

## SDLV124 – Voluminal paving stone subjected to a pressure harmonic

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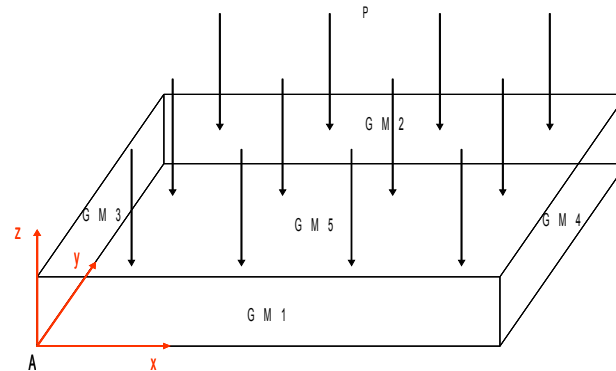
### Summary:

The objective of this CAS-test is to validate calculation harmonic of a rectangular paving stone modelled in voluminal elements subjected to a sinusoidal pressure. One also validates the harmonic calculation of answer on a matrix projected on modal basis.

The reference solution is obtained using a transitory calculation carried out on the same model.

## 1 Problem of reference

### 1.1 Geometry



Dimensions of the paving stone ( $m$ ) :

length (according to  $x$ ) : 0.35  
width (according to  $y$ ) : 0.25  
thickness (according to  $z$ ) : 0.01

### 1.2 Elastic properties of material

$E = 1.8 \times 10^{11} Pa$  Young modulus  
 $\nu = 0.3$  Poisson's ratio  
 $\rho = 7800.0 kg.m^{-3}$  Density  
 $\alpha = 3 \times 10^{-5} s$   
 $\beta = 0.001 s^{-1}$

Coefficients  $\alpha$  and  $\beta$  allow to build a matrix of viscous damping proportional to rigidity and the mass  $[C] = \alpha[K] + \beta[M]$ .

### 1.3 Boundary conditions and loadings

- Embedding of the side faces
- Harmonic pressure of amplitude  $p = 10^5 Pa$  at a frequency  $f = 1500 Hz$  on the higher face

## 2 Reference solution

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### 2.1 Method of calculating

It is a question of calculating the answer of a voluminal paving stone subjected to a harmonic pressure on its higher face. The reference solution is obtained by carrying out a transitory calculation of answer on physical basis by using the diagram of integration of Newmark with the parameters  $\alpha=0.25$  and  $\delta=0.5$ .

### 2.2 Sizes and results of reference

One proposes to test the following sizes:

- Following displacement  $x$  at the point of coordinates  $(0.1575, 0.125, 0)$
- Constraint and deformation at the point of Gauss of a mesh containing the node of coordinates  $(0.3325, 0.05, 0)$
- Constraint and deformation with the node of coordinates  $(0.3325, 0.05, 0)$

### 2.3 Uncertainties on the solution

It is considered that the mode is established at the end of 90 periods of the excitation. The values of reference selected are those raised on the 98<sup>ième</sup> and 99<sup>ième</sup> periods of the transitory answer.

## 3 Modeling A

### 3.1 Characteristics of modeling A

One calculates the harmonic answer (to 1500 Hz) on physical basis and the matrix projected on the first fifteen clean modes of the structure.

The paving stone is modelled using the voluminal elements 3D

### 3.2 Characteristics of the grid

Many nodes: 1764

Many meshes:

QUAD4 : 1040

HEXA8 : 1200

Names and coordinates of the nodes of control:

N433 : (0.1575, 0.125, 0)

N627 : (0.3325, 0.05, 0)

### 3.3 Sizes tested and results

Identification	Reference	Type of reference	Tolerance
Calculation on physical basis: DX with the node N433	$9.0386 E-7 m$	'AUTRE_ASTER'	0.1 %
Calculation on projected matrix: DX with the node N433	$9.0386 E-7 m$	'AUTRE_ASTER'	0.1 %
SIXX at the point of Gauss number 1 of the mesh M1145	$4.5806 E6 Pa$	'AUTRE_ASTER'	0.1 %
SIXX with the node N627 mesh M1145	$4.7080 E6 Pa$	'AUTRE_ASTER'	0.1 %
EPXX at the point of Gauss number 1 of the mesh M1145	$2.31494 E-5$	'AUTRE_ASTER'	0.1 %
EPXX with the node N627 mesh M1145	$2.14060 E-5$	'AUTRE_ASTER'	0.1 %

Note: the tests are made by intercomparison between harmonic calculation and transitory calculation on physical basis.

The kinetic energy is calculated ECIN\_ELEM mesh M1145 :

Option	Component	Reference	Type of reference	Tolerance
ECIN_ELEM	TOTAL	$7.02862 10^{-7}$	NON_REGRESSION	-

## 4 Modeling B

### 4.1 Characteristics of modeling B

Modeling B is a copy of the modeling A in which one replaced material ELAS by a material ELAS\_ORTH in order to in the case of validate the taking into account of the parameters of damping orthotropic materials.

### 4.2 Sizes tested and results

Identification	Reference	Type of reference	Tolerance
Calculation on physical basis: DX with the node N433	9.05292783145e-07 m	'AUTRE_ASTER'	1E-4 %
Calculation on projected matrix: DX with the node N433	8.96432120282e-07 m	'AUTRE_ASTER'	1E-4 %
SIXX at the point of Gauss number 1 of the mesh M1145	4590176.44097 Pa	'AUTRE_ASTER'	1E-4 %
SIXX with the node N627 mesh M1145	4715493.552 Pa	'AUTRE_ASTER'	1E-4 %
EPXX at the point of Gauss number 1 of the mesh M1145	2.31913955511e-05	'AUTRE_ASTER'	1E-4 %
EPXX with the node N627 mesh M1145	2.14446331642e-05	'AUTRE_ASTER'	1E-4 %

Note: the tests are made by intercomparison between harmonic calculation and transitory calculation on physical basis.

The kinetic energy is calculated ECIN\_ELEM mesh M1145 :

Option	Component	Reference	Type of reference	Tolerance
ECIN_ELEM	TOTAL	7.02862 10 <sup>-7</sup>	'AUTRE_ASTER'	1E-4 %

## 5 Summary of the results

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The computation results of the harmonic answer (on physical basis and modal basis) are very close to those obtained with a transitory calculation are equivalent which was used as reference.