SZLZ111 - Damage of Lemaître-Sermageen Summarized `postprocessing`

POST_FATIGUE:

The purpose of this test is computation of the damage of Lemaître-Sermage “`LEMAITRE`” from an unspecified load history multiaxial and history of the cumulated plastic strain.

One calculates the damage from the data of the tensor of the stresses and the plastic strain cumulated in all times t_i (provided by the user).

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

1 Problem of reference

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

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

$$D=0 \qquad \text{not}$$

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

1.1 Materials properties

$Temp(°C)$	$E(MPa)$	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 Modelization A

In this modelization, one compared to the checks the computation of the damage of Lemaître-Sermage reference solution given in [V9.01.109]. The values of the exhibitor s and of S in the statement of the damage of generalized Lemaître are worth:

$s=1.0$ and $S=7.0$

1.1.2 Modelization B

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

$s=1.003$ and $S=7.0$

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 strain)**
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

the load history being very simple, the results of reference can be obtained manually by applying the algorithms presented in the reference document [R7.04.01].

2.2 Results of reference

2.2.1 Modelization 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 Modelization B

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

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

Damage (Excel computation)	**Damage (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 from 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 analytical

solution Solution.

2.4 Bibliographical references

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

3 Modelization A

3.1 Results of the modelization A

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

4 Modelization B

4.1 Results of the modelization B

Identification		Reference
Point 1	Damage	0,0000000000
Item 2	Damage	0,0008401910
Item 3	Damage	0,0143249000
Item 4	Damage	0,1762380000
Item 5	Damage	0,5133290000
Item 6	Damage	0,5863320000
Item 7	Damage	0,7028150000
Item 8	Damage	0,7412430000
Item 9	Damage	0,7967720000

5 Summary of the results

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