SZLZ110 - Damage of Lemaître generalized in postprocessing

Summary:

The purpose of this test is calculation of the damage of generalized Lemaître “`LEMAIT_S`“starting from the data of the tensor of the constraints and the plastic deformation cumulated at every moment t_i (provided by the user).

The characteristics material E (Young modulus), ν (Poisson's ratio), S and p_d (parameters of material) can depend on the temperature, which must thus be provided by the user at the same moments as the constants and the plastic deformation.

1 Problem of reference

The damage is calculated $D(t)$ starting from the data of the tensor of the constraints $\sigma(t)$ and of the cumulated plastic deformation $p(t)$ exit of a calculation in thermomechanics. The kinetics of damage is given by:

$$\dot{D}=\frac{1}{(1-D)^{2s}}\left[\frac{1}{3\text{ES}}(1+\nu)\sigma_{eq}^2+\frac{3}{2\text{ES}}(1-2\nu)\sigma_H^2\right]^s\dot{p} \quad \text{if } p>p_d$$

$$D=0 \quad \text{if not}$$

σ_{eq} is the equivalent constraint of von Mises
σ_H is the hydrostatic constraint
p_d represent the threshold of damage
S is a characteristic materials (MPa)
s is a characteristic materials

1.1 Properties materials

$Temp(°C)$	$E(MPa)$	ν	$S(MPa)$	P_d	s	
					Case 1	Case 2
0.	143006.0E+6	0.33	7.0	1.005E-6	0.8	1,003
20.	143006.0E+6	0.33	7.0	1.005E-6	0.8	1,003
40.	143006.0E+6	0.33	7.0	1.005E-6	0.8	1,003

Two values of the exhibitor s are successively used for the validation of the developments in `CALC_CHAMP`.

1.2 Loading

The loading corresponds to a tensile test at constant temperature and speed of imposed deformation. It is defined in the paragraph [§2.2].

2 Reference solution

2.1 Method of calculating used for the reference solution

The reference solution is generated starting from the option POST_FATIGUE. Adopted methodology consists in defining a history of loading in constraints and to recover the evolution of the cumulated plastic deformation associated starting from a tensile test $3\mathrm{D}$ in thermo-viscoplasticity.

History of loading $\sigma(t)$ and $p(t)$ is then used in a calculation POST_FATIGUE with the parameters materials presented to the paragraph [§1.1] to define a reference solution.

2.2 Results of Reference

The result of reference of the damage of Lemaître is got for a tensile test to imposed deformation and constant temperature. The state of stresses and the cumulated plastic deformation resulting from this test are the following:

Time $[s]$	**Constraint** $Sxx(t)[Pa]$	**Cumulated plastic deformation** $P(t)$
50	7.15030E+06	0.000000E+00
100	1.43006E+07	0.000000E+00
150	2.14509E+07	0.000000E+00
200	2.86012E+07	0.000000E+00
250	3.57515E+07	0.000000E+00
300	4.29018E+07	0.000000E+00
350	5.00521E+07	0.000000E+00
400	5.72024E+07	0.000000E+00
450	6.43527E+07	0.000000E+00
500	7.15030E+07	0.000000E+00
550	7.86533E+07	0.000000E+00
600	8.58036E+07	0.000000E+00
650	9.29539E+07	0.000000E+00
700	1.00091E+08	9.547120E-08
750	1.06433E+08	5.747160E-06
800	1.10614E+08	2.650910E-05
850	1.12888E+08	6.060610E-05
900	1.14130E+08	1.019250E-04
950	1.14913E+08	1.464460E-04
1000	1.15508E+08	1.922890E-04

This history of loading is then used with the operator POST_FATIGUE option LEMAIT_S to estimate the damage according to time with the properties materials defined in the paragraph [§1.1]. The temperature is supposed to be constant and equalizes with $20°C$. One finds, according to the value of the parameter s used, following damage:

	Damage (reference)	
Time $[s]$	Case $s=0.8$	Case $s=1.003$
50	0.00000E+00	0.00000E+00
100	0.00000E+00	0.00000E+00
150	0.00000E+00	0.00000E+00
200	0.00000E+00	0.00000E+00
250	0.00000E+00	0.00000E+00
300	0.00000E+00	0.00000E+00
350	0.00000E+00	0.00000E+00
400	0.00000E+00	0.00000E+00
450	0.00000E+00	0.00000E+00
500	0.00000E+00	0.00000E+00
550	0.00000E+00	0.00000E+00
600	0.00000E+00	0.00000E+00
650	0.00000E+00	0.00000E+00
700	0.00000E+00	0.00000E+00
750	5.43732E-03	3.19264E-02
800	2.75450E-02	1.90334E-01
850	6.75939E-02	1.00000E+00
900	1.21543E-01	1.00000E+00
950	1.87318E-01	1.00000E+00
1000	2.66202E-01	1.00000E+00

2.3 Uncertainty on the solution

Numerically generated solution.

2.4 Bibliographical references

[1] A.M. DONORE: Estimate of the lifetime in fatigue to great numbers of cycles and in fatigue oligocyclic. Note [R7.04.01] Index B.

3 Modeling A

3.1 Characteristics of modeling

A modeling is used 3D.

3.2 Characteristics of the grid

The grid contains 54 elements of the type QUAD4 and 27 elements of the type HEXA8, for a total of 64 nodes.

3.3 Sizes tested and results

The values of the sizes are tested DOM_LEM.

Identification		Reference		% Tolerance	
		$s=0.8$	$s=1.003$	$s=0.8$	$s=1.003$
Point 1	Too bad	0.0000000	0.0000000	0,001	0,001
Point 2	Too bad	0.0000000	0.0000000	0,001	0,001
Point 3	Too bad	0.0000000	0.0000000	0,001	0,001
Point 4	Too bad	0.0000000	0.0000000	0,001	0,001
Point 5	Too bad	0.0000000	0.0000000	0,001	0,001
Point 6	Too bad	0.0000000	0.0000000	0,001	0,001
Point 7	Too bad	0.0000000	0.0000000	0,001	0,001
Point 8	Too bad	0.0000000	0.0000000	0,001	0,001
Point 9	Too bad	0.0000000	0.0000000	0,001	0,001
Point 10	Too bad	0.0000000	0.0000000	0,001	0,001
Point 11	Too bad	0.0000000	0.0000000	0,001	0,001
Point 12	Too bad	0.0000000	0.0000000	0,001	0,001
Point 13	Too bad	0.0000000	0.0000000	0,001	0,001
Point 14	Too bad	0.0000000	0.0000000	0,001	0,001
Point 15	Too bad	0.0054373	0.0319264	0,001	0,001
Point 16	Too bad	0.0275450	0.1903340	0,001	0,001
Point 17	Too bad	0.0675939	1.0000000	0,001	0,001
Point 18	Too bad	0.1215430	1.0000000	0,001	0,001
Point 19	Too bad	0.1873180	1.0000000	0,001	0,001
Point 20	Too bad	0.2662020	1.0000000	0,001	0,001

One calculates the rate of triaxiality of the constraints, the equivalent constraint of damage, and the damage of Lemaître at the first point of Gauss of the mesh M_1 :

Identification	Component	Increment	Reference (NON_REGRESSION)	Tolerance (%)
ENDO_ELGA	TRIAX	15	0.333333	0.1
ENDO_ELGA	SI_ENDO	15	$1.06433\ 10^{-8}$	0.1
ENDO_ELGA	COENDO	15	$5.65806\ 10^{3}$	0.1
ENDO_ELGA	DOM_LEM	15	$5.43728\ 10^{-3}$	0.1

4 Summary of the results

Results provided by *Code_Aster* coincide with the values of reference.