SSLV120 - Stretching of an orthotropic parallelepiped under its own Summarized

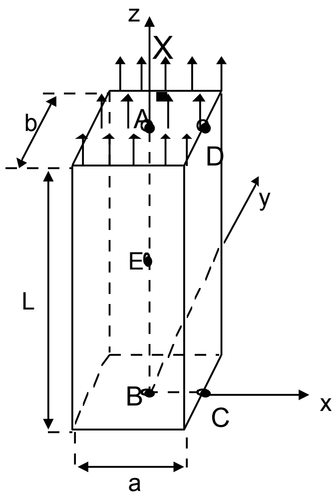
weight:

This test of structural mechanics allows the evaluating of displacements and the stresses of a parallelepiped becoming deformed under its own weight. The material is elastic linear orthotropic. The modelization is three-dimensional. The model is similar to test VPCS SSLV07 (but in this case the material is isotropic) and with test SSLV121 (in this case the material is isotropic transverse).

The variations of the results got by *Aster* range between 0,00 and 0,5% of the analytically calculated reference.

1 Problem of reference

1.1 Geometry



Hauteur : $L=3m$ Largeur : $a=1m$ Epaisseur : $b=1r$

Coordinated of the points (in meters):

	A	B	C	D	E	X
x	0.	0.	0.5.0.5		0.	0.
y	0.	0.	0.	0.	0.	0.5
z	3.	0.	0.	3.	1.5	3.

1.2 Material properties

Young's moduli in the directions x , y and z :

$$E_L=5.10^{11}\,Pa \quad E_T=5.10^{11}\,Pa \quad E_N=2.10^{11}\,Pa\,.$$

Poisson's ratios in the planes xy , xz and yz :

$$\nu_{\mathrm{LT}}=0.1 \quad \nu_{\mathrm{LN}}=0.3 \quad \nu_{\mathrm{TN}}=0.1\,.$$

Shear moduli in the planes xy , xz and yz :

$$G_{\mathrm{LT}}=7.69231\,10^{10}\,Pa \quad G_{\mathrm{LN}}=7.69231\,10^{10}\,Pa$$
$$G_{\mathrm{TN}}=7.69231\,10^{10}\,Pa\,.$$

Density: $\rho=7800\,kg/m^3$.

1.3 Boundary conditions and loadings

Point: A ($u=v=w=0$, $\theta_x=\theta_y=\theta_z=0$)

Inertia loading following the axis z : $\rho\,g\,z$
Uniform stress with the tension for the upper face:

$\sigma_z = \rho g L = +229554. Pa$

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution is resulting from that given in file SSLV07/89 of guide VPCS (while considering in more one orthotropic elastic matrix). The analytical statement of the solution is the following one:

Displacements:

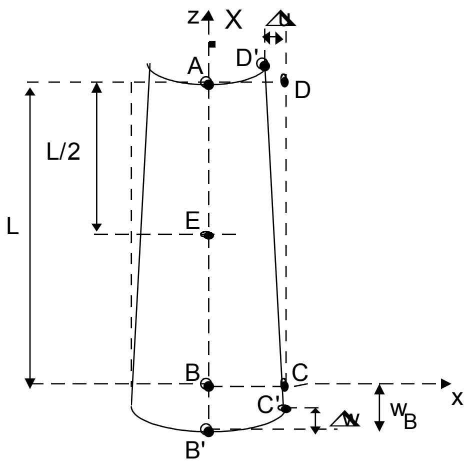
$$u = -\frac{\nu_{NL} \rho g x z}{E_N}$$

$$v = -\frac{\nu_{NT} \rho g y z}{E_N}$$

$$w = \frac{\rho g z^2}{2 E_N} + \frac{\rho g}{2 E_N} (\nu_{NL} x^2 + \nu_{NT} y^2) - \frac{\rho g L^2}{2 E_N}$$

Stresses:

$$\sigma_{zz} = \rho g z \quad \sigma_{zz} = \sigma_{yy} = \sigma_{xy} = \sigma_{yz} = \sigma_{zx} = 0$$



2.2 Results of reference

Displacement of the points B C D , E and X.

Stresses σ_{zz} in A and E

2.3 Uncertainty on the solution

exact analytical Results.

2.4 Bibliographical references

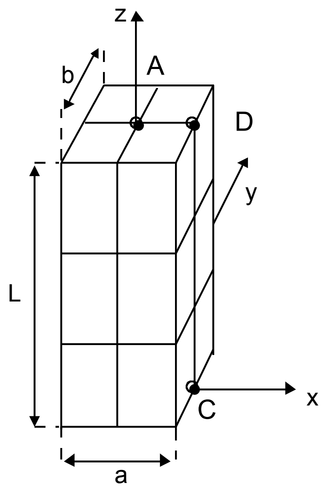
• TIMOSHENKO (S.P) Theory of elasticity - Paris - Polytechnic Library CH. Béranger, p.279 with 282 (1961)

• S.W. TSAI, H.T. HAHN - Introduction to composite materials. Technomic Publishing Company (1980).

3 Modelization A

3.1 Characteristic of the modelization

3D meshes hexa20



Cutting:

3 elements in height
2 elements in width and thickness

limiting Conditions:

on axis AB	DDL_IMPO: (GROUP_NO: ABsansA DX=0., DY=0.)
in A and D	(THE NODE IS OUTSIDE THE FIELD OF DEFINITION WITH A RIGHT PROFILE OF THE EXCLU TYPE NODE: A DX=0., DY=0., DZ=0.) (THE NODE IS OUTSIDE THE FIELD OF DEFINITION WITH A RIGHT PROFILE OF THE EXCLU TYPE NODE: D DY=0.)

Names of the nodes:

$A=N59$	$B=N53$	$C=N12$
$D=N18$	$E=N56$	$X=N70$

3.2 Characteristics of the mesh

Many nodes: 111

Number of meshes and types: 12 HEXA20

3.3 Values tested

Identification	Reference
U_B	0.
V_B	0.
W_B	-1.721655 E-6
U_C	0.
V_C	0.

W_C	-1.715916 E-6
U_D	-6.88662 E-08
V_D	0.
W_D	5.73885 E-9
U_E	0.
V_E	0.
W_E	-1.29124125 E-06
(Pa)	
$\sigma_{zz}\ (A)$	2.29554 10^5
$\sigma_{zz}\ (E)$	1.14777 10^5
$\sigma_{zz}\ (X)$	2.29554 10^5
U_X	0.
V_X	– - 2.29554 E-8
W_X	1.91295 E-9

3.4 Remarks

The modelization in HEXA20 is completely acceptable for this coarse mesh.

4 Summary of the results

the results concerning displacements and the forced are very close to the analytical solution with the adopted modelization (< 0.2% for displacements, < 0.5% for the stresses).

The elastic coefficients in the 3 directions of orthotropy were selected so as to obtain the same values of displacements at the points B C, D and E that those calculated for an isotropic material (test SSLV007) or isotropic transverse (test SSLV121). Numerically, these values are very close to those of these tests at the points considered (about 10^{-6}) the difference resulting from the method of construction of the stiffness matrixes in the various cases. At the point X, these values differ but correspond well to the reference solution.