

SSNP163 – Validation of the law of behavior of steels under irradiations in plane constraints

Summary:

This elementary test aims to validate the law of behavior `IRRAD3M` steels under irradiations in plane constraints.

1 Problem of reference

1.1 Geometry

It is about a square plate of with dimensions 1 mm

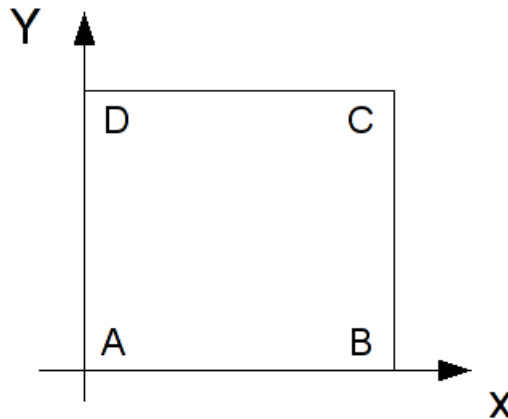


Figure 1.1-a : Geometry of the problem.

1.2 Properties materials

The various properties materials are given below.

The parameters materials used in this case test **do not have to be used to make studies**. They do not correspond to real characteristics.

Young modulus: $E = 210000.0 - 30.0 T$ in MPa

Poisson's ratio: $\nu = 0.30 + 5.0E-05 T$

Thermal dilation coefficient: $\alpha = (15.0 + 0.002 T) 1.0E-06$

Plastic part

$$\kappa = 0.8$$

Elastic limit with 0.2% in MPa : $R_{02} = R_{02}^0 \cdot C_{w_R_e} \cdot I_{r_R_e}$
with

$$R_{02}^0 = 270.0 - 0.65 T + 0.001 T^2$$

$$C_{w_R_e} = 1.0$$

$$I_{r_R_e} = \left(4.0 - 3.0 e^{\frac{-IRRA}{3}} \right)$$

Ultimate constraint in MPa : $R_m = R_{02(T,IRRA)} + (R_m^0 - R_{02}^0) \cdot C_{w_R_m} \cdot I_{r_R_m}$
with

$$R_m^0 = 600.0 - 1.5 T + 0.010 T^2$$

$$C_{w_R_m} = 0.50$$

$$I_{r_R_m} = 0.005 - 0.002 \left(1.0 - e^{\frac{-IRRA}{4.0}} \right) + e^{\frac{-IRRA}{1.8}}$$

Lengthening distributed: $\epsilon_u = \ln(1.0 + \epsilon_u^0 \cdot C_{w_e_u} \cdot I_{r_e_u} \cdot 1.0E-02)$

with

$$\epsilon_u^0 = 5.0 - 0.15 T + 0.0007 T^2$$

$$C_{w_e_u} = 1.0$$

$$I_{r_e_u} = e^{-IRRA}$$

Irradiation part

$$A_{i0} = 3.0E-06 \text{ MPa}^{-1} \cdot \text{dpa}^{-1}$$

$$\eta_{is} = 1000 \text{ MPa} \cdot \text{dpa}$$

Swelling part

$$R = 0.0020 \text{ dpa}^{-1}$$

$$\alpha = 1.0$$

$$\phi_0 = 40.0 \text{ dpa}$$

1.3 Boundary conditions and loadings

For the edges AB and DC , $DY = 0$

For the edge AD , $DX = 0$

One applies moreover one linear slope of temperature having for maximum 400°C as well as a linear slope of irradiation having for maximum 140 dpa .

2 Reference solution

2.1 Results of reference

It is a case test of not-regression.

3 Modeling A

3.1 Characteristics of modeling

The modeling used in the case test is the following one: **Elements 2D 'C_PLAN' (QUA4)**

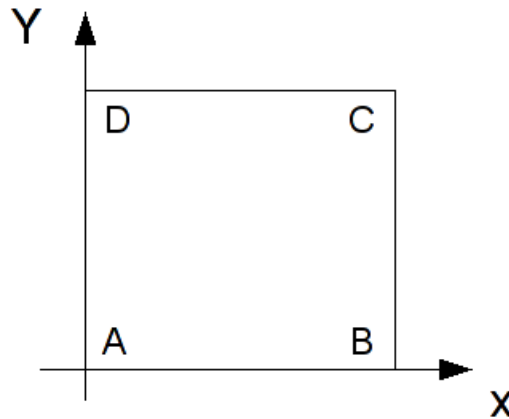


Figure 3.1-a : Geometry and grid of modeling used.

Cutting: 1 mesh QUAD4 according to the axis of x
1 mesh QUAD4 according to the axis of y

Nodes:

A : mesh $M1$ node $N1$
 B : mesh $M1$ node $N2$
 C : mesh $M1$ node $N3$
 D : mesh $M1$ node $N4$

3.2 Characteristics of the grid

Many nodes: 4
Many meshes and types: 1 QUAD4, 3 SEG2.

3.3 Sizes tested and results

Identification	Field	Size	Reference	Tolerance
t= 20 M1 Point 1	SIEF_ELGA	SIYY	-2,20348E+02	1.0E-04%
t=120 M1 Point 1	SIEF_ELGA	SIYY	-8,73333E-04	1.0E-04%
t=160 M1 Point 1	SIEF_ELGA	SIYY	-2,22222E+02	1.0E-04%
t=200 M1 Point 1	SIEF_ELGA	SIYY	-2,22222E+02	1.0E-04%
t= 90 M1 Point 1	VARI_ELGA	V1	4,76458E-03	1.0E-04%
t=100 M1 Point 1	VARI_ELGA	V1	5,38907E-03	1.0E-04%
t=110 M1 Point 1	VARI_ELGA	V2	1,30893E+03	1.0E-04%
t=200 M1 Point 1	VARI_ELGA	V2	2,31584E+04	1.0E-04%
t=200 M1 Point 1	VARI_ELGA	V4	6,66667E-02	1.0E-04%
t=110 M1 Point 1	VARI_ELGA	V3	9,26799E-04	1.0E-04%
t=200 M1 Point 1	VARI_ELGA	V3	6,64753E-02	1.0E-04%

4 Comments

This case test makes it possible to make sure of the perennality of the results resulting from the law from behavior `IRRAD3M` in plane constraints.