SSNL127 - Tensile test with the model CORR_ACIER

Summary:

This test of nonlinear quasi-static mechanics makes it possible to validate the elastoplastic model endommageable CORR_ACIER.

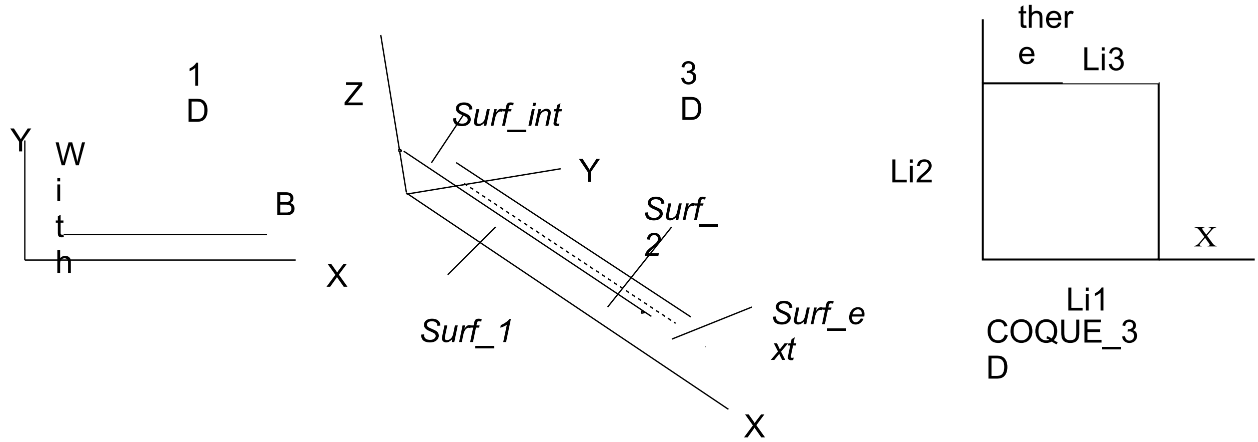
5 modelings make it possible to validate the behavior:

1) modelings A, B, C in $1D$ for the elements BAR, POU_D_EM, POU_D_TGM ;
2) modeling D in 3D in the case of an axisymmetric test-tube (homogeneous stress and strain state) subjected to a simple tensile test; modeling 3D test-tube is produced with elements CU20 ;
3) modeling E in COQUE_3D in the case of a plate subjected to a simple traction, with a mesh QUAD9.

1 Problem of reference

1.1 Geometry

The geometry is selected voluntarily simple, to translate a stress and strain state homogeneous, as it is the case in uniaxial traction. In the case 1D and 3D, it is here about a bar of diameter $\phi = 6\ mm$ and length. In 3D, one does not net that a quarter of the bar. Traction is done with displacement imposed in 1D and 3D with the length test-tube. In the case COQUE_3D, the plate is square on side, and thickness $\pi \frac{\phi^2}{4}$ (so that the efforts are identical to the case 1D).



1.2 Properties of material

Module of YOUNG = $2.E11\ Pa$
Poisson's ratio $\nu = 0.33$

Keyword CORR_ACIER :
Coefficient of damage D_CORR = 0.2
Parameters of work hardening ECRO_K = $500\ MPa$
Elastic limit ECRO_M = 2.781
SY = $500.\ MPa$

The degree of corrosion is given using the order CREA_CHAM :
NOM_CMP = 'CORR' VALE = 0.0,2.5,13 (in for hundred)

1.3 Boundary conditions and loadings

Modeling 1D
Displacements DX DZ and DY blocked at the point A
Displacement DX and DZ imposed on the point B

Modeling 3D
Displacement DX prevented on $Surf_{\text{int}}$
Displacement DY prevented on $Surf_1$
Displacement DZ prevented on $Surf_2$
Displacement DX imposed on $Surf_{ext}$

Modeling COQUE_3D :

Displacement DX prevented on $Li4$
Displacement DY prevented on $Li1$
Displacement DX imposed on $Li3$

1.4 Initial conditions

Worthless constraints and deformations.

2 Reference solution

2.1 Method of calculating

The reference solution is consisted the results of the tensile tests carried out on corroded bars (the initial diameter is $6\,mm$). Following these tests, one notes the reduction in the plastic deformation with rupture with increase in the degree of corrosion.

2.2 Results of reference

Evolution of the plastic deformation with rupture of the bars corroded according to the degree of corrosion (the reduction of the diameter of bars or thickness of flat reinforcement compared to those not corroded) is presented on [Figure 2.2-a] and it [Figure 2.2-b].

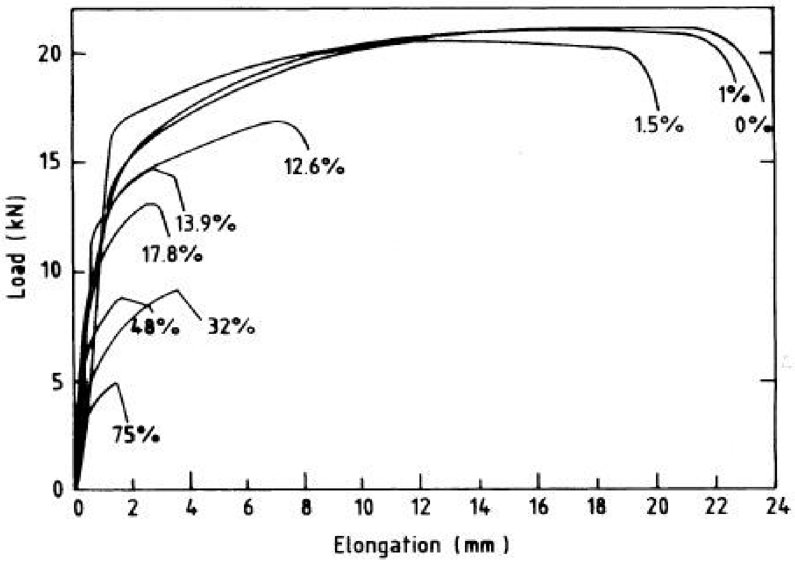


Figure 2.2.a Influence of corrosion on the behavior of steel according to the rate of corrosion

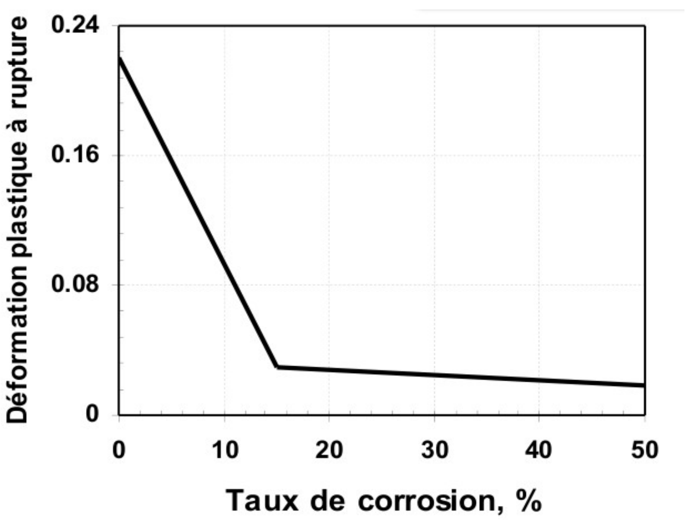


Figure 2.2.b Evolution of the plastic deformation with rupture according to the rate of corrosion

2.3 Uncertainties on the solution

Precision of the codes.

2.4 Bibliographical references

1) A.A. ALMUSALLAM: “Effect of dismantles of corrosion one the properties of reinforcing steel bars”, Construction and Building Materials 15.2001.

2) A. OUGLOVA, Y. BERTHAUD, I. PETRE-LAZAR: “Experimental characterization of the corrosion of steels in the concrete on old analogues. First approach of modeling “, HT 2/25/030 /A, EDF, 2002.

3 Modeling A

3.1 Characteristics of modeling

It is about an element BAR. Maximum displacement at the point B is of $0.021\mathrm{m}$, it is reached in 50 increments.

3.2 Characteristics of the grid

Many nodes: 10
Number of meshs and type: 10 (SEG2)

3.3 Sizes tested and results

The efforts maximum (in N) are:

Identification	Imposed displacement (m)	Reference
0% of corrosion	0,019	21857.1
2.5% of corrosion	0.0164	21451.6
13% of corrosion	0.0075	19610.1

efforts corresponding to maximum displacement at the point B are:

Identification	Imposed displacement (m)	Reference
0% of corrosion	0.02	21193.7
2.5% of corrosion	0,018	20557.6
13% of corrosion	0,008	18758.6

The cumulated equivalent plastic deformation maximum is worth:

Identification	Imposed displacement (m)	Reference
0% of corrosion	0.02	0.19625
2.5% of corrosion	0,018	0.17636
13% of corrosion	0,008	0.07668

The damage is worth:

Identification	Imposed displacement (m)	Reference
0% of corrosion	0.0192	0.00229
2.5% of corrosion	0.0164	0.01371
13% of corrosion	0.0075	0.01188

4 Modeling B

4.1 Characteristics of modeling

It is about an element POU_D_EM (beam multifibre). Maximum displacement at the point B is of 0.021m, it is reached in 50 increments.

4.2 Characteristics of the grid

Many nodes: 10
Number of meshs and type: 10 (SEG2)

4.3 Sizes tested and results

The efforts maximum (in N) are:

Identification	Imposed displacement (m)	Reference
0% of corrosion	0,019	21857.1
2.5% of corrosion	0.0164	21451.6
13% of corrosion	0.0075	19610.1

efforts corresponding to maximum displacement at the point B are:

Identification	Imposed displacement (m)	Reference
0% of corrosion	0.02	21193.7
2.5% of corrosion	0,018	20557.6
13% of corrosion	0,008	18758.6

The cumulated equivalent plastic deformation maximum is worth:

Identification	Imposed displacement (m)	Reference
0% of corrosion	0.02	0.19625
2.5% of corrosion	0,018	0.17636
13% of corrosion	0,008	0.07668

The damage is worth:

Identification	Imposed displacement (m)	Reference
0% of corrosion	0.0192	0.00229
2.5% of corrosion	0.0164	0.01371
13% of corrosion	0.0075	0.01188

5 Modeling C

5.1 Characteristics of modeling

It is about an element POU_D_TGM (beam multifibre). Maximum displacement at the point B is of 0.021m , it is reached in 50 increments.

5.2 Characteristics of the grid

Many nodes: 10
Number of meshs and type: 10 (SEG2)

5.3 Sizes tested and results

The efforts maximum (in N) are:

Identification	**Imposed displacement (m)**	**Reference**
0% of corrosion	0,019	21857.1
2.5% of corrosion	0.0164	21451.6
13% of corrosion	0.0075	19610.1

efforts corresponding to maximum displacement at the point B are:

Identification	**Imposed displacement (m)**	**Reference**
0% of corrosion	0.02	21193.7
2.5% of corrosion	0,018	20557.6
13% of corrosion	0,008	18758.6

The cumulated equivalent plastic deformation maximum is worth:

Identification	**Imposed displacement (m)**	**Reference**
0% of corrosion	0.02	0.19625
2.5% of corrosion	0,018	0.17636
13% of corrosion	0,008	0.07668

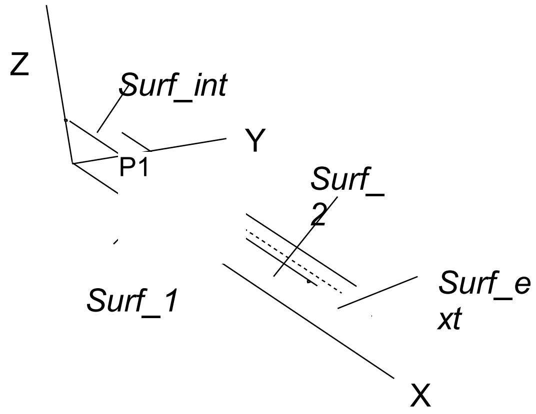
The damage is worth:

Identification	**Imposed displacement (m)**	**Reference**
0% of corrosion	0.0192	0.00229
2.5% of corrosion	0.0164	0.01371
13% of corrosion	0.0075	0.01188

6 Modeling D

6.1 Characteristics of modeling

It is about a modeling 3D.



6.2 Characteristics of the grid

Many nodes: 39
Number of meshs and type: 3 (HEXA20)

6.3 Sizes tested and results

The efforts maximum (in N) are:

Identification	Imposed displacement (m)	Reference
0% of corrosion	0,019	7,730 10^{8}
2.5% of corrosion	0.0164	7,588 10^{8}
13% of corrosion	0.0075	6,936 10^{8}

efforts corresponding to maximum displacement at the point B are:

Identification	Imposed displacement (m)	Reference
0% of corrosion	0.02	7,487 10^{8}
2.5% of corrosion	0,018	7,261 10^{8}
13% of corrosion	0,008	6,612 10^{8}

The cumulated equivalent plastic deformation maximum is worth:

Identification	Imposed displacement (m)	Reference
0% of corrosion	0.02	0.19625
2.5% of corrosion	0,018	0.17636
13% of corrosion	0,008	0.07668

The damage is worth:

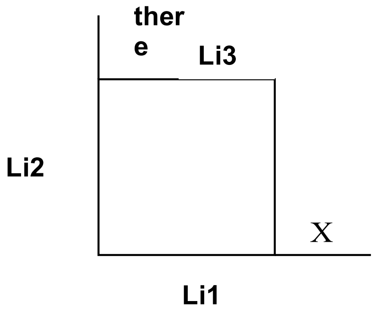
Identification	Imposed displacement (m)	Reference
0% of corrosion	0.0192	0.00345

2.5% of corrosion	0.0164	0.01505
13% of corrosion	0.0075	0,015

7 Modeling E

7.1 Characteristics of modeling

It is about a modeling COQUE_3D.



COQUE_3D

7.2 Characteristics of the grid

Many nodes: 9
Number of meshs and type: 1 (QUAD9)

7.3 Sizes tested and results

The efforts maximum (in N) are:

Identification	Imposed displacement (m)	Reference	Tolerance
0% of corrosion	0,019	21857.1	4,00%
2.5% of corrosion	0.0164	21451.6	7,00%
13% of corrosion	0.0075	19610.1	4,00%

efforts corresponding to maximum displacement at the point B are:

Identification	Imposed displacement (m)	Reference	Tolerance
0% of corrosion	0.02	21193.7	2,00%
2.5% of corrosion	0,018	20557.6	1,00%
13% of corrosion	0,008	18758.6	0.5%

8 Summary of the results

For modelings A, B, C, D, E the results correspond well to those obtained in experiments.

The curves effort-displacement obtained for the 3 rates of corrosion tested are the following ones: