SDLS127 - Harmonic answer of a viscoelastic plate sandwich embedded on an edge

Summary:

The objective of this test is to validate the calculation of the harmonic answer of a structure comprising at the same time standard elastic materials, and viscoelastic materials whose properties depend on the frequency.

Three modelings are carried out:
- Modeling A : direct calculation on physical basis, by calculating the assembled matrices frequency by frequency; this modeling is used as reference;
- Modeling b: preliminary calculation of the real clean modes, then harmonic calculation on modal basis;
- Modeling C: preliminary calculation of the real clean modes improved (“beta-modes”), then harmonic calculation on modal basis.

1 Problem of reference

1.1 Geometry

Image 1.1-1: Geometry of the plate sandwich.

Plate rectangular sandwich made up of three layers of different materials:

Side 0.05 m X 0.15 m

Thickness: aluminium (above): 0.5 mm
viscoelastic material (center): 1 mm
steel (below): 1 mm

1.2 Properties of materials

The material of the layer of the top is aluminium (elastic isotropic); its properties are constant:

- Young modulus $E=70\ 000\ MPa$
- Poisson's ratio $\nu=0,3$
- density $\rho=2700\ kg/m^3$
- damping hysteretic $\eta=0,001$

The material of the layer of the lower part is steel (elastic isotropic); its properties are constant:

- Young modulus $E=210\ 000\ MPa$
- Poisson's ratio $\nu=0,3$
- density $\rho=7800\ kg/m^3$
- damping hysteretic $\eta=0,002$

The material of the central layer is viscoelastic (elastomer); some of its properties are dependent on the frequency:

Frequency (Hz)	Real part of the Young modulus E (MPa)	Factor of loss η
1	23.2	1.1
10	58	0.85
50	145	0.7
100	203	0.6
500	348	0.4
1000	435	0.35
1500	464	0.34

Table 1.2-1 : Properties dependent on the frequency of viscoelastic material.

The others are constant:

- Poisson's ratio $\nu=0{,}45$
- density $\rho=1200\,kg/m^3$

1.3 Boundary conditions and loadings

Boundary conditions:

- embedding on an edge of the layer of steel.

Loading:

- nodal force at point a: FZ=1.

1.4 Initial conditions

Without object (harmonic calculation).

2 Reference solution

2.1 Method of calculating

The harmonic answer Co-localised to point A is calculated by a direct method, frequency by frequency. Thus, frequency by frequency:

- a viscoelastic material is defined whose properties are interpolated starting from the data of Table 1.2-1 ;
- one calculates the assembled matrices of mass and hysteretic rigidity;
- one résoud the equation of dynamics in physical base (operator `DYNA_LINE_HARM` [U4.53.11]).

2.2 Sizes and results of reference

The tests are carried out on frequency response Co-localised to point A to 1 Hz, 100 Hz and 500 Hz.

2.3 Uncertainties on the solution

Digital solution.

3 Modeling A

3.1 Characteristics of modeling

Viscoelastic material: modeling `3D`.
Material steel: modeling `DKT` (the surface elements are the lower skin of the voluminal elements of the viscoelastic layer).
Material aluminium: modeling `DKT` (the surface elements are the higher skin of the voluminal elements of the viscoelastic layer).

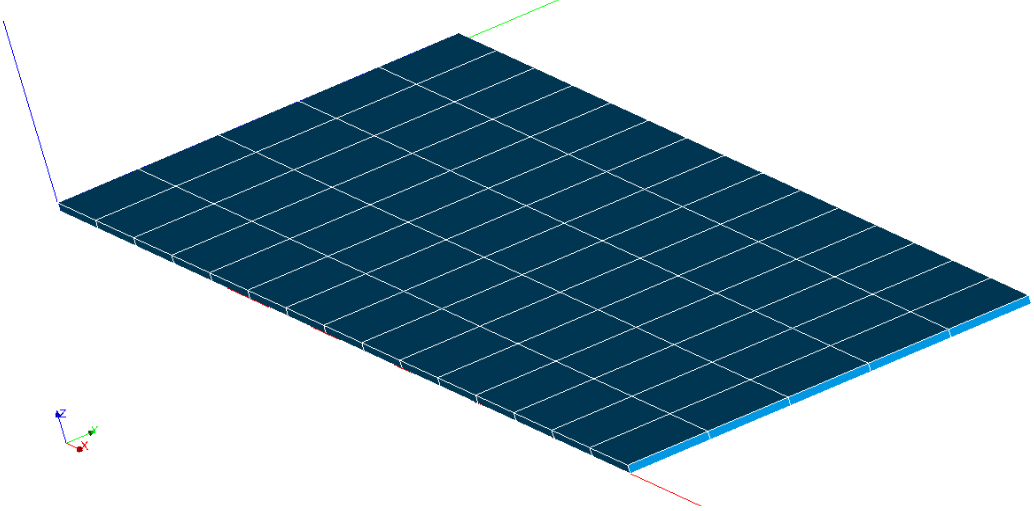

Image 3.1-1 : Grid of the plate sandwich.

3.2 Characteristics of the grid

Many nodes 192
Many meshs 349

of which: elements	`SEG2`	84
	`QUAD4`	190
	`HEXA8`	75

3.3 Sizes tested and results

This modeling is used as reference, the tests are thus carried out only to check the not-regression of the code.

One tests the values of displacement according to axis Z at point A.

Direct method
Size
DZ (NUME_ORDE=1)
DZ (NUME_ORDE=100)
DZ (NUME_ORDE=500)

4 Modeling B

4.1 Characteristics of modeling

Idem that for modeling A.

4.2 Characteristics of the grid

Idem that for modeling A.

4.3 Sizes tested and results

The method used for calculation of the clean modes is the method “mode real” (`TYPE_MODE=' REEL'`).
One tests the values of displacement according to axis Z at point A.

Method “real mode”	
Size	**Reference**
DZ (NUME_ORDE=1)	3.84063122275e-04 - 8.77803614739e-05j
DZ (NUME_ORDE=100)	-1.1663671537e-04 - 9.6134604316e-06j
DZ (NUME_ORDE=500)	-1.302768494 e-05 - 1.65977932083 e-06j

5 Modeling C

5.1 Characteristics of modeling

Idem that for modeling A.

5.2 Characteristics of the grid

Idem that for modeling A.

5.3 Sizes tested and results

The method used for calculation of the clean modes is the method " β - mode " (`TYPE_MODE='BETA'`).
One tests the values of displacement according to axis Z at point A.

Method "beta mode"	
Size	**Reference**
DZ (NUME_ORDE=1)	3.84063122275e-04 - 8.77803614739e-05j
DZ (NUME_ORDE=100)	-1.1663671537e-04 - 9.6134604316e-06j
DZ (NUME_ORDE=500)	-1.302768494 e-05 - 1.65977932083 e-06j

Table 5.3-1: Sizes tested and results of reference for modeling C.

6 Summary of the results

Method “real mode”
The got results reveal a maximum error of 2.61% compared to the reference solution.

Method “ β-mode “
The got results reveal a maximum error of 2.71% compared to the reference solution.