SSNL111 - Three thermoelastoplastic bars Perfect Von Mises

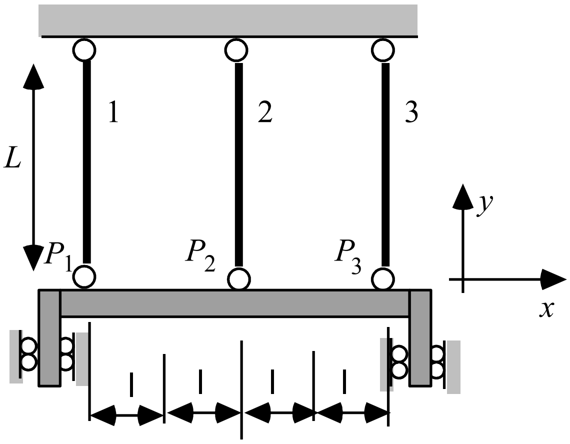
Summary:

This quasi-static test enters within the framework of the validation of the relations of elastoplastic behavior. Three perfect, parallel thermoelastoplastic bars, rotulées on a rigid support at an end and rotulées on a rigid bar with the other, undergo an external thermal loading.

This application, where all the fields are uniform in each bar makes it possible to validate 2 types of digital modelings: massive finite elements ($2D$ plane constraints), plates and bars.

1 Problem of reference

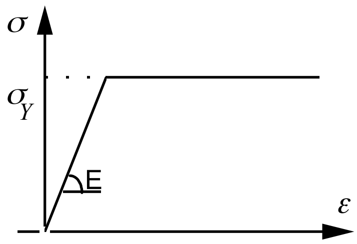
1.1 Geometry



The three bars have the same length $L=1\text{m}$, and are spaced of $l=1\text{m}$.

1.2 Material properties

Law of standard perfect thermoelastoplastic behavior, with criterion of Von Mises. The plastic deformations are worthless in an initial state.



E = 200000 MPa
ν = 0.3
σ_Y = 200 MPa
α = 0.00001

1.3 Boundary conditions and loadings

The three bars have a following blocked displacement Oy at the points higher ends, where they are articulated, and they are attached at the lower points $P_{1,} P_{2,} P_3$, that one can represent by a rigid frame compels to move vertically, length $4l$ on which the three bars are articulated. The bars are free of mechanical effort.

The way of loading is described by the change of the temperature, uniform in each bar ($T^{max}=330°C$):

2 Reference solution

2.1 Method of calculating used for the reference solution

To refer to the document [bib1] which provides the thermoelastoplastic solution.

2.2 Results of reference

Modeling A
σ_{yy} in $P1$, $P2$, $P3$.

Modeling B
Normal effort N constant on each bar (value identical to σ_{yy} , because a section was taken equalize with 1).

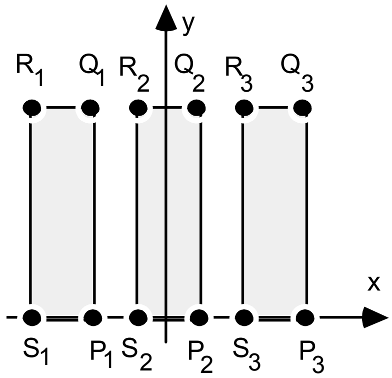
2.3 Bibliographical references

- S. ANDRIEUX: Thermoelastoplastic TD 1 Three bars perfect Von Mises. In “Initiation with thermoplasticity in Code_Aster”, HI-74/96/November 13th, 1996 (manual of reference of the course).

3 Modeling A

3.1 Characteristics of modeling

Elements $2D$ (QUAD4). Modeling C_PLAN.



3.2 Characteristics of the grid

Many nodes: 12.
Many meshs and types: 3 QUAD4.

3.3 Sizes tested and results

Identification	Moments	Node	Reference	*Aster*	Variation $\%$
σ_{yy}	1	*P1*	– 200	– 200.00000	0
σ_{yy}		*P2*	100	100.00000	0
σ_{yy}		*P3*	100	100.00000	0
σ_{yy}	2	*P1*	– 200	– 200.00036	1.8 E-4
σ_{yy}		*P2*	100	100.00017	1.7 E-4
σ_{yy}		*P3*	100	100.00017	1.7 E-4
σ_{yy}	3	*P1*	20	19.99978	– 1.1 E-3
σ_{yy}		*P2*	– 120	– 119.99989	– 0.8 E-4
σ_{yy}		*P3*	100	100.00010	1 E-4
σ_{yy}	4	*P1*	200	200.00060	3 E-4
σ_{yy}		*P2*	– 100	– 100.00008	0.8 E-4
σ_{yy}		*P3*	– 100	– 100.00008	0.8 E-4
σ_{yy}	5	*P1*	200	200.00002	0.1 E-4
σ_{yy}		*P2*	– 100	– 100.00011	1.1 E-4
σ_{yy}		*P3*	– 100	– 100.00011	1.1 E-4

4 Modeling B

4.1 Characteristics of modeling

3 elements $1D$ (SEG2). Modeling BAR
In this modeling, one duplicated the second calculation with STAT_NON_LINE in order to leave the elastic zone and thus to be able to make a validation of the unelastic deformations (EPSP_ELGA) besides the validation of the options EPVC_ELGA and EPME_ELGA on the elements BAR realized on the elastic design.

To achieve this goal the section of the bar and the parameters of non-linearity of material were modified. The section passes to a surface of 1.5 and the parameters of work hardening are the following:

D_SIGM_EPSI = 180
SY = $100.$

4.2 Characteristics of the grid

Many nodes: 6
Many meshs: 3 SEG2

4.3 Sizes tested and results

Elastic design:

Identification	Moments	Bar N °	Reference	*Aster*	Variation $\%$
normal effort N	1	1	– 200	– 200	0
normal effort N		2	100	100	0
normal effort N		3	100	100	0
normal effort N	2	1	– 200	– 200	0
normal effort N		2	100	100	0
normal effort N		3	100	100	0
normal effort N	3	1	20	20	0
normal effort N		2	– 120	– 120	0
normal effort N		3	100	100	0
normal effort N	4	1	200	200	0
normal effort N		2	– 100	– 100	0
normal effort N		3	– 100	– 100	0
normal effort N	5	1	200	200	0
normal effort N		2	– 100	– 100	0
normal effort N		3	– 100	– 100	0

Moment	Mesh/Not	Field/Component	Type of reference	Value of reference	Tolerance (%)
1.0	BARR1/1	EPVC/EPTHER_L	'ANALYTICAL'	150.0E-5	0.1
2.0	BARR1/1	EPVC/EPTHER_L	'ANALYTICAL'	330.0E-5	0.1
3.0	BARR1/1	EPVC/EPTHER_L	'ANALYTICAL'	220.0E-5	0.1

Moment	Mesh/Not	Field/Component	Type of reference	Value of reference	Tolerance (%)
1.0	BARR1/1	EPME/EPXX	'ANALYTICAL'	-1.0E-3	0.1
2.0	BARR1/1	EPME/EPXX	'ANALYTICAL'	-22.0E-4	0.1
3.0	BARR1/1	EPME/EPXX	'ANALYTICAL'	0.	0.1

Non-linear calculation:

Moment	Mesh/Not	Field/Component	Type of reference	Value of reference	Tolerance (%)
1.0	BARR1/1	EPME/EPXX	'NON_REGRESSION'	-	-
1.0	BARR1/1	EPSP/EPXX	'NON_REGRESSION'	-	-

5 Summary of the results

Results provided by *Code_Aster* are in excellent agreement with the analytical solution.