SZLZ101 - Calculation of the damage/Method RAINFLOW

Summary:

The purpose of this test is calculation of the damage starting from a history of loading in constraints.

Starting from a simple history of loading defined by DEFI_FONCTION, one extracts the elementary cycles by the method of counting of cycles of the RAINFLOW [R7.04.01], then one calculates the elementary damage associated with each cycle, by interpolation on the curve of Wöhler of material.

One tests various possibilities of introducing the curve of Wöhler, as well as the taking into account of the elastoplastic coefficient of concentration.

To finish, one determines the total damage undergone by the part by cumulating all the elementary damage by the linear rule To mine.

This example is a test of validation of software POSTDAM developed by Department REME, provided in the handbook of validation of version 1.0 of this software.

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

1 Problem of reference

1.1 Geometry

The analysis consists in determining the damage undergone by a part in a point to which one provides the history of loading in constraints.

Starting from a simple history of loading defined by DEFI_FONCTION, one extracts the elementary cycles by the method of counting of cycles of RAINFLOW [R7.04.01], then one calculates the elementary damage associated with each cycle, by interpolation on the curve of Wöhler of material.
One tests various possibilities of introducing the curve of Wöhler and the taking into account or not of an elastoplastic coefficient of concentration:

- The curve of Wöhler is defined in the form:

$$S_{alt} = \text{contrainte alternée} = 1/2(E_C/E)\Delta\sigma \qquad X = \text{LOG}_{10}(S_{alt})$$
$$N = 10^{a0+a1X+a2X^2+a3X^3} \qquad D = \begin{cases} 1/N \text{ si } S_{alt} \geq S_I \\ 0. \text{ sinon} \end{cases}$$

  with:
  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_I limit of endurance of material.
- The curve of Wöhler is defined in the same form and moreover one takes account of an elastoplastic coefficient of concentration defined by:

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

  where
  S_m is the acceptable maximum constraint,
  and n and m two constants depending on material.
- The curve of Wöhler is defined in the analytical form of Basquin: $D = A\,S_{alt}^{\beta}$

To finish, one determines the total damage undergone by the part by cumulating all the elementary damage by the linear rule To mine.

1.2 Material properties

Parameters of definition of the curve of Wöhler:

$a0$	$a1$	$a2$	$a3$	Ec	E	Sl
55.81	– 43.06	11.91	– 1.16	200000.	200000.	180.

Parameters of definition of the elastoplastic coefficient of concentration Ke :

Sm	n	m
126.	0.3	1.7

Parameters of definition of the curve of Wöhler in the form analytical of Basquin:

A	β
1.001730939 E-14	4,065

History of the loading

t	0.	1.	2.

$\sigma(t)$	0.	1000.	0.

2 Reference solution

2.1 Method of calculating used for the reference solution

This test is resulting from the handbook of validation of software POSTDAM version 1.0. The reference solutions are given in this document.

2.2 Results of reference

The counting of the elementary cycles by method RAINFLOW leads to:

Nb_Cycl = 1 Cycle 1 Vale_Min: 0. Vale_Max: 1000.

- **First call** with POST_FATIGUE :

  Cycle 1 Too bad: 2.858503E-4

  The calculation of the total damage by linear office plurality To mine:

  Too bad: 2.858503E-4

- **Second call** with POST_FATIGUE :

  Cycle 1 Too bad: 1.224941E-2

  The calculation of the total damage by linear office plurality To mine:

  Too bad: 1.224941E-2

- **Third call** with POST_FATIGUE :

  Cycle 1 Too bad: 9.377005E-4

  The calculation of the total damage by linear office plurality To mine:

  Too bad: 9.377005E-4

2.3 Uncertainty on the solution

Analytical solution.

2.4 Bibliographical references

1.Handbook of validation POSTDAM 1.0. Baker I., Vatin E. HP-14/93/016/B.

3 Modeling A

3.1 Sizes tested and results

Identification		Reference
NB_CYCL		1.
Cycle 1	VALE_MIN	0.
	VALE_MAX	1000.
First call to POST_FATIGUE :		
Cycle 1	TOO BAD	2.858503E-4
DOMM_CUMU		2.858503E-4
Second call to POST_FATIGUE :		
Cycle 1	TOO BAD	1.22494E-2
DOMM_CUMU		1.22494E-2
Third call to POST_FATIGUE :		
Cycle 1	TOO BAD	9.377005E-4
DOMM_CUMU		9.377005E-4

4 Summary of the results

Results provided by *Code_Aster* are perfectly identical to the values of reference.