SDLV129 - Vibratory tiredness of a paddle of ventilator

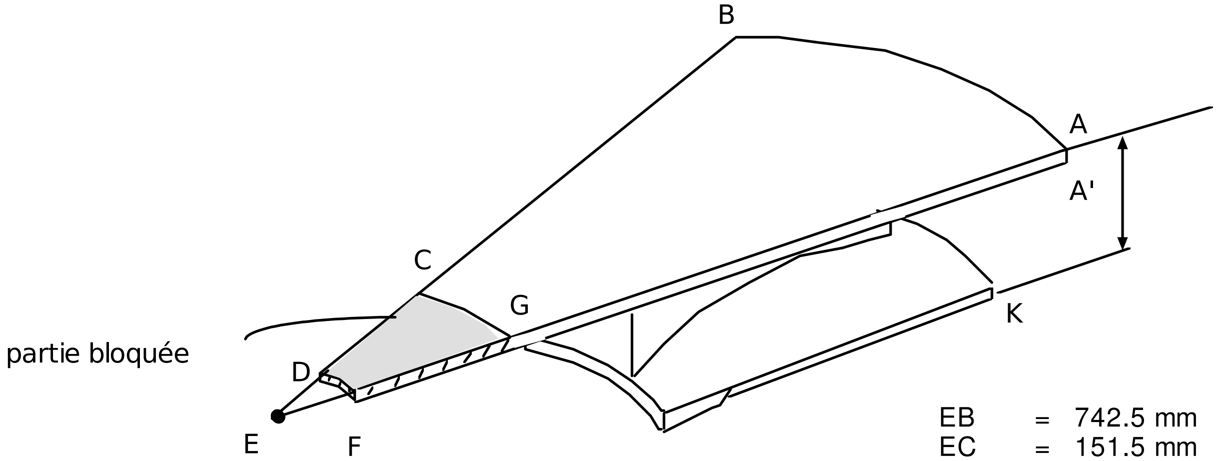
Summary:

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

This case test comprises only one modeling. The values of reference are of standard not-regression. One analytically checks in some nodes, starting from the constraints calculated by Code_Aster, that postprocessing in fatigue is correct.

1 Problem of reference

1.1 Geometry



EB	=	742.5 mm
EC	=	151.5 mm
ED	=	56 mm
AA'	=	10 mm
AK	=	208 mm
$\widehat{BEA}$	=	67.5°

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

Embedding 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 calculation. One is interested here only in the validation of postprocessing in fatigue; the values of the constraints and displacements to the node considered are those resulting from calculation with *Code_Aster*.

2.2 Results of reference

One is interested more particularly:

- with the coefficient of maximum amplitude acceptable associated with the node $N111$ 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 clean mode only; a request with the first two clean modes. One supposes in the last case that the weight of the second clean mode is equal to half of the weight of the first clean mode.

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

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

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

In these two formulas, S_l represent limited 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 constraint of material. $S_u=1000$ in this test.

Case	Static stress σ_{stat}	Dynamic stress 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 given point $\partial \tilde{u}$ (corresponding for example to the position of a sensor), an additional operation is to be realized, to 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 $(\beta_i)_{1 \le i \le N}$ relative weights of the various clean 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 statically charged does not correspond to the node more penalizing: the coefficient α calculated above is not the value minimal on all the grid (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

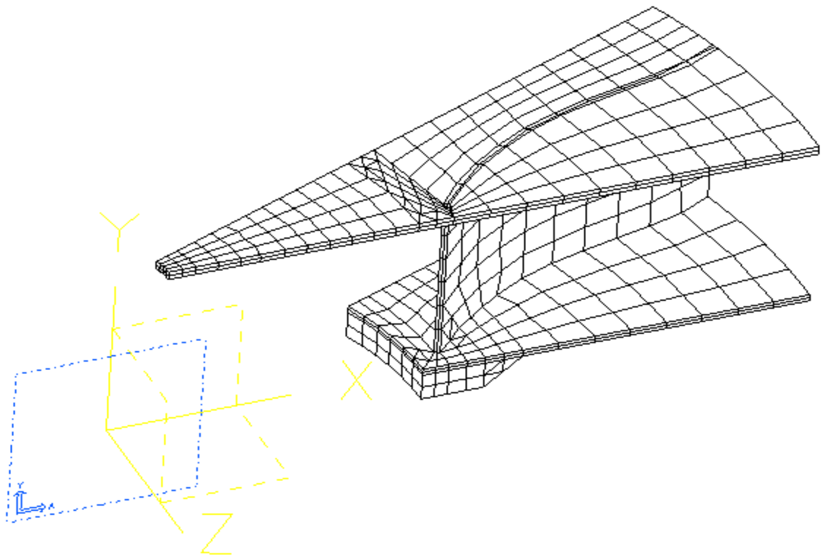
No, the solution is analytical.

3 Modeling A

3.1 Characteristics of the grid

Many nodes: 4945

Many meshs and types: 768 `HEXA20` , 120 `PENTA15`.



3.2 Sizes tested and results

One indicates below the whole of the values tested. One distinguishes the tests of not-regression and the references analytical. For these last, the whole of the results calculated with *Code_Aster* is equal to the analytical results.

Parameter	**Place**	**Reference**	***Type***
Constraint of von Mises – result static	N111 / M294	$307{,}71\,MPa$	Not - regression
Constraint of von Mises – mode 1	N111 / M294	$9{,}80\,MPa$	Not - regression
Constraint of von Mises – 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
Acceptable maximum displacement Mode 1+0,5 Mode 2	N194	8.73	Analytical

4 Summaries of the results

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