SZLZ106 - Tiredness under random request

Summary:

The purpose of this test is calculation of the damage starting from a random request which is characterized by its spectral moments.

From the spectral moments of the random loading one determines the average damage undergone by the structure [R7.04.02].

With this intention one has two methods of counting of cycles of constraints:

- method of counting of the peaks of constraints,
- method of the goings beyond a given level.

One tests also various possibilities of introduction the curve of Wöhler as well as the taking into account of the elastoplastic coefficient of concentration Ke.

The results of reference of this test are the values provided by software POSTDAM developed by Department REME (EDF-DER-EP).

Results provided by the operator `POST_FATI_ALEA` are completely identical to those provided by software POSTDAM.

1 Problem of reference

The analysis consists in determining the average damage undergone by a part subjected to a random loading.

Loading of the random type is entirely characterized by the values of the spectral moments of order 0.2 and 4: λ_0, λ_2 and λ_4 who are introduced under the keywords MOMENT_SPEC_0, MOMENT_SPEC_2 and MOMENT_SPEC_4.

For the calculation of the damage it is necessary to choose a method of counting among the two available ones in *Code_Aster* :

- method of counting of the peaks of constraints,
- method of counting of going beyond a given level.

It is necessary moreover introduce the curve of Wöhler of the material which can be defined in three distinct mathematical forms:

- function point by point, which gives the value amongst cycles to the rupture, according to the alternate constraint S_{alt},
- analytical form of Basquin: $D = A\, S_{alt}^{\beta}$;
- analytical form "zones current"

S_{alt} = alternate constraint = $1/2\,(E_C/E)\,\Delta\sigma$

$X = \log_{10}(S_{alt})$

$N = 10^{a0 + a1\,X + a2\,X^2 + a3\,X^3}$

$$D = \begin{cases} 1./N & \text{if } S_{alt} \geq S_l \\ 0. & \text{if not} \end{cases}$$

where E_C = Young Modulus associated with the curve with tiredness with material,
E = Young Modulus used to determine the constraints,
constants of material $a0$, $a1$, $a2$ and $a3$,
and S_l limit of endurance of material.

Moreover, one can possibly take account of a plastic coefficient of concentration élasto - Ke , defined by:

$$\begin{cases} K_e = 1 & si \quad \Delta\sigma < 3\,S_m \\ K_e = 1 + (1-n)/(\Delta\sigma/3\,S_m - 1)/(n(m-1)) & si \quad 3\,S_m < \Delta\sigma < 3\,m\,S_m \\ K_e = 1/n & si \quad 3\,m\,S_m < \Delta\sigma \end{cases}$$

where S_m is the acceptable maximum constraint,
and n and m two constants depending on material.

In this test, for a single given random loading, one determines the average damage in ten distinct configurations, according to the shape of the curve of Wöhler and the method of counting of cycles.

1.1 Material properties for the study of tiredness

The properties of material relate to the data of a curve of Wöhler making it possible to determine the number of cycles to the rupture for a level of loading given.

1.1.1 Curve of Wöhler in analytical form Basquin

Configuration 1

With	β
1.0017309939 E-14	4,065

Configuration 2

With	β
32. E-13	5.

1.1.2 Curve of Wöhler in form "zones current"

Parameters of definition of configuration 3:

$a0$	$a1$	$a2$	$a3$	Ec	E	Sl
11,495	– 5.	0.25	– 0.07	220000.	200000.	5.

Parameters of definition of configuration 4:

$a0$	$a1$	$a2$	$a3$	Ec	E	Sl
11,495	– 5.	0.25	– 0.07	220000.	200000.	5.

Moreover, one takes one account an elastoplastic coefficient of concentration Ke defined by the parameters for this configuration.

Sm	n	m
60.	0.6	1.4

1.1.3 Curve of Wöhler in form function point by point (configuration 5)

S_{alt}	1.	2.	5.	25.	30.	35.	40.
N	3.125E+11	976562.5E+4	1.E+8	32000.	12860.09	5949.899	3051.76

S_{alt}	45.	50.	55.	60.	65.	70.	75.
N	1693.51	1000.0	620,921	401.8779	269,329	185,934	131.6869

S_{alt}	80.	85.	90.	95.	100.	105.	110.
N	95.3674	70.4296	52.9221	40.3861	31.25	24.4852	19.40379

S_{alt}	115.	120.	125.	130.	135.	140.	145.
N	15.5368	12.55869	10.23999	8.41653	6.96917	5.81045	4.8754

S_{alt}	150.	155.	160.	165	170.	175.	180.
N	4.11523	3.49294	2.98023	2.55523	2.20093	1.90397	1.65382

S_{alt}	185.	190.	195.	200.
N	1.44209	1.26207	1.10835	0.976562

1.2 History of the loading

The random loading is entirely characterized by the values of the spectral moments:

λ_0	λ_2	λ_4
182.5984664	96098024.76	6.346193569E+13

2 Reference solution

2.1 Method of calculating used for the reference solution

The values of reference mentioned in this document are the values provided by software POSTDAM developed by Department REME.

2.2 Results of Reference

	Configuration 1		**Configuration 2**	
Method of counting	Level	PEAK	Level	PEAK
Average damage	3.851827E-7	3.853037E-7	3.129527E-3	3.129848E-3

	Configuration 3		**Configuration 4**	
Method of counting	Level	PEAK	Level	PEAK
Average damage	2.298920E-3	2.299282E-3	2.298920E-3	2.299282E-3

	Configuration 5	
Method of counting	Level	PEAK
Average damage	3.129531E-3	3.129903E-3

3 Modeling A

3.1 Values tested

	Configuration 1: Method going beyond of level	Configuration 1: Method peaks of constraints
	Reference	Reference
Too bad means	3.851827E – 7	3.853037E – 7

	Configuration 2: Method going beyond of level	Configuration 2: Method peaks of constraints
	Reference	Reference
Too bad means	3.129527E-3	3.129848E-3

	Configuration 3: Method going beyond of level	Configuration 3: Method peaks of constraints
	Reference	Reference
Too bad means	2.298920E-3	2.299282E-3

	Configuration 4: Method going beyond of level	Configuration 4: Method peaks of constraints
	Reference	Reference
Too bad means	2.298920E-3	2.299282E-3

	Configuration 5: Method going beyond of level	Configuration 5: Method peaks of constraints
	Reference	Reference
Too bad means	3.129531E-3	3.129903E-3

4 Summary of the results

Results got with *Code_Aster* are completely similar to those provided by software POSTDAM.