SDLV129 - Vibratory fatigue of a paddle of Summarized

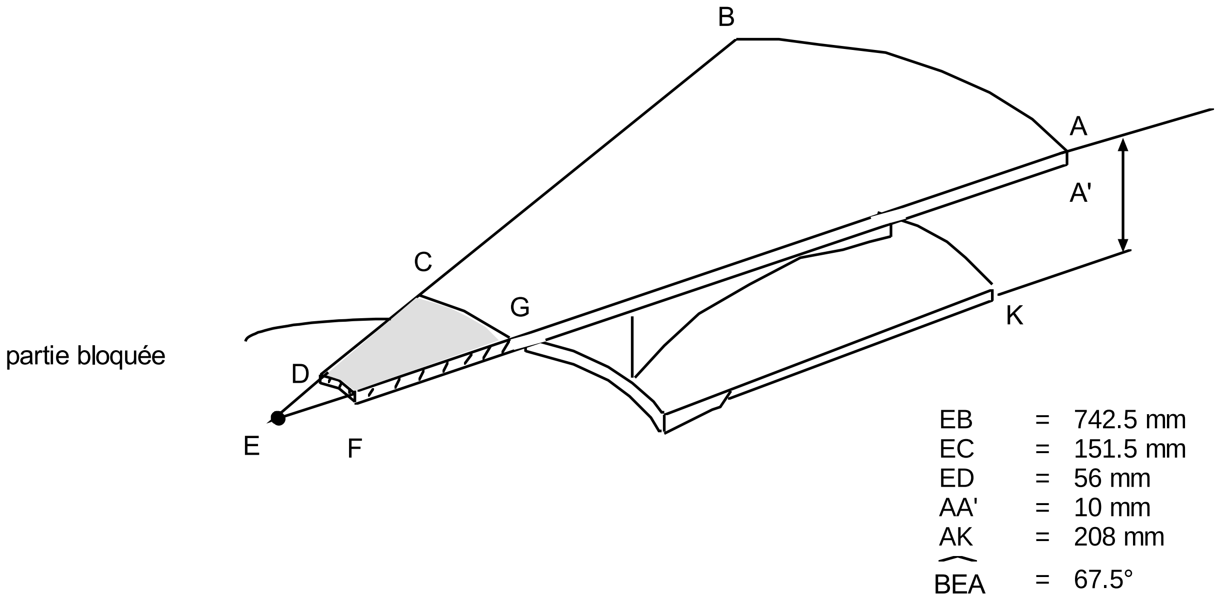
ventilator:

This case test makes it possible to validate the computation of the amplitude of maximum vibration acceptable for a paddle of ventilator. The computation is based on the computation of the modal stresses then postprocessing with operator `CALC_FATIGUE`.

This case test comprises only one modelization. The values of reference are of standard NON-regression. One analytically checks in some nodes, starting from the stresses calculated by Code_Aster, that postprocessing in fatigue is correct.

1 Problem of reference

1.1 Geometry



1.2 Material properties

$E=210\,000\,MPa$

$\nu=0.3$

$\rho=7.8\,10^{-6}\,kg/mm^3$

$S_u=1000\,MPa$ (stress the rupture)

$S_l=500\,MPa$ (limit of endurance)

1.3 Boundary conditions and loadings

Fixed support of the end of the higher veil in the hub (shaded zone).

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution is obtained analytically in a given node of computation. One is interested here only in the validation of postprocessing in fatigue; the values of the stresses and displacements to the node considered are those resulting from computation with *Code_Aster*.

2.2 Results of reference

One is interested more particularly:

- with the coefficient of maximum amplitude acceptable associated with the node $N111$ of the mesh 294 , which is the node statically charged;
- with the maximum amplitude of acceptable vibration for the node $N194$ (at the end of wing).

Two cases are considered: a request with the first eigen mode only; a request with the first two eigen modes. One supposes in the last case that the weight of the second eigen mode is equal to half of the weight of the first eigen mode.

The table below corresponds to the first computation. The static stress σ_{stat} (signed von Mises) with the node considered is of $307{,}71\,MPa$; the modal stresses of the first two modes are respectively $9{,}80\,MPa$ and $-31{,}15\,MPa$.

The modal stresses correspond to normalized stresses. The purpose is, knowing the static stress, to calculate the maximum amplitude of variation of the dynamic stress (sum of the modal stresses taken into account) allowing an unlimited endurance of structure. The coefficient α corresponds to this maximum amplitude. It is calculated either by means of the line of Goodman, or by means of the parabola To stack:

$$\alpha_{Goodman}=S_l\left(1-\frac{\sigma_{stat}}{S_u}\right)/\sigma_{dyn} \text{ and } \alpha_{Gerber}=S_l\left(1-\left(\frac{\sigma_{stat}}{S_u}\right)^2\right)/\sigma_{dyn}$$

In these two formulas, S_l represents the restricted one of endurance. $S_l=500$ in this test is associated with the amplitude of the alternating load with $1.E6$ cycles. S_u is the maximum stress of the material. $S_u=1000$ in this test.

Case	Forced statiqueformule σ_{stat}	Forced dynamic σ_{dyn}	α_{Gerber}	$\alpha_{Goodman}$
Mode 1	$307{,}71\,MPa$	$9{,}80\,MPa$	46,18	35,32
Mode 1 + 0,5 Mode 2	$307{,}71\,MPa$	$25{,}37\,MPa$	17,83	13,64

to pass from the coefficient α with the acceptable amplitude of vibration in a point given $\partial\tilde{u}$ (corresponding for example to the position of a sensor), an additional operation is to be realized, see documentation [U4.83.02].

One notes $\tilde{u}^i_{mod}$ displacement at the point of interest associated with the mode i ; the acceptable amplitude of vibration in this point is then:

$$\partial \tilde{u} = min(\alpha) \sum_{i=1}^{N} \beta_i \tilde{u}^i_{mod}$$

where $(\beta_i)_{1 \le i \le N}$ the relative weights of the various eigen modes considered.

This operation is clarified below for the node $N194$ (at the end of wing). It is noted that the values of $\beta_i, \tilde{u}^i_{mod}$ are obtained with Code_Aster.

It is noted that the node the charged statically does not correspond to node more penalizing: the coefficient α calculated above is not the value minimal on all the mesh (confer for the value minimal for the correction To stack below).

Case	DX (mm)	DY (mm)	DZ (mm)	α^{min}_{Gerber}	DX^{max} (mm)	DY^{max} (mm)	DZ^{max} (mm)	D^{max} (mm)
Mode 1	0.38	1	-0.05	31,36	11,91	31,36	1,56	33,58
Mode 2	*0.24*	*0.27*	*0.92*	/	/	/	/	/
Mode 1 + 0,5Mode 2	0.49	1.14	0.51	8,73	3,28	7,56	3,40	9,92

2.3 Uncertainty on the solution

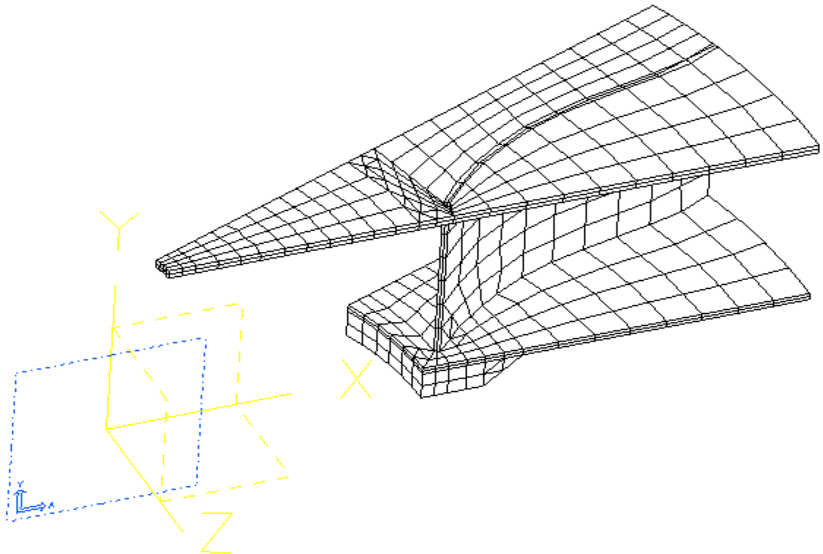
No, the solution is analytical.

3 Modelization A

3.1 Characteristic of the mesh

Many nodes: 4945

Number of meshes and types: 768 HEXA20 , 120 PENTA15.



3.2 Quantities tested and results

One indicates below all the values tested. One and the distinguishes the tests from NON-regression analytical references. For these last, all the results calculated with *Code_Aster* are equal to the analytical results.

Parameter	Standard	Reference	*Place*
Von Mises stress – result static	N111/M294	$307{,}71\ MPa$	Not - regression
Von Mises stress – mode 1	N111/M294	$9{,}80\ MPa$	Not - regression
Von Mises stress – mode 2	N111/M294	$-31{,}15\ MPa$	Not - regression
$\alpha_{Goodman}$ Mode 1	N111/M294	35,32	Analytical
$\alpha_{Goodman}$ Mode 1	min	21,13	Not - regression
$\alpha_{Goodman}$ Mode 1+0,5 mode 2	N111/M294	13,64	Analytical
$\alpha_{Goodman}$ Mode 1+0,5 mode 2	min	6,66	Not - regression
α_{Gerber} Mode 1	N111/M294	46,18	Analytical
α_{Gerber} Mode 1	min	27,71	Not - regression
maximum Displacement acceptable Mode 1+0,5 Mode 2	Analytical	N194	8,73

4 Summaries of the results

This test makes it possible to validate postprocessing in fatigue vibratory of a modal computation with operator CALC_FATIGUE.