

SSLV307 - Cylinder obliques under load axial uniform

Summary:

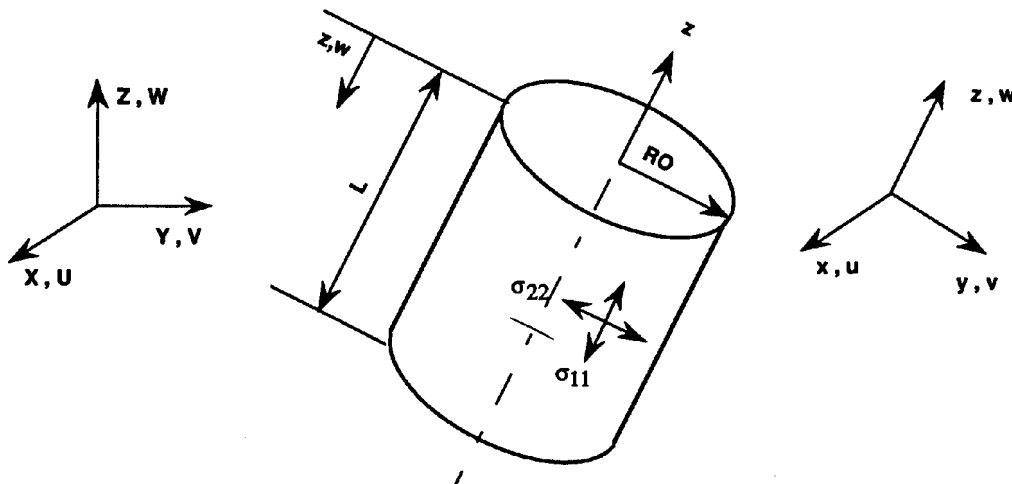
The purpose of the test is to validate the various types of linear relations, defined by the keywords LIAISON_DDL , LIAISON_OBLIQUE , LIAISON_GROUP .

It also makes it possible to test the option “symmetries cyclic” starting from the modeling of a sector of the cylinder.

The analysis is carried out in 3D.

1 Problem of reference

1.1 Geometry



Average radius: $R_o = 1 \text{ m}$
 Thickness: $h = 0.02 \text{ m}$
 Height: $L = 4 \text{ m}$

Cosine directors of the axis of the cylinder: $(0.0, 0.5, \frac{\sqrt{3}}{2})$

Local axis x parallel with the total axis X .

1.2 Material properties

$$E = 2.1 \times 10^{11} \text{ Pa}$$

$$\nu = 0.3$$

1.3 Boundary conditions and loadings

- Axial displacement no one at the low end ($w=0$)
For the other boundary conditions (linear relations), to see paragraph [§3].
- Uniform axial loading per unit of length $q = 10000 \text{ N/m}$, applied at the high end.

1.4 Initial conditions

Without object for the static analysis.

2 Reference solution

2.1 Method of calculating used for the reference solution

- Radial displacement in local reference mark (x, y, z) :

$$u_r = \frac{qvRo}{Eh} = - \frac{1}{4} U^2 + \frac{\sqrt{3}}{2} V - 0.5 W \frac{1}{2}$$

where U, V, W = component of displacement in the total reference mark (X, Y, Z) .

- If $\sigma_{xx}, \sigma_{yy}, \sigma_{zz} = \sigma_{11}$ are the constraints in the local reference mark, the constraints expressed in the total reference mark are worth:

$$\begin{aligned} \sigma_{xx} &= \sigma_{xx} \\ &= 3/4 \sigma_{yy} + 1/4 \sigma_{11} & \sigma_{11} &= q/h \\ \sigma_{zz} &= 1/4 \sigma_{yy} + 3/4 \sigma_{11} \\ \sigma_{yz} &= - \frac{\sqrt{3}}{4} \sigma_{yy} + \frac{\sqrt{3}}{4} \sigma_{11} \end{aligned}$$

In the local plan (x, z) , $\sigma_{yy} = 0$ (circumferential constraint),

from where $\sigma_{yy} = 1/4 \sigma_{11}, \sigma_{zz} = 3/4 \sigma_{11}$

2.2 Results of reference

- Radial displacement: $u_r = -7.14 \times 10^{-7} m$
- In the local plan (x, z) , $\sigma_{yy} = 1.25 \times 10^5 Pa$, $\sigma_{zz} = 3.75 \times 10^5 Pa$

2.3 Uncertainty on the solution

- Analytical solution

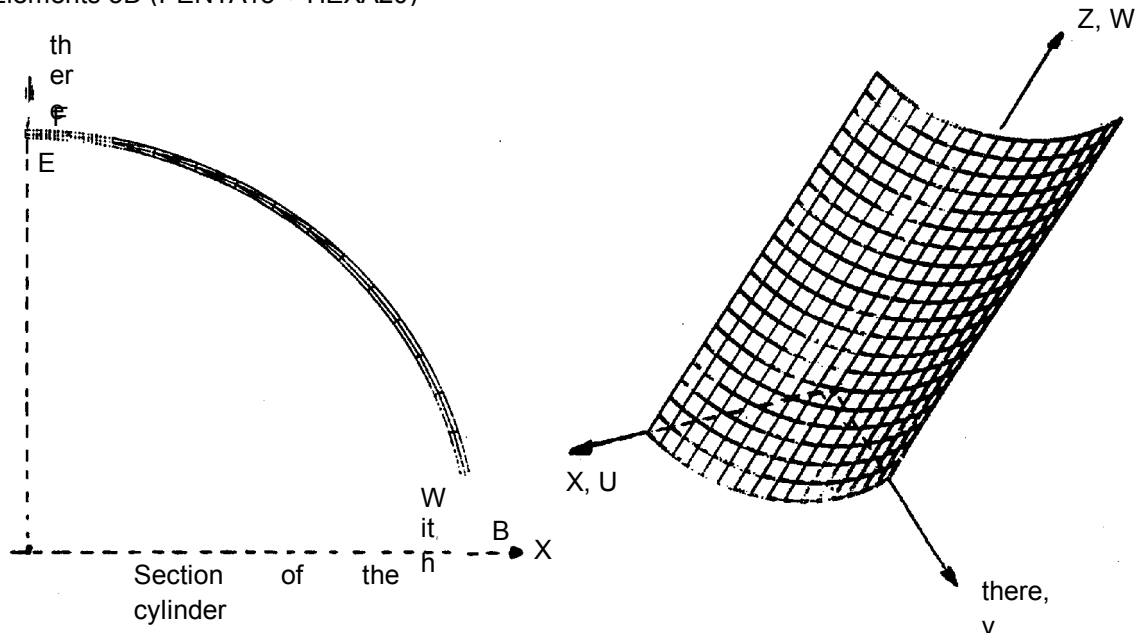
2.4 Bibliographical references

- R.J. ROARK and W.C. YOUNG: Formulated for stress and strain, 5^e edition. New York, Mc Graw-Hill, 1975

3 Modeling A

3.1 Characteristics of modeling

Elements 3D (PENTA15 + HEXA20)



Modeling:

1/4 of the cylinder following the circumference

2 zones: zone 1 = lower part ($0 \leq z \leq L/2$)
zone 2 = upper part ($L/2 \leq z \leq L$)

Cutting:

20 elements according to the length
16 elements according to the circumference
2 elements in the thickness

Coordinates of the points (r, θ, z)

	Wit h	G	B	E	G1	F	A2 A' 2	H H'	B2 B' 2	E2 E' 2	H1 H' 1	F2 F' 2	A3	I	B3	E3	I1	F3
r	IH	R	Re	IH	R	Re	IH	R	Re	IH	R	Re	IH	R	Re	IH	R	Re
θ	0.	0.	0.	90.	90.	90.	0.	0	.0.	90.	90.	90.	0.	0.	0.	90.	90.	90.
z	0.	0.	0.	0.	0.	0.	L/2	L/2	L/2	L/2	L/2	L/2	L	L	L	L	L	L

R_i = interior ray

R_e = external ray

points $A_2, H, B_2, E_2, H_2, F_2$ are in the section $z = L/2$ zone 1

points $A' 2, H', B' 2, E' 2, H' 2, F' 2$ are opposite respective in zone 2

Boundary conditions:

- Conditions of support $w=0$ at the base (section $z=0$.) introduced by the keyword LIAISON_OBLIQUE
- Conditions of symmetry $v=0$ on the face AB introduced by the keyword LIAISON_OBLIQUE
- Conditions of symmetry $u=0$ on the face EF introduced by the keyword LIAISON_OBLIQUE
- Identification of the nodes common to the 2 zones (section $z=L/2$) by the keyword LIAISON_GROUP.

Loading:

Density of surface charge $p=q/h=500000\text{ N/m}^2$, along the axis, that is to say in total reference mark:

$$F_x=0.$$

$$F_y=p/2$$

$$F_z=p\frac{\sqrt{3}}{2}$$

Name of the nodes:

plan $z=0$. $A=N\ 1$ $B=N\ 321$ $E=N\ 1740$ $F=N\ 1541$ $G=N\ 1540$

plan $z=2$ (zone 1) $A2=N\ 961$ $B2=N\ 993$ $E2=N\ 2141$ $F2=N\ 2122$ $H=N\ 962$ $HI=N\ 2121$

plan $z=2$ (zone 2) $A'2=N\ 3361$ $B'2=N\ 3364$ $E'2=N\ 2151$ $F'2=N\ 2151$ $H'=N\ 3360$ $H'1=N\ 2156$

plan $z=4$ $A3=N\ 3359$ $B3=N\ 3355$ $I=N\ 3356$ $E3=N\ 2151$ $F3=N\ 2154$ $II=N\ 2150$

3.2 Characteristics of the grid

Many nodes: 4298

Many meshes and types: 160 HEXA20, 320 PENTA15

3.3 Values tested

Values of displacements U, V, W read on file

Localization	Type of value	Reference
Not G	$U(m)$	$-7,143 \times 10^{-7}$
	$V(m)$	0.
	$W(m)$	0.
Not H, H'	$U(m)$	$-7,143 \times 10^{-7}$
Not I	$U(m)$	$-7,143 \times 10^{-7}$

Not $G1$	$U(m)$	0.
Points $H1, H'1$	$U(m)$	0.

Values of displacements u, v, u_r in local reference mark calculated from U, V, W

Localization	Type of value	Reference
Not G	$u_r(m)$	$-7,143 \times 10^{-7}$
	$v(m)$	0.
Not H, H'	$u_r(m)$	$-7,143 \times 10^{-7}$
	$v(m)$	0.
Not I	$u_r(m)$	$-7,143 \times 10^{-7}$
	$v(m)$	0.
Not $A2, A'2$	$v(m)$	0.
Points $B2, B'2$		
Not $G1$	$u(m)$	0.
	$u_r(m)$	$-7,143 \times 10^{-7}$
Points $H1, H'1$	$u(m)$	0.
	$u_r(m)$	$-7,143 \times 10^{-7}$
Not II	$u(m)$	0.
	$u_r(m)$	$-7,143 \times 10^{-7}$
Points $E2, E'2$	$u(m)$	0.
Points $F2, F'2$	$u(m)$	0.
Points A, B, G		
$A2, B2, H$	$\sigma_{YY}(Pa)$	1.25×10^5
$A'2, B'2, H'$		
$A3, B3, I$		
Points A, B, G		
$A2, B2, H$	$\sigma_{ZZ}(Pa)$	3.75×10^5
$A'2, B'2, H'$		
$A3, B3, I$		

3.4 Remarks

- Radial displacement u_r is obtained with a good precision.

- Conditions of symmetry on the face AB ($v=0$ locally, that is to say $\frac{\sqrt{3}}{2}V - 05W = 0$) are checked at the points $A2, A'2, G, B2, B'2, H, H', I$ considered.
In the same way, conditions of symmetry on the face EF ($u=U=0$) are checked at the points $E2, E'2, F2, F'2, G1, H1, H'1, I1$ considered.
The keyword `LIAISON_OBLIQUE` is thus validated.
- Identification of the nodes common to the 2 zones by the keyword `LIAISON_GROUP` is also validated: displacements U, V, W are identical to the points $A'2, B'2, H', E'2, F'2, H'1$ in comparison with displacements with opposite respective $A2, B2, H, E2, F2, H1$.