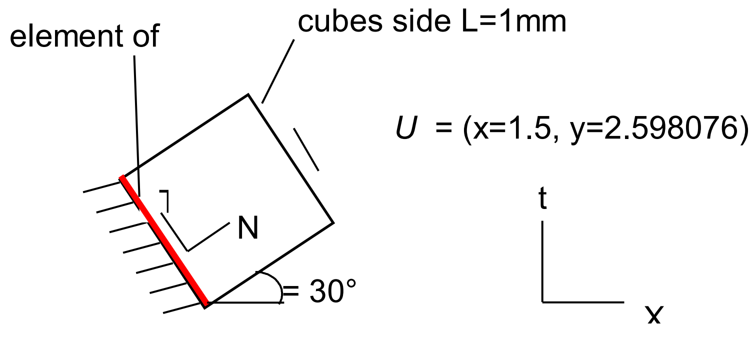
SSNP126 - Validation of constitutive law `JOINT_BA` (steel-concrete connection) in 2D plane

Abstract:

Validation of constitutive law `JOINT_BA` of steel-concrete connection by means of the element of plane $2D$ joint. This joined element is embedded in two nodes and bound to an element cubes with the characteristics of an unspecified elastic material. By applying a monotonic loading in sliding to the cubic element, one checks the degradation of the interface, as well as the transition of the small strains at the beginning of the experiment, with the great observable slidings starting from the peak of the strength of connection. In this case test, the parameters used do not correspond to the data of a particular experimental case. However, the validation is carried out by comparison with results got with code FEAP of Professor Taylor, of Berkeley, software in which this formulation was established.

1 Problem of reference

1.1 Geometry



Appears 1.1-a: Geometry and boundary conditions

1.2 Properties of the Cubic

material *:* elastic

$E=2,1\cdot 10^6 \quad MPa$, $\nu=0$

Element of joint :

- constitutive law `ELAS` with the following parameters:

  $E=2,1\cdot 10^6 \quad MPa$, $\nu=0$

- constitutive law `JOINT_BA` with the following parameters:

  - Initial parameters:

coefficient of penetration:	$Hpen=0.64\text{mm}$	(key word: `HPEN`)
modulus of stiffness:	$G_{lia}=6.65\times 10^{+3\text{MPa}}$	(key word: `GTT`)

  - Parameters of tangential damage:

threshold of elastic strain:	$\varepsilon_{\gamma}^{0}=5\times 10^{-4}$	(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:	$\varepsilon_{\gamma}^{2}=9.6\times 10-1$	(key word: `GAMD2`)
coefficient of damage area 2:	$Ad_2=6\times 10^{-5}\ MPa^{-1}$	(key word: `AD2`)
coefficient of damage area 2:	$Bd_2=1.0$	(key word: `BD2`)

- Parameters for the friction of cracks and containment:

friction:	$\gamma=10.0\,MPa$	(key word: `VIFROT`)
kinematic hardening:	$\alpha=4\times10^{-1}\,MPa^{-1}$	(key word: `FA`)
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 on the left face of the element of joint.
The mechanical loading is imposed in the form of displacements imposed on the right face of the cube in increments of $0.01\times U$ on each time step, from 0 to 300.

1.4 Notice

the constitutive law of the element of joint is given locally (reference (n,t)), computations of the system are carried out in the total reference (x,y). The basic change was taken into account in computations. The case test was developed with a rotation of $30°$ with an aim of validating this basic change.

2 Reference solution

It acts of a comparison code-code. The reference used is code FEAP version 7.4 of Professor R.L. Taylor, of the University of California, Berkeley. The results were got with the same geometrical and material parameters, as well as the same discretization in time.

2.1 Bibliographical references

[1] TAYLOR R.L. – FEAP: A Finite Element Analysis Program version 7.4. To use, Theory, To program & Example Manuals - University Of California At Berkeley, the USA, December 2000.

3 Modelization A

3.1 Characteristic of the modelization

Modelization in plane strains (key word `D_PLAN`) for the cube on side 1.
Modelization fissures planes (key word `PLAN_JOINT`) for the element of joint.

The cube is one $QUAD4$.
The element of joint is one $QUAD4$ degenerated (confused nodes).

3.2 Characteristics of the mesh

Many nodes: 6
Number and type of meshes: 2 $QUAD4$.

4 Results of the modelization A

4.1 Quantities tested and results

One tests the components yy and xy of the element which correspond to the components norm and tangential of the local model of behavior in the interface, starting from stress field `SIEF_ELGA` as well as the value of the damage D_T (which corresponds to the second variable of field `VARI_ELGA`). The values are tested as in Gauss point 1 of the joined element, with 4 time step different: at the beginning of loading, during the phase of growth of the damage, after the peak of the maximum strength of connection and at the end of the loading.

Field `SIEF_ELGA` component `SIGN`

Identification	Reference	*Code_Aster*	% difference
For a displacement imposed $U_{TT} = 0.2\,mm$	-9.94080 E-02	-1.00976 E-01	1.577
For a displacement imposed $U_{TT} = 0.8\,mm$	-1.54560 E-01	-1.52328 E-01	-1.444
For a displacement imposed $U_{TT} = 1.2\,mm$	-1.44060 E-01	-1.47200 E-01	2.180
For a displacement imposed $U_{TT} = 3.0\,mm$	-1.06920 E-01	-1.06914 E-01	-0.006

Field `SIEF_ELGA` component `SITX`

Identification	Reference	*Code_Aster*	% difference
For a displacement imposed $U_{TT} = 0.2\,mm$	-7.58900 E+00	-7.65768 E+00	0.905
For a displacement imposed $U_{TT} = 0.8\,mm$	-1.17960 E+01	-1.15521 E+01	-2.068
For a displacement imposed $U_{TT} = 1.2\,mm$	-1.09950 E+01	-1.11632 E+01	1.530
For a displacement imposed $U_{TT} = 3.0\,mm$	-8.15940 E+00	-8.10802 E+00	-0.630

Field `VARI_ELGA` component `V2` (variable of tangential damage)

Identification	Reference	*Code_Aster*	% difference
For a displacement imposed $U_{TT} = 0.2\,mm$	9.97203 E-01	9.97203 E-01	-2 . 19 E-05
For a displacement imposed $U_{TT} = 0.8\,mm$	9.98948 E-01	9.98915 E-01	-0.003
For a displacement imposed $U_{TT} = 1.2\,mm$	9.99369 E-01	9.99309 E-01	-0.006
For a displacement imposed $U_{TT} = 3.0\,mm$	9.99854 E-01	9.99821 E-01	-0.003

5 Summary of the results

the comparison of the results resulting from *the Code_Aster* and those obtained numerically by code FEAP of Professor Taylor from Berkeley are satisfactory (the maximum change is of 2.18% on the stresses).

The purpose of the modelization is to test the stability of the constitutive law by means of the already existing elements joined in *the Code_Aster* : one can consider that the model installation of is correct. However, since the maximum strength of connection between steel reinforcements and the concrete is reached beyond the frame of the small strains, it is necessary to pay attention to the choice of the increments of time in particular when `JOINT_BA` is used in combination with other nonlinear constitutive laws (model MAZARS, for example).