

## SDLV131 - Simulation of a gauge of deformation by the order OBSERVATION

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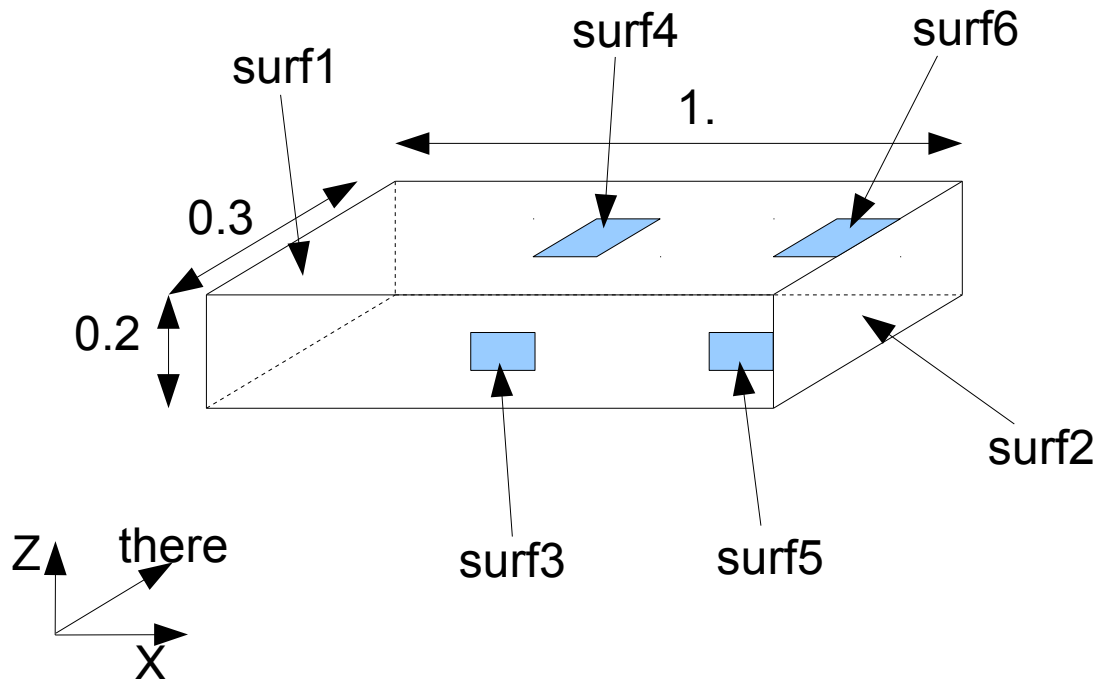
### Summary:

This test validates the operation of the calculation of the median value of a field of deformation on an entity given by the user. The field of deformation thus is estimated that a gauge of deformation would have measured. One carries out this calculation via the macro-order `OBSERVATION`. The treated case is a beam in simple traction modelled by voluminal elements.

This case test also validates the observation of mixed fields: only one call to the order `OBSERVATION` for the statement of fields of different nature (`DEPL`, `QUICKLY`,...).

## 1 Problem of reference

### 1.1 Geometry



### 1.2 Properties of material

Young modulus:  $E = 2.110^{11} \text{ N/m}^2$

Poisson's ratio:  $\nu = 0.3$

Density:  $\rho = 7800. \text{ kg/m}^3$

### 1.3 Boundary conditions and loadings

A horizontal displacement is imposed  $u_x = 0.0$  on the face *surf1*.

A displacement is imposed  $u_y = 0.0$  on the nodes which are on the central line of the higher face and on the central line of the lower face.

A displacement is imposed  $u_z = 0.0$  on the nodes which are on the central lines of the side faces.

A surface force is applied  $F_B$  on the face *surf2* according to the direction  $x$ ,

$$F_B = 1000. \text{ N/m}^2,$$

These boundary conditions make it possible to obtain a behavior of the beam in simple traction.

### 1.4 Initial conditions

Without object

## 2 Reference solution

### 2.1 Method of calculating

The deformation is estimated starting from the relative lengthening of the beam.

The lengthening of a beam length  $L$  following a longitudinal force  $F$  is written:

$$\Delta L = \frac{FL}{ES}$$

In our case, one applies a force per unit of area  $F_B$  at the loose lead of the beam, thus the relative lengthening of the beam is put in the following form:

$$\frac{\Delta L}{L} = \epsilon_{xx} = \frac{F_B}{E}$$

For this case test, one calculation results resulting from a static calculation, a harmonic calculation, a transitory calculation and of a modal calculation.

For the static case, one obtains:

$$\epsilon_{xx} = \frac{F_B}{E} \quad \text{and} \quad \epsilon_{yy} = \epsilon_{zz} = -\nu \epsilon_{xx}$$

For the dynamic cases, the system is governed by the following equation:

$$M \frac{\partial^2 u}{\partial t^2} + K u = F_{ext}$$

For a beam in traction and compression, if one considers a model which contains one element, the matrices of mass  $M$  and of rigidity  $K$  put themselves in the following form:

$$M = \frac{\rho SL}{6} \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} \quad K = \frac{ES}{L} \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \quad \text{with: } u = \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

$u_1$  and  $u_2$  are displacements of the nodes of the element.

In harmonic answer of pulsation  $\omega$ , displacements of the nodes of the element are governed by the following relation:

$$\frac{ES}{L} \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} - \omega^2 \frac{\rho SL}{6} \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} = \begin{bmatrix} F_1 \\ F_2 \end{bmatrix}$$

By exploiting the second-row forward of this relation, and by applying the boundary conditions ( $u_1=0$  and  $F_2=F=F_B S$ ), one obtains:

$$u_2 = \frac{F_B}{\frac{E}{L} - \omega^2 \frac{\rho L}{3}} = \Delta L$$

The deformation at the loose lead of the beam is written:

$$\varepsilon_{xx} = \frac{\Delta L}{L} = \frac{F_B}{E - \omega^2 \frac{\rho L^2}{3}} \quad \text{and} \quad \varepsilon_{yy} = \varepsilon_{zz} = -\nu \varepsilon_{xx}$$

The reference solution for the transitory solution can be obtained same manner. If a longitudinal force is applied  $F(t) = F_B \sin(\omega_0 t)$  with an initial condition of beam in balance (initial displacement no one and worthless initial speed), one obtains:

$$u_2(t) = \frac{3 F_B}{\rho L \omega_0^2} \left[ t - \frac{\sin(\omega_0 t)}{\omega_0} \right] = \Delta L \quad \text{with:} \quad \omega_0^2 = \frac{3 E}{\rho L^2}$$

And the deformation at the loose lead of the beam is written:

$$\varepsilon_{xx} = \frac{\Delta L}{L} = \frac{3 F_B}{\rho L^2 \omega_0^2} \left[ t - \frac{\sin(\omega_0 t)}{\omega_0} \right] \quad \text{and} \quad \varepsilon_{yy} = \varepsilon_{zz} = -\nu \varepsilon_{xx}$$

In the case of modal calculation, one carries out a test of not-regression on the deformations calculated at the point medium of the beam.

One also simulates a rotation of 90 degrees in order to check the change of reference mark in OBSERVATION.

## 2.2 Sizes and results of reference

One tests the value of the average deformation on surfaces: *surf3* , *surf4* , *surf5* and *surf6* . The got results are then projected on the model "measures" which understands only the nodes *P3* , *P4* , *P5* and *P6* associated with surfaces *surf3* , *surf4* , *surf5* and *surf6* .

For the validation of the static solution, one has chooses:  $F_B = 1000. N/m^2$

For the validation of the harmonic solution, one chose:  $F_B = 1000.(1 + 2j) N/m^2$  and:  
 $\omega = 2\pi 200 rd s^{-1}$

For the validation of the transitory solution, one chose:  $F_B = 1000. t N/m^2$  and the solution is tested at the moment  $t = 1 s$

One also tests the values of the fields obtained by mixed observation.

## 2.3 Uncertainties on the solution

Analytical solution for the static case, the harmonic case and the transitory case.  
One suggests a solution of not-regression in the case of the modal deformation.

## 2.4 Bibliographical reference

[R3.08.01] "exact" Elements of beams (right and curved).

## 3 Modeling A

### 3.1 Characteristics of modeling

One calculates the average deformation resulting from a static calculation of answer with MECA\_STATIQUE.

One also calls upon the operator **OBSERVATION** for the statements of fields of displacement and deformation.

### 3.2 Characteristics of the grid

Nodes: 1029  
Meshs: 720 HEXA8

### 3.3 Sizes tested and results

One tests the value of the deformation to the nodes which are in the middle of the beam.

Identification	Reference	Aster	Tolerance
$\varepsilon_{xx}$ in <i>P3</i>	4.7619047619 048D-09	4.7619047619 047D-09	0.1%
$\varepsilon_{zz}$ in <i>P3</i>	- 1.4285714285 714D-09	- 1.4285714285 714D-09	0.1%
$\varepsilon_{yy}$ in <i>P4</i> (after rotation of $90^\circ$ )	4.7619047619 048D-09	4.7619047619 047D-09	0.1%
$\varepsilon_{xx}$ in <i>P4</i> (after rotation of $90^\circ$ )	- 1.4285714285 714D-09	- 1.4285714285 714D-09	0.1%

Tests for the mixed observation:

Identification	Reference	Aster	Tolerance
$\varepsilon_{xx}$ in <i>P3</i>	4.7619047619 048D-09	4.7619047619 047D-09	0.1%
<i>DX</i> in <i>P5</i> (m)	4.7619047619 048D-09	4.5238095238 095D-09	6.0%

## 4 Modeling B

### 4.1 Characteristics of modeling

One calculates the average deformation resulting from a harmonic calculation.  
One chooses a frequency of excitation equalizes with  $200\text{ Hz}$ .

One also calls upon the operator **OBSERVATION** for the statements of fields of displacement and deformation.

### 4.2 Characteristics of the grid

Nodes: 1029  
Meshs: 720 HEXA8

### 4.3 Sizes tested and results

One tests the value of the deformation to the nodes which are at the loose lead of the beam.

Identification	Reference	Aster	Tolerance
$\varepsilon_{xx}$ in <i>P5</i>	4.8568623280 004D-09 + i9.713724656 0009D-09	4.7813760355 714D-09 + i9.562752071 1429D-09	2.0%
$\varepsilon_{zz}$ in <i>P5</i>	- 1.4570586984 001D-09 - i2.914117396 8003D-09	- 1.4339303380 850D-09 - i2.867860676 1701D-09	2.0%
$\varepsilon_{yy}$ in <i>P6</i> (after rotation of $90^\circ$ )	4.8568623280 004D-09 + i9.713724656 0009D-09	4.7792223250 189D-09 + i9.558444650 0377D-09	2.0%
$\varepsilon_{xx}$ in <i>P6</i> (after rotation of $90^\circ$ )	- 1.4570586984 001D-09 - i2.914117396 8003D-09	- 1.4339110329 539D-09 - i2.867822065 9079D-09	2.0%

Tests for the mixed observation:

Identification	Reference	Aster	Tolerance
$\varepsilon_{xx}$ in <i>P5</i>	4.8568623280 004E-09 + i9.713724656 0009E-09	4.7792696544 452E-09 + i9.558539308 8903E-09	2.0%

# Code\_Aster

Version  
default

Titre : SDLV131 - Simulation d'une jauge de déformation pa[...]  
Responsable : ANDRIAMBOLOLONA Harinaivo

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d2c1c4eae01

Displacement $DX$ in $P5$ (m)	4.8568623280 004E-09 +	4.6188418141 639E-09 +	5.0%
	i9.713724656 0009E-09	i9.237683628 3278E-09	
Speed $DX$ in $P5$ (m/s)	-	-	5.0%
	1.2206626407 315E-05 +	1.1608415609 177E-05 +	
	i6.103313203 6573E-06	i5.804207804 5883E-06	

## 5 Modeling C

### 5.1 Characteristics of modeling

One calculates the average deformation resulting from a transitory calculation on physical basis. For the resolution of the system, one chooses a temporal discretization equalizes with  $0.1 s$ .

One also calls upon the operator **OBSERVATION** for the statements of fields of displacement and deformation.

### 5.2 Characteristics of the grid

Nodes: 1029  
Meshs: 720 HEXA8

### 5.3 Sizes tested and results

One tests the value of the deformation to the nodes which are at the loose lead of the beam at the moment  $t=1 s$ .

Identification	Reference	Aster	Tolerance
$\varepsilon_{xx}$ in $P5$	4.7614812131 879D-09	4.7619095908 375D-09	2.0%
$\varepsilon_{zz}$ in $P5$	- 1.4284443639 564D-09	- 1.4285727587 481D-09	2.0%
$\varepsilon_{yy}$ in $P6$ (after rotation of $90^\circ$ )	4.7614812131 879D-09	4.7619090586 422D-09	2.0%
$\varepsilon_{xx}$ in $P6$ (after rotation of $90^\circ$ )	- 1.4284443639 564D-09	- 1.4285727564 358D-09	2.0%

Tests for the mixed observation:

Identification	Reference	Aster	Tolerance
$\varepsilon_{xx}$ in $P5$	4.7614812131 879E-09	4.7619090690 47E-09	2.0%
Displacement $DX$ in $P5$ (m)	4.7614812131 879E-09	4.5238330203 209E-09	6.0%



## 6 Modeling D

### 6.1 Characteristics of modeling

One calculates the average deformation resulting from a modal calculation with `CALC_MODES`.

One also calls upon the operator `OBSERVATION` for the statements of fields of displacement and deformation.

### 6.2 Characteristics of the grid

Nodes: 1029  
Meshs: 720 `HEXA8`

### 6.3 Sizes tested and results

One tests the median value of the deformation of the first longitudinal mode of the beam to the nodes which are in the medium and the loose lead. The values of reference are those obtained with the version 10.1 (test of not-regression). They are given with four significant figures.

Identification	Reference	Aster	Tolerance
$\epsilon_{xx}$ in <i>P3</i>	1,012	1.0120571181 683D+00	0.1%
$\epsilon_{zz}$ in <i>P3</i>	-3.063D-1	- 3.0631275158 658D-01	0.1%
$\epsilon_{xx}$ in <i>P5</i>	1.762D-1	1.7617357057 031D-01	0.1%
$\epsilon_{zz}$ in <i>P5</i>	-4.646D-2	- 4.6458825653 459D-02	0.1%
$\epsilon_{yy}$ in <i>P4</i> (after rotation of 90°)	1,017	1.0168194189 613D+00	0.1%
$\epsilon_{xx}$ in <i>P4</i> (after rotation of 90°)	-3.118D-1	- 3.1181161388 859D-01	0.1%
$\epsilon_{yy}$ in <i>P6</i> (after rotation of 90°)	1.533D-1	1.5327248667 577D-01	0.1%
$\epsilon_{xx}$ in <i>P6</i> (after rotation of 90°)	-4.178D-2	- 4.1782881091 537D-02	0.1%

Tests for the mixed observation:

Identification	Reference	Aster	% difference
$\varepsilon_{xx}$ in $P3$	1,01	1.0144135640 865	0.1%
Displacement $DX$ in $P3$ (m)	0.7570	0.7570567975 9059	0.1%

## 7 Summary of the results

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The purpose of these tests are to check the good progress of calculation of the median value of the field of deformation using the macro-order `OBSERVATION`. The reference solution is analytical for the static answer, the harmonic answer and the transitory answer.

This case test also validates the mixed observation of field (`DEPL`, `QUICKLY`,...) with only one call to the operator `OBSERVATION`.

The differences between the solutions obtained with Aster and the analytical solutions are very weak. For the results resulting from a modal calculation, a test of not-regression is proposed.