SSLV07 - Stretching of a parallelepiped under its own weight

Summary:

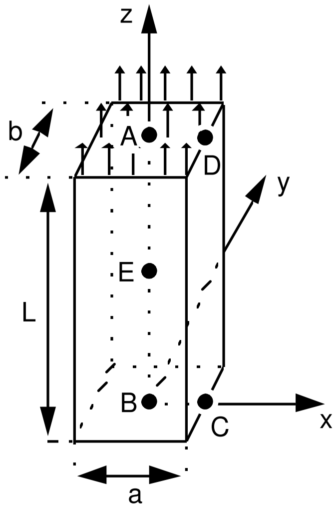
This static test 3D makes it possible to validate the following features:

- loading in actual weight (gravity or internal force) and in uniform pressure,
- calculation of the potential energy of the structure,
- estimator of error in residue (modeling B)
- incompressible elements (modeling D).

It understands 4 modelings. Its interest lies in the description of the effect of the Poisson's ratio (of contraction).

1 Problem of reference

1.1 Geometry



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

Coordinates of the points (in meters):

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

1.2 Material properties

$E=2\,10^{11}\,MPa$

$\nu=0.3$

$\rho=7\;800\;\;kg/m^3$

1.3 Boundary conditions and loadings

Not A : ($u=v=w=0$, $\theta_x=\theta_y=\theta_z=0$)

Actual weight following the axis z

Uniform constraint with traction for the higher face: $\sigma_z=\rho\,g\,L=+229\,554.\,Pa$

2 Reference solution

2.1 Method of calculating used for the reference solution

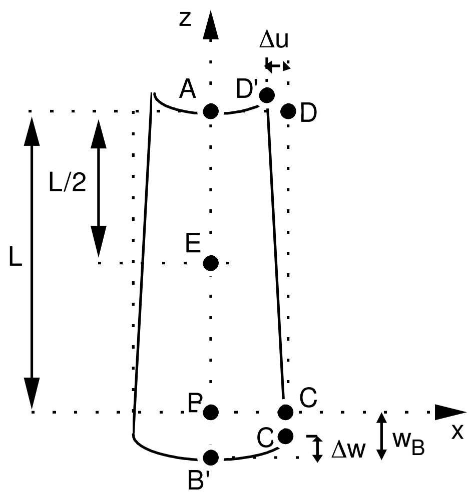
The reference solution is that given in card SSLV07/89 of the guide VPCS which presents the method of calculating in the following way:

Displacements:

$$u=-\frac{\nu\rho g x z}{E}$$
$$v=-\frac{\nu\rho g y z}{E}$$
$$w=\frac{\rho g z^2}{2E}+\frac{\nu\rho g}{2E}(x^2+y^2)-\frac{\rho g L^2}{2E}$$

Constraints:

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



2.2 Results of reference

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

Constraints σ_{zz} in A and E.

2.3 Uncertainty on the solution

Analytical solution.

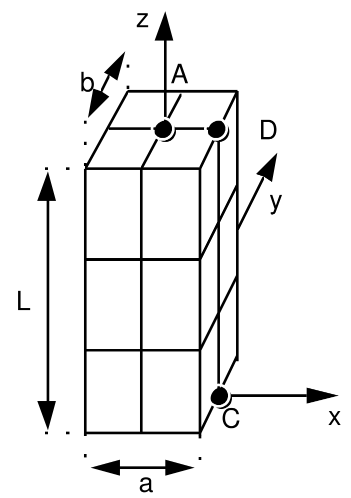
2.4 Bibliographical references

1) S.P. TIMOSHENKO. Theory of elasticity. Paris. Polytechnic bookstore. CH. Béranger, p.279 with 282 (1961).

3 Modeling A

3.1 Characteristics of modeling

3D



Cutting: 3 in height
2 in width and thickness
meshs hexa20

Limiting conditions: $DX=DY=0$ on $]AB]$, $DY=0$ in D, $DZ=0$ in A

Names of the nodes: $Point\ A=N59$ $Point\ B=N53$
$Point\ C=N12$ $Point\ D=N18$
$Point\ E=N56$

3.2 Characteristics of the grid

Many nodes: 111

Many meshs and types: 12 HEXA20

3.3 Sizes tested and results

Localization	Type of value (m)	Reference
Not B	U_B	0.
	V_B	0.
	W_B	$-1.721655\ 10^{-6}$
Not C	U_C	0.
	V_C	0.
	W_C	$-1.707308\ 10^{-6}$
Not D	U_D	$-1.721655\ 10^{-7}$
	V_D	0.

	W_D	1.434713 10^{-8}
Not E	U_E	0.
	V_E	0.
	W_E	– 1.291241 10^{-6}
	(Pa)	
Not A	σ_{zz}	2.29554 10^5
Not E	σ_{zz}	1.14777 10^5

3.4 Remarks

Modeling in HEXA20 is completely acceptable for this coarse grid. This modeling also makes it possible to test the good taking into account of the application of gravity a list of meshs or groups of meshs targeted.

4 Modeling B

4.1 Characteristics of modeling

3D

Cutting: 12 in height
8 in width and thickness
meshs HEXA8

Limiting conditions: $DX=DY=0$ on $]AB[$, $DY=0$ in D, $DZ=0$ in A

Names of the nodes:
$Point\ A=N533$ $Point\ B=N521$
$Point\ C=N989$ $Point\ D=N1001$
$Point\ E=N527$

4.2 Characteristics of the grid

Many nodes: 1053

Many meshs and types: 768 HEXA8

4.3 Remarks

This modeling makes it possible to test the estimator of error in residue in 3D.

4.4 Sizes tested and results

Localization	Type of value (m)	Reference
Not B	U_B	0.
	V_B	0.
	W_B	$-1.721655\ 10^{-6}$
Not C	U_C	0.
	V_C	0.
	W_C	$-1.707308\ 10^{-6}$
Not D	U_D	$-1.721655\ 10^{-7}$
	V_D	0.
	W_D	$1.434713\ 10^{-8}$
Not E	U_E	0.
	V_E	0.
	W_E	$-1.291241\ 10^{-6}$
	(Pa)	
Not A	σ_{zz}	$2.29554\ 10^5$
HEX12	relative error	1.15
HEX600	relative error	1.30

4.5 Remarks

The grid remains insufficient for a modeling in HEXA8. The total relative error is weak (3%) but exceeds 20% on certain meshs.

5 Modeling C

5.1 Characteristics of modeling

3D

Cutting: 12 in height
8 in width and thickness
meshs hexa8

Limiting conditions: $DX=DY=0$ on $]AB[$, $DY=0$ in D, $DZ=0$ in A

Names of the nodes: $Point\ A=N533$, $Point\ B=N521$, $Point\ C=N989$, $Point\ D=N1001$, $Point\ E=N527$

5.2 Characteristics of the grid

Many nodes: 1053

Many meshs and types: 768 HEXA8

5.3 Remarks

This modeling makes it possible to test the keyword `FORCE_INTERNE` in `AFFE_CHAR_MECA_F`.

5.4 Sizes tested and results

Localization	Type of value (m)	Reference
Not B	U_B	0.
	V_B	0.
	W_B	$-1.721655\ 10^{-6}$
Not C	U_C	0.
	V_C	0.
	W_C	$-1.707308\ 10^{-6}$
Not D	U_D	$-1.721655\ 10^{-7}$
	V_D	0.
	W_D	$1.434713\ 10^{-8}$
Not E	U_E	0.
	V_E	0.
	W_E	$-1.291241\ 10^{-6}$
	(Pa)	
Not A	σ_{zz}	$2.29554\ 10^{5}$

5.5 Remarks

The grid remains insufficient for a modeling in HEXA8.

6 Modeling D

6.1 Characteristics of modeling

3D

Cutting: 3 in height
2 in width and thickness
meshs hexa20

Limiting conditions: $DX=DY=0$ on $]AB]$, $DY=0$ in D, $DZ=0$ in A

Names of the nodes: $Point\ A=N59$ $Point\ B=N53$
$Point\ C=N12$ $Point\ D=N18$
$Point\ E=N56$

6.2 Characteristics of the grid

Many nodes: 111

Many meshs and types: 12 HEXA20

6.3 Sizes tested and results

Localization	Type of value (m)	Reference
Not B	U_B	0.
	V_B	0.
	W_B	$-1.721655\ 10^{-6}$
Not C	U_C	0.
	V_C	0.
	W_C	$-1.707308\ 10^{-6}$
Not D	U_D	$-1.721655\ 10^{-7}$
	V_D	0.
	W_D	$1.434713\ 10^{-8}$
Not E	U_E	0.
	V_E	0.
	W_E	$-1.291241\ 10^{-6}$
	(Pa)	
Not A	σ_{zz}	$2.29554\ 10^{5}$
Not E	σ_{zz}	$1.14777\ 10^{5}$

6.4 Remarks

Incompressible elements HEXA20 give the same results as the standard elements.

7 Summary of the results

Type of value (m)	Reference	Aster Hexa20 (A)	Aster Hexa8 (B)
U_B	0.		
V_B	0.		
W_B	$-1.721655\ 10^{-6}$	< 0.1%	< 0.1%
U_C	0.		X
V_C	0.		
W_C	$-1.707308\ 10^{-6}$	< 0.1%	0.1%
U_D	$-1.721655\ 10^{-7}$	< 0.1%	– 2.2%
V_D	0.		
W_D	$1.434713\ 10^{-8}$	– 0.2%	– 15.5%
U_E	0.		
V_E	0.		
W_E	$-1.291241\ 10^{-6}$	< 0.1%	< 0.1%
(Pa)			
$A\ \sigma_{zz}$	$2.29554\ 10^{5}$	< 0.1%	– 5.3%
$E\ \sigma_{zz}$	$1.14777\ 10^{5}$	< 0.1%	< 0.1%

Modeling: With (HEXA20 cutting: 3 in Z, 2 in X and Y)
B (HEXA8 cutting: 12 in Z, 8 in X and Y)

Modeling in HEXA8 would require a grid much finer.