ_2/σ_1 is fixed at -0.052.

4.2 Characteristics of the mesh

The mesh contains 1 element of type QUAD4.

4.3 Quantities tested and results

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

Standard	identification	Increment of reference	Value of reference	Forced
Tolerance σ_{yy}	6	"ANALYTIQUE"	$-3589800\,Pa$	5%
Strain ε_{yy}	6	"ANALYTIQUE"	$-1{,}05E\text{-}004$	5%
Stress σ_{yy}	46	"ANALYTIQUE"	$-27899998\,Pa$	5%

Table 4.3-1: Summary of the 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 stress with fracture.

5 Summary of the results

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

Note: the gain compared to the model of 1984 is especially visible in bi--compression i.e. for the ratio $\omega=0.52$. 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.