SSLV307 - Cylinder obliques under axial loading uniform

Abstract:

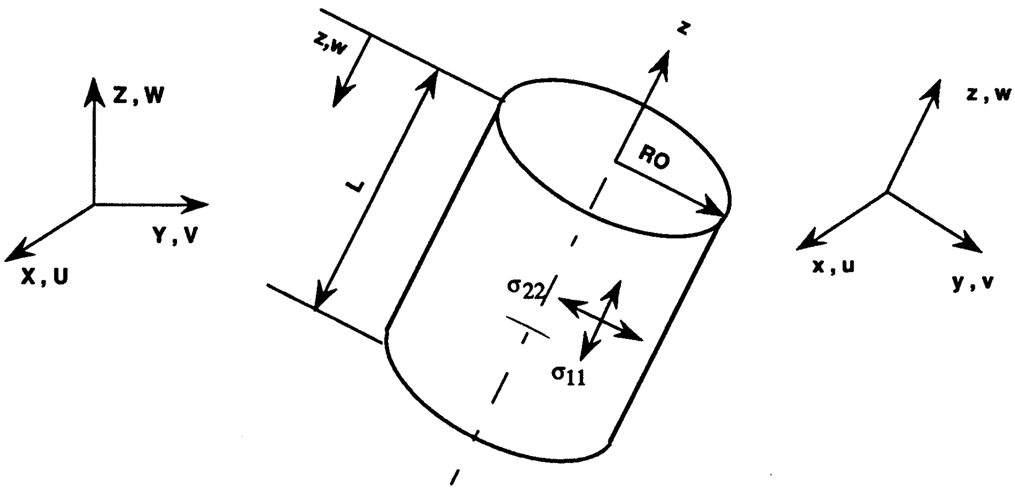
The purpose of the test is validating the various types of linear relations, defined by key words LIAISON_DDL , LIAISON_OBLIQUE , LIAISON_GROUP .

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

The analysis is carried out in 3D.

1 Problem of reference

1.1 Geometry



Average radius: $R_o = 1\,m$
Thickness: $h = 0.02\,m$
Height: $L = 4\,m$

Cosine directors of the axis of the cylinder: $(0.0, 0,5\ , \frac{\sqrt{3}}{2})$
Center local x parallel with the total axis X.

1.2 Material properties

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

$\nu = 0.3$

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 $q = 10000\,N/m$, 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 coordinate system $(x,\ y,\ z)$:

$$u_r = \frac{qvRo}{Eh} = - \left[U^2 + \left(\frac{\sqrt{3}}{2} V - 0.5\, W \right)^2 \right]^{1/2}$$

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

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

$$\sigma_{xx} = \sigma_{xx}$$

$$= 3/4 \sigma_{yy} + 1/4 \sigma_{11} \qquad \sigma_{11} = q/h$$

$$\sigma_{zz} = 1/4 \sigma_{yy} + 3/4 \sigma_{11}$$

$$\sigma_{yz} = -\frac{\sqrt{3}}{4} \sigma_{yy} + \frac{\sqrt{3}}{4} \sigma_{11}$$

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

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 plane (x, z) $\sigma_{yy} = 1.25 \times 10^5 Pa$, $\sigma_{zz} = 3.75 \times 10^5 Pa$

2.3 Uncertainty on the analytical

- solution Solution

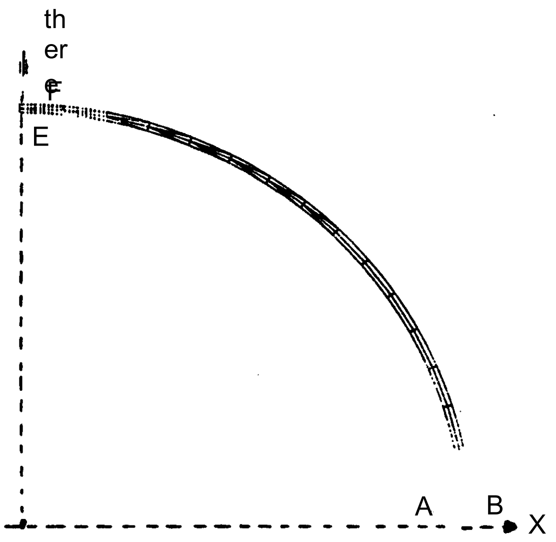
2.4 bibliographical References

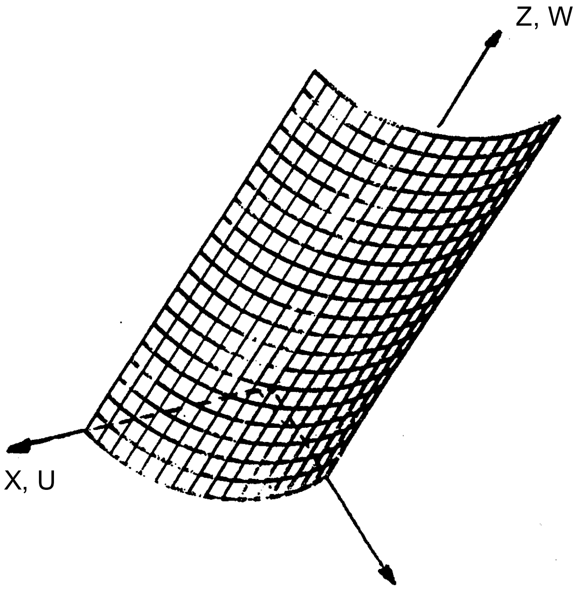
1) R.J. ROARK and W.C. YOUNG: Formulated for stress and strain, 5 è edition. New York, Mc Graw-Hill, 1975

3 Modelization A

3.1 Characteristic of the modelization

Elements 3D (PENTA15 + HEXA20)





Section of the there,

Modelization:

1/4 of the cylinder following the circumference
2 zones: zone 1 = lower part $(0 \leq z \leq L/2)$
zones 2 = Cutting $(L/2 \leq Z \leq L)$

upper part:

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

Coordinated of the points (r, θ, z)

	A	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

Ri = interior radius
Re = external radius

the points $A2, H, B2, E2, H2, F2$ are in the section $z=L/2$ of zone 1
the points $A'2, H', B'2, E'2, H'2, F'2$ are opposite respective in the zone 2

Boundary conditions:

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

Loading:

Density of surface charge $p=q/h=500000\,N/m2$, along the axis, is in total reference:

$$Fx=0.$$

$$Fy=p/2$$

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

Name of the nodes:

plane $z=0.$	$A=N\,1$	$B=N\,321$	$E=N\,1740$	$F=N\,1541$	$G=N\,1540$	
plane $z=2$ (zone 1)	$A2=N\,961$	$B2=N\,993$	$E2=N\,2141$	$F2=N\,2122$	$H=N\,962$	$H1=N\,2121$
plane $z=2$ (zone 2)	$A'2=N\,3361$	$B'2=N\,3364$	$E'2=N\,2159$	$F'2=N\,215$[illegible]	$H'=N\,3360$	$H'1=N\,2156$
plane $z=4$	$A3=N\,3359$	$B3=N\,3355$	$I=N\,3356$	$E3=N\,2151$	$F3=N\,2154$	$I1=N\,2150$

3.2 Characteristics of the mesh

Many nodes: 4298

Number of meshes and types: 160 HEXA20, 320 PENTA15

3.3 Values tested

Values of displacements U, V, W read on Standard

file	Localization of value	Reference
Not G	$U(m)$	-7.143×10^{-7}
	$V(m)$	0.
	$W(m)$	0.
Not H, H'	$U(m)$	-7.143×10^{-7}

Point I	$U(m)$	– 7.143 X 10 $^{-7}$
Item $G1$	$U(m)$	0.
Items $H1, H'1$	$U(m)$	0.

Values of the displacements u, v, u_r in local coordinate system calculated from U, V, W

Standard	Localization of value	Reference
Not G	$u_r(m)$	– 7.143 X 10 $^{-7}$
	$v(m)$	0.
Not H, H'	$u_r(m)$	– 7.143 X 10 $^{-7}$
	$v(m)$	0.
Not I	$u_r(m)$	– 7.143 X 10 $^{-7}$
	$v(m)$	0.
Not $A2, A'2$ Items $B2, B'2$	$v(m)$	0.
Point $G1$	$u(m)$	0.
	$u_r(m)$	– 7.143 X 10 $^{-7}$
Items $H1, H'1$	$u(m)$	0.
	$u_r(m)$	– 7.143 X 10 $^{-7}$
Item $I1$	$u(m)$	0.
	$u_r(m)$	– 7.143 X 10 $^{-7}$
Items $E2, E'2$	$u(m)$	0.
Items $F2, F'2$	$u(m)$	0.
Points A, B, G $A2, B2, H$ $A'2, B'2, H'$ $A3, B3, I$	$\sigma_{YY}(Pa)$	1.25 X 10 ^{5}
Points A, B, G $A2, B2, H$ $A'2, B'2, H'$ $A3, B3, I$	$\sigma_{ZZ}(Pa)$	3.75 X 10 ^{5}

3.4 Remarks

- radial displacement ur is obtained with a good accuracy.

- The 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, the 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.
Key word `LIAISON_OBLIQUE` is thus validated.

- The identification of the nodes common to 2 zones by the key word `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 $A2, B2, H, E2, F2, H1$.