SSNA112 – Axisymmetric test of wrenching for the study of steel-concrete connection: model JOINT_BA

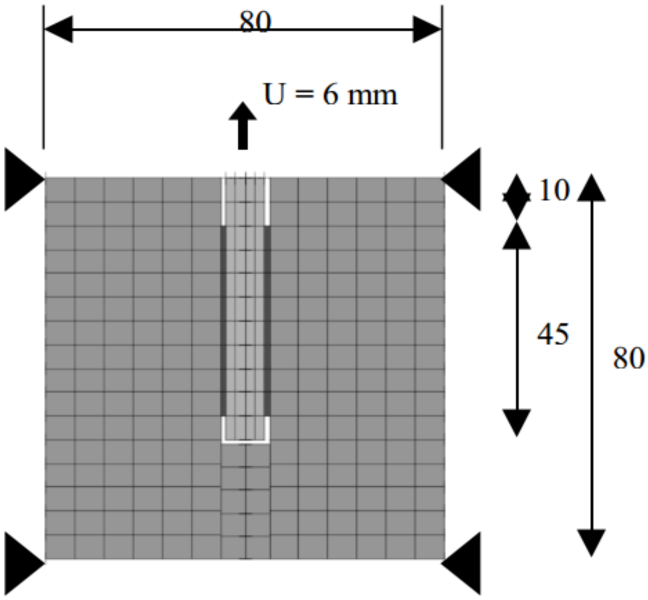
Summarized:

In this case test of mechanics one modelled the test of wrenching carried out by Borderie & Pijaudier- Pooch [bib1] of which the goal was to study the influence of the stress state in the matrix on the mechanical properties of the interface. The geometrical data and the characteristic materials result from their ratio, and the numerical results will be compared with the experimental results.

For the axisymmetric modelization, one uses elements QUAD4 for the concrete and steel, in combination with elements joined for the interface (see Doc. [R3.06.09]). The concrete and steel are considered elastic in order to test only to it not linearity of the constitutive law of steel-concrete connection, JOINT_BA (see document [R7.01.21]). One carries out a monotonous computation with the displacements imposed at the end of the steel bar.

1 Problem of reference

1.1 Geometry and boundary conditions



Appears 1.1-a: Geometry and boundary conditions

1.2 Properties of the material

Steel : elastic

$E = 2.1 \times 10^5 MPa$

$\nu = 0.3$

Concrete : elastic

$E = 1.55 \times 10^4 MPa$

$\nu = 0.17$

Element of joint :

- constitutive law ELAS with the following parameters:

  $E = 1.55 \times 10^4 MPa$

  $\nu = 0.17$

- constitutive law JOINT_BA with the following parameters:

•Initial parameters:

coefficient of penetration: $Hpen = 0.64\, mm$ (key word: HPEN) modulus of stiffness: $G_{lia} = 6.65 \mathrm{x} 10^{3} MPa$ (key word: GTT)

• Parameters of tangential damage:

threshold of elastic strain:	$\varepsilon_\gamma^0=5\times10^{-4}$	(key word: GAMD0)
coefficient of damage area 1:	$Ad_1=1.0$	(key word: AD1)
coefficient of damage area 1:	$Bd_1=0.5$	(key word: BD1)
threshold of the great slidings:	$\varepsilon_\gamma^2=9.6\times10^{-1}$	(key word: GAMD2)
coefficient of damage area 2:	$Ad_2=4\times10^{-5}\,MPa^{-1}$	(key word: AD2)
coefficient of damage area 2:	$Bd_2=1.0$	(key word: BD2)

• Parameters for the friction of cracks and containment:

coefficient material by friction:	$\gamma=10.0\,MPa$	(key word: VIFROT)
coefficient by kinematic hardening:	$\alpha=4\times10^{-1}\,MPa^{-1}$	(key word: FA)
coefficient of containment:	$c=1.0$	(key word: FC)

• Parameters of normal damage:

normal strain criticizes (opening):	$\varepsilon_N^0=9\times10^{-1}$	(key word: EPSTR0)
coefficient of normal damage:	$Ad_N=1\times10^{-9}\,MPa^{-1}$	(key word: ADN)
coefficient of normal damage:	$Bd_N=1.5$	(key word: BDN)

1.3 Boundary conditions and loadings

null Displacements imposed (fixed support) on the side face of the elements of the concrete.
The rotational axis is fixed in the middle of the steel bar.
The mechanical loading into monotonous is applied in the form of displacements imposed to the end of the steel bar in two stages:

- 20 increments of $0.005\,mm$, for $U=\{0\,\text{à}\,0.1\,mm\}$
- 118 increments of $0.05\,mm$, for $U=\{0.1\,\text{à}\,6\,mm\}$

2 Reference solution

It is about a numerical comparison - experimental. The work of Borderie & Pijaudier-Pooch [bib1] consisted in a trial run of wrenchings carried out on fibers and reinforcements for reinforced concrete. The object of these tests was to study the influence of the stress state in the matrix on the mechanical properties of the interface.

Each specimen was a cube of $80\times 80\times 80\,mm$ which the concrete paste was $Grade\,C30/37$ (gravel of $16\,mm$) with a strength at the time of the test (three days after the casting and with 4 hours a heat treatment) of $14.5\,MPa$, a Young modulus of $15500\,MPa$ and a Poisson's ratio of $0{,}17$. For reinforcements, they used deformed bars of $8\,mm$ diameter, with a length of contact steel-concrete of $45\,mm$, $10\,mm$ freer at the edge of the concrete, which made it possible to eliminate the singularities in the field from the concrete stresses in the clamped surface of the cube. The test was carried out with controlled displacements ($\dot{u}=8.3\times 10\mathrm{E}\text{-}3\,mm/s$) and four levels of containment: $0{,}5$, 10 and $15\,MPa$, constant during each experiment.

2.1 bibliographical References

• the BORDERIE C. & PIJAUDIER-CABOT G. - experimental Study of the behavior of the reinforced materials: Experimental determination of the constitutive laws of the interface matrix fiber. Laboratory of Mechanics and Technology (LMT); ENS Cachan/CNRS/Université Paris 6 ; Contract I 70/1F 3146 with Electricity of France, 1994

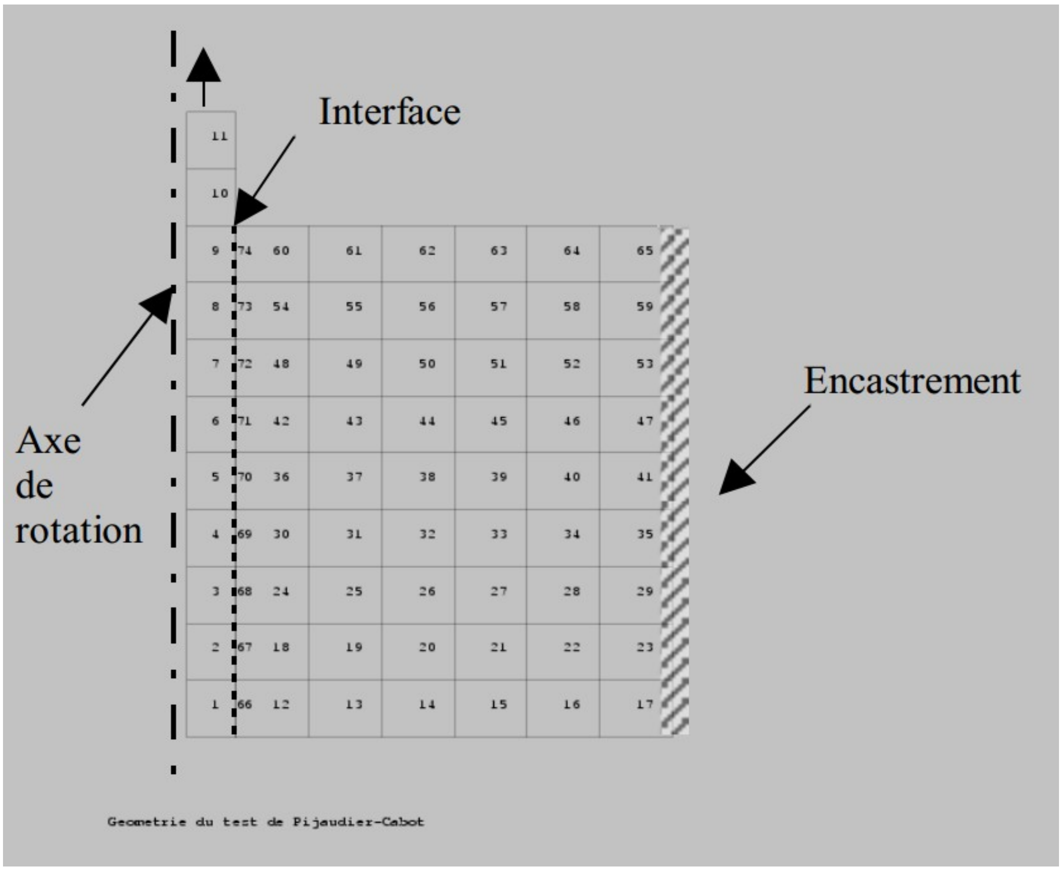
3 Modelization A

3.1 Characteristic of the modelization

It acts of an axisymmetric $2D$ modelization, where one can identify 2 groups of elements:

Axisymmetric modelization (key word `AXIS`) for the elements of the concrete and steel.
Modelization fissures axisymmetric (key word `AXIS_JOINT`) for the element of joint.

The concrete and steel are modelled with elements `QUAD4`.
The interface is modelled with degenerated `elements` QUAD4 (confused nodes).



Appear 4.1-a: Modelization of the test into axisymmetric

3.2 Characteristics of the mesh

Many nodes: 94 (with 20 confused nodes)
Number of meshes and type: 11 `QUAD4` for steel
\+ 9 `QUAD4` for the interface
\+ 54 `QUAD4` for the concrete.

3.3 Quantities tested and results

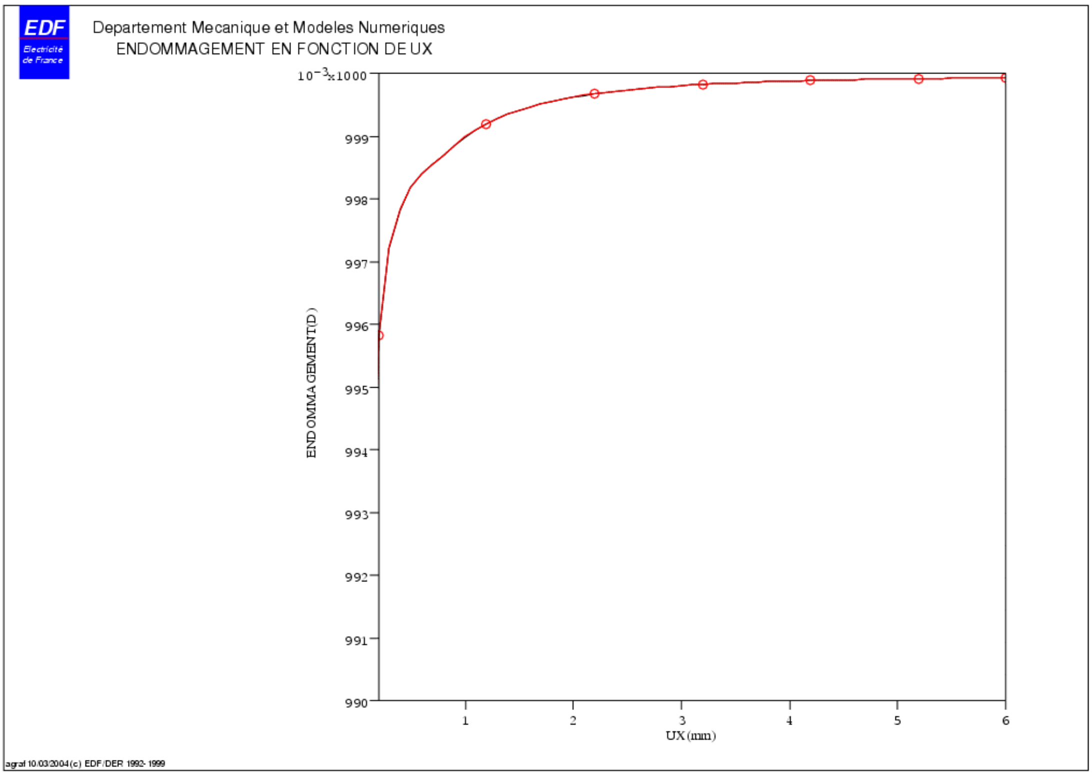
One tests the components xy of the element which correspond to the tangential components of the local model of behavior in the interface, starting from stress field SIEF_ELGA. The values are tested as in Gauss point 2 of the joined element, with 4 time step different: at the beginning of the loading, during the phase of growth of the damage, in the peak of maximum strength and after the peak of the strength of connection.

Field SIEF_ELGA component SITX

Identification	Reference	% tolerance
For a displacement imposed $U_{TT}=0.2\,mm$	-7.20 E+00	5
For a displacement imposed $U_{TT}=0.8\,mm$	-1.14 E+01	5
For a displacement imposed $U_{TT}=1.0\,mm$	-1.26 E+01	5
For a displacement imposed $U_{TT}=1.6\,mm$	-1.22 E+01	5

3.4 Evolution of the damage

to observe the coherence of the evolution of the damage in the various connection elements, one builds the graphics of the variable of damage compared to imposed displacement.



4 Summary of the results

With lower deviations than 5.0% compared to the experimental results got by Borderie & Pijaudier-Pooch [bib1], one considers that the axisymmetric simulation of the test of wrenching is satisfactory. However, in order to test the stability of the constitutive law in combination with other models (model MAZARS for the concrete, for example), it will be necessary to decrease the size of time step by considering that the other models are made normally for formulations in small strains.