

SZLZ111 - Damage of Lemaître-Sermage in postprocessing POST_FATIGUE

Summary:

The purpose of this test is calculation of the damage of Lemaître-Sermage "LEMAITRE" starting from a history of multiaxial loading unspecified and history of the cumulated plastic deformation.

One calculates the damage starting from the data of the tensor of the constraints and the plastic deformation cumulated in every moment t_i (provided by the user).

The characteristics material E (Young modulus), ν (Poisson's ratio) and S (parameter of material) must depend on the temperature T . This one must thus be provided by the user at the same moments as $\sigma(t)$ and $p(t)$.

1 Problem of reference

One calculates the damage, $D(t)$, starting from the data of the tensor of the constraints, $\sigma(t)$, and of the cumulated plastic deformation, $p(t)$.

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

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

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)
0.	2.E+5	0.	7.
20.	2.E+5	0.	7.
40.	2.E+5	0.	7.

$$p_d = 0.02$$

1.1.1 Modeling A

In this modeling, one checks the calculation of the damage of Lemaître-Sermage compared to the reference solution given daNS [V9.01.109]. Values of the exhibitor s and of S in the expression of the damage of generalized Lemaître are worth:

$$s = 1.0 \quad \text{and} \quad S = 7.0$$

1.1.2 Modeling B

In this second modeling, one checks the calculation of the damage of Lemaître-Sermage compared to an analytical solution obtained by applying the algorithms presented in the document of référence [R7.04.01]. S values of the exhibitor s and of S in the expression of the damage of generalized Lemaître are worth:

$$s = 1.003 \quad \text{and} \quad S = 7.0$$

1.2 History of the loading

t	43.11	100.	1000.	10000.	20000.	21000.	22000.	22200.	22400.
$\sigma_{xx}(t)$	300.	300.	300.	300.	300.	300.	300.	300.	300.
$\sigma_{yy}(t)$	0.	0.	0.	0.	0.	0.	0.	0.	0.
$\sigma_{zz}(t)$	0.	0.	0.	0.	0.	0.	0.	0.	0.
$\sigma_{xy}(t)$	0.	0.	0.	0.	0.	0.	0.	0.	0.
$\sigma_{xz}(t)$	0.	0.	0.	0.	0.	0.	0.	0.	0.
$\sigma_{yz}(t)$	0.	0.	0.	0.	0.	0.	0.	0.	0.
Temp	20.	20.	20.	20.	20.	20.	20.	20.	20.

t	$p(t)$ (Cumulated Plastic deformation)
43.11	0.019996
100.	0.046384
1000.	0.46384
10000.	4.6384
20000.	9.2768
21000.	9.74064
22000.	10.20448
22200.	10.297248
22400.	10.390016

2 Reference solution

2.1 Method of calculating used for the reference solution

History of loading being very simple, results of reference EPuvent being obtained manually by applying the algorithms presented in the reference document [R7.04.01].

2.2 Results of reference

2.2.1 Modeling A

t	$D(t)$ (Damage)
43.11	0.
100.	0.000848907
1000.	0.014474925
10000.	0.178374238
20000.	0.524693005
21000.	0.602827469
22000.	0.73829052
22200.	0.792149807
22400.	0.967604351

2.2.2 Modeling B

The results of reference for the case test number 2 are got using a spreadsheet in which the expression of the damage of Lemaître-Sermage was established according to a diagram of digital integration identical to that used in the routine `POST_FATIGUE` of `Code_Aster`.

One initially checks that uncertainty on the results got for the value $s=1.0$ via the spreadsheet is acceptable:

Too bad (Excel calculation)	Too bad (reference solution)	Difference (%)
0.0000000000	0.0000000000	0.00000%
0.0008489062	0.0008489070	-0.00010%
0.0144749268	0.0144749250	0.00001%
0.1783742841	0.1783742380	0.00003%
0.5246932887	0.5246930050	0.00005%
0.6028278917	0.6028274690	0.00007%
0.7382915411	0.7382905200	0.00014%
0.7921514337	0.7921498070	0.00021%
0.9676720845	0.9676043510	0.00700%

In the second time, one generates a reference solution for a value of $s = 1,003$:

t	$D(t)$ (Damage – Excel solution)
43.11	0.0
100.	0.004742198
1000.	0.083020455
10000.	1.809947268
20000.	2.003578566
21000.	0.083020455
22000.	0.178700399
22200.	0.199207053
22400.	0.220252827

2.3 Uncertainty on the solution

Analytical 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 Results of modeling A

	Identification	Reference
Point 1	Too bad	0.
Point 2	Too bad	0.000848907
Point 3	Too bad	0.014474925
Point 4	Too bad	0.178374238
Point 5	Too bad	0.524693005
Point 6	Too bad	0.602827469
Point 7	Too bad	0.73829052
Point 8	Too bad	0.792149807
Point 9	Too bad	0.967604351

4 Modeling B

4.1 Results of modeling B

	Identification	Reference
Point 1	Too bad	0.0000000000
Point 2	Too bad	0.0008401910
Point 3	Too bad	0.0143249000
Point 4	Too bad	0.1762380000
Point 5	Too bad	0.5133290000
Point 6	Too bad	0.5863320000
Point 7	Too bad	0.7028150000
Point 8	Too bad	0.7412430000
Point 9	Too bad	0.7967720000

5 Summary of the results

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