

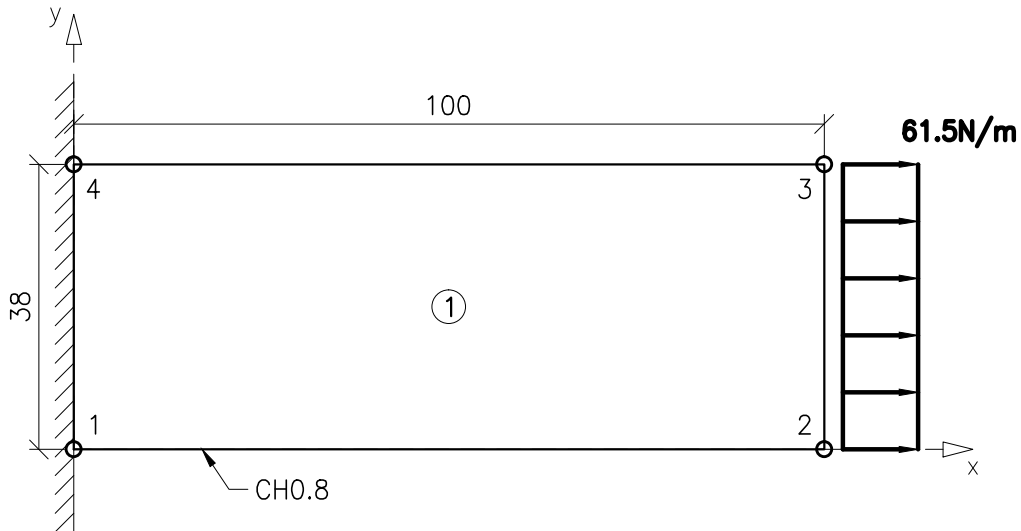
# EXERCÍCIO 3.A

## PROBLEMA:

EXTRAIR TENSÃO EQUIVALENTE AO LONGO DA CHAPA, FATOR DE SEGURANÇA QUANTO À TENSÃO DE ESCOAMENTO, DEFORMAÇÃO E DESLOCAMENTO AXIAL E FORÇA AO LONGO DA CHAPA NA DIREÇÃO X. MODIFICAR O MODELO PARA INCLUIR O FURO, RECALCULAR E COMPARAR OS RESULTADOS.

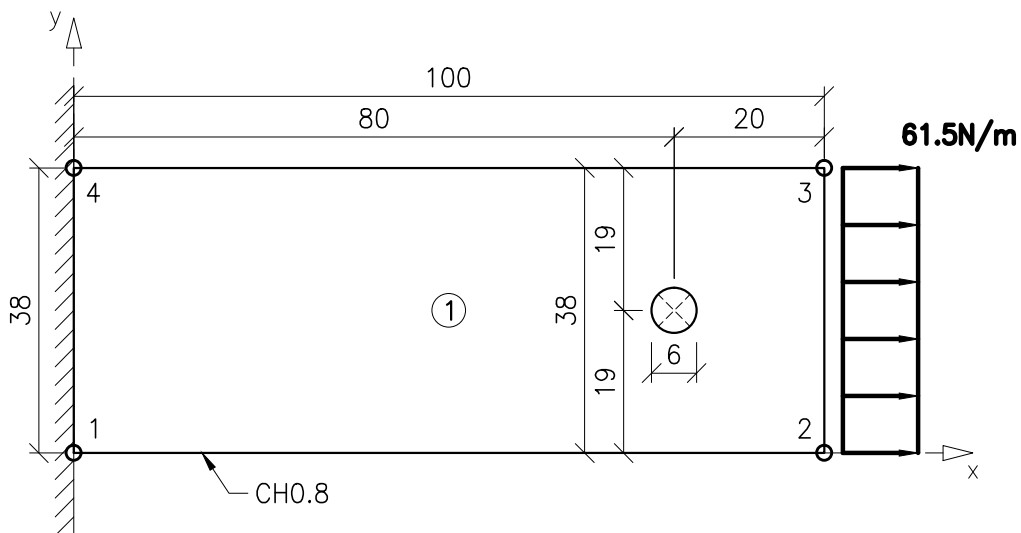
## DADOS:

$E = 200\text{GPa}$   
 $\nu = 0.3$   
 $f_y = 230\text{MPa}$



### CHAPA SEM FURO

ESC.: 1/1 COTAS EM MILÍMETROS



### CHAPA PERFURADA

ESC.: 1/1 COTAS EM MILÍMETROS

## EXERCÍCIO 3.A

Análise de uma chapa tracionada

/prep7	Preprocessor	
ET,1,181	Element Type → Add/Edit/Delete → Add... → Library of Element Types = Structural Mass ; Shell ; 3D 4node 181 → OK → Close	
MP,EX,1,200 MP,PRXY,1,0.3	Material Props → Material Models → Structural → Linear → Elastic → Isotropic → EX = 200 PRXY = 0.3 → OK	
SECTYPE,1,SHELL,,ESPESS,3 SECDATA,0.8,1	Sections → Shell → Lay-up → Add/Edit → Name = ESPESS ID = 1 Thickness = 0.8 Material ID = 1 → OK	
K,1,0,0,0 K,2,100,0,0 K,3,100,38,0 K,4,0,38,0	Modeling → Create → Keypoints → In Active CS → Keypoint number = 1 Location in active CS = 0, 0, 0 → Apply → Keypoint number = 2 Location in active CS = 100, 0, 0 → Apply → Keypoint number = 3 Location in active CS = 100, 38, 0 → Apply → Keypoint number = 4 Location in active CS = 0, 38, 0 → OK	
A,1,2,3,4	Modeling → Create → Areas → Arbitrary → Through KPs → <b>Clickar nos keypoints 1, 2, 3 e 4</b> → OK	
LSEL,S,LOC,X,0 DL,ALL,,ALL,0 ALLSEL	Loads → Define Loads → Apply → Structural → Displacement → On Lines → <b>Clickar na line vertical à esquerda</b> → DOFs to be constrained = All DOF → OK	
LSEL,S,LOC,X,100 SFL,ALL,PRES,-0.0615 ALLSEL	Loads → Define Loads → Apply → Structural → Pressure → On Lines → <b>Clickar na line vertical à direita</b> → Load PRES value = -0.0615 → OK	

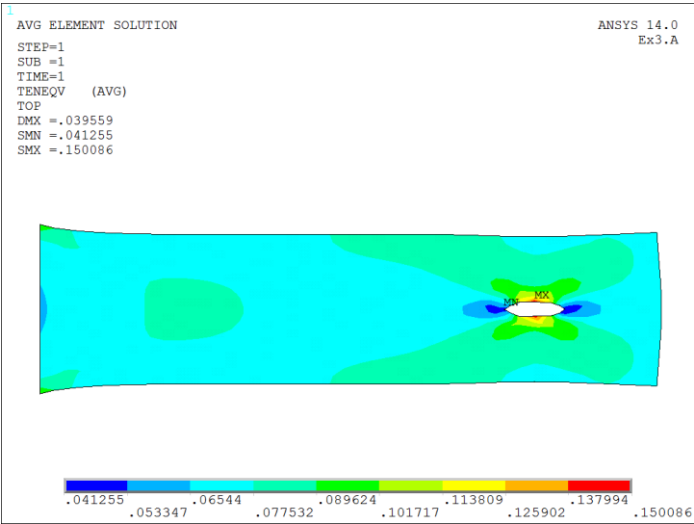
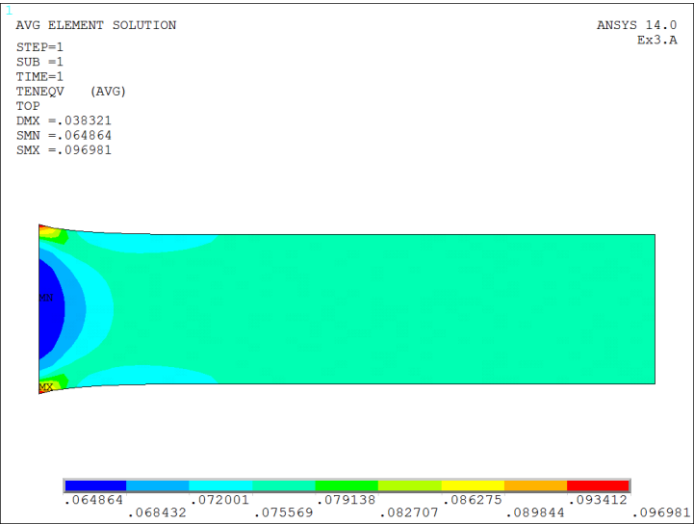
/PSF,PRES,NORM,2	PlotCtrls → Symbols → Surface Load Symbols = Pressures Show pres and convect as = Arrows → OK	
AATT,1,,1,,1	Meshing → Mesh Attributes → All Areas → Material number = 1 Element type number = 1 SHELL181 Element section = 1 ESPESS → OK	
AESIZE,ALL,2	Meshing → Size Cntrls → ManualSize → Areas → All Areas → Element edge length = 2 → OK	
AMESH,ALL	Meshing → Mesh → Areas → Free → <b>Clicar na area 1</b> → OK	
/ESHAPE,,1	PlotCtrls → Style → Size and Shape → Display of Element = ON → OK	
EPLOT	Plot → Elements	
<b>/solu</b>	<b>Solution</b>	
SOLVE	Solve → Current LS → OK	
<b>/post1</b>	<b>General Postproc</b>	
SET,,1	Read Results → First Set	
PLDISP	Plot Results → Deformed Shape → Items to be plotted = Def shape only → OK	
PRRSOL	List Results → Reaction Solu → Item to be listed = All items → OK	
ETABLE,TENEQV,S,EQV ETABLE,FX,SMISC,1 ETABLE,DEFX,EPEL,X ETABLE,DESLOCX,U,X	Element Table → Define Table → Add... → User label for item = TENEQV Results data item = Stress ; von Mises SEQV → Apply → User label for item = FX Results data item = By sequence num ; SMISC, 1 → Apply → User label for item = DEFX Results data item = Strain-elastic ; X-dir'n EPEL X → Apply → User label for item = DESLOCX Results data item = DOF solution ; Translation UX	

	→ OK → Close	
SALLOW,0.23	Safety Factor → Allowable Strs → Constant → Allowable stress = 0.23 → OK	
SFCALC,FSTEN,TENEQV,,3	Safety Factor → SF for ElemTable → Item to be calculated = 1/SF Label for calculated item = FSTEN Elem table item for stress = TENEQV → OK	
/DSCALE,,1000 /REPLOT	PlotCtrls → Style → Displacement Scaling... → Displacement scale factor = User specified User specified factor = 1000 → OK	
PLETAB,TENEQV,AVG	Element Table → Plot Elem Table → Item to be plotted = TENEQV Average at common nodes? = Yes - average → OK	
PLETAB,FSTEN,AVG	Element Table → Plot Elem Table → Item to be plotted = FSTEN Average at common nodes? = Yes - average → OK	
PLETAB,DEFX,AVG	Element Table → Plot Elem Table → Item to be plotted = DEFX Average at common nodes? = Yes - average → OK	
PLETAB,DESLOCX,AVG	Element Table → Plot Elem Table → Item to be plotted = DESLOCX Average at common nodes? = Yes - average → OK	
PLETAB,FX,AVG	Element Table → Plot Elem Table → Item to be plotted = FX Average at common nodes? = Yes - average → OK	
/EOF	<b>!! INTERROMPER MODELAGEM AQUI</b>	
<b>/prep7</b>	<b>Preprocessor</b>	
ACLEAR,ALL	Meshing → Clear → Areas → Pick All	
CYL4,80,19,3	Modeling → Create → Areas → Circle → Solid Circle →	

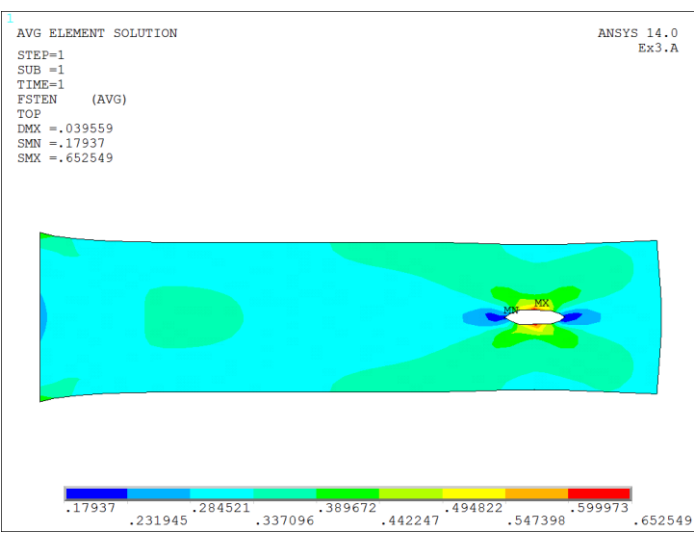
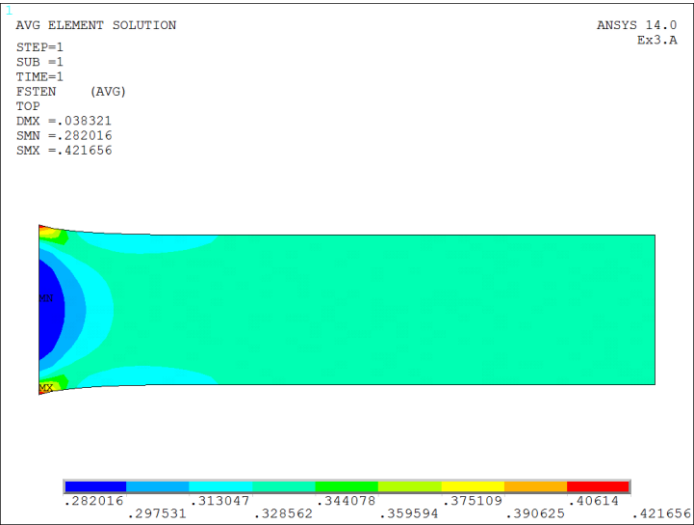
	WP X = 80 WP Y = 19 Radius = 3 → OK	
ASBA,1,2,,,DELETE	Modeling → Operate → Booleans → Subtract → Areas → <i>Clickar na area 1</i> → OK → <i>Clickar na area 2</i> → OK	
AATT,1,,1,,1	Meshing → Mesh Attributes → All Areas → Material number = 1 Element type number = 1 SHELL181 Element section = 1 ESPESS → OK	
AESIZE,ALL,2	Meshing → Size Cntrls → ManualSize → Areas → All Areas → Element edge length = 2 → OK	
AMESH,ALL	Meshing → Mesh → Areas → Free → Pick All → OK	
<b>/solu</b>	<b>Solution</b>	
SOLVE	Solve → Current LS → OK	
<b>/post1</b>	<b>General Postproc</b>	
SET,,1	Read Results → First Set	
PLDISP	Plot Results → Deformed Shape → Items to be plotted = Def shape only → OK	
PRRSOL	List Results → Reaction Solu → Item to be listed = All items → OK	
ETABLE,REFL	Element Table → Define Table → Update → Close	
SFCALC,FSTEN,TENEQV,,3	Safety Factor → SF for ElemTable → Item to be calculated = 1/SF Label for calculated item = FSTEN Elem table item for stress = TENEQV → OK	
PLETAB,TENEQV,AVG	Element Table → Plot Elem Table → Item to be plotted = TENEQV Average at common nodes? = Yes - average → OK	
PLETAB,FSTEN,AVG	Element Table → Plot Elem Table →	

	Item to be plotted = FSTEN Average at common nodes? = Yes - average → OK	
PLETAB,DEFX,AVG	Element Table → Plot Elem Table → Item to be plotted = DEFX Average at common nodes? = Yes - average → OK	
PLETAB,DESLOCX,AVG	Element Table → Plot Elem Table → Item to be plotted = DESLOCX Average at common nodes? = Yes - average → OK	
PLETAB,FX,AVG	Element Table → Plot Elem Table → Item to be plotted = FX Average at common nodes? = Yes - average → OK	
<b>FINISH</b>	<b>Finish</b>	

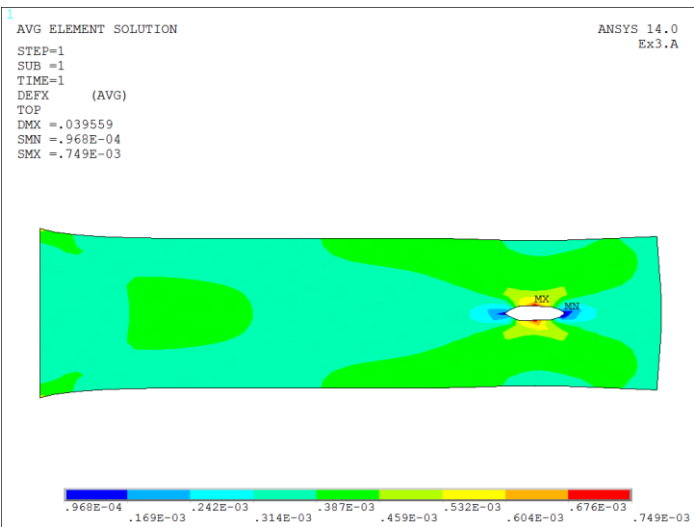
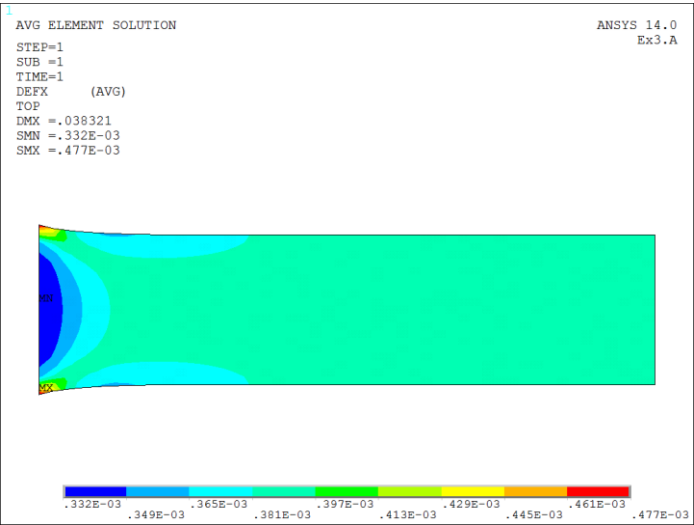
TENSÃO EQUIVALENTE (VON MISES)



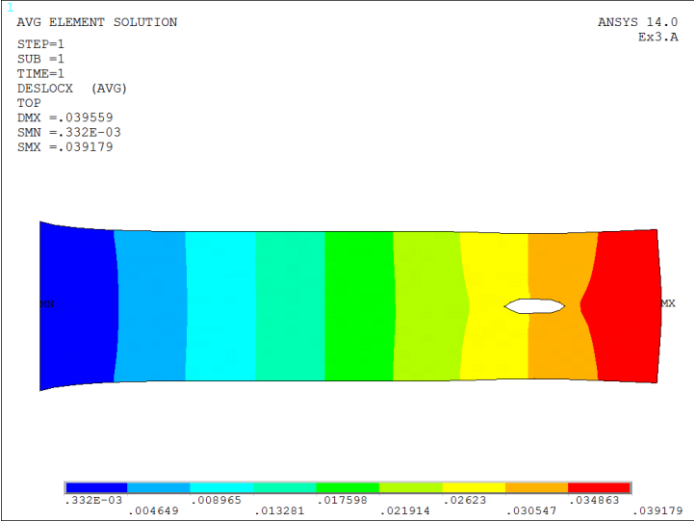
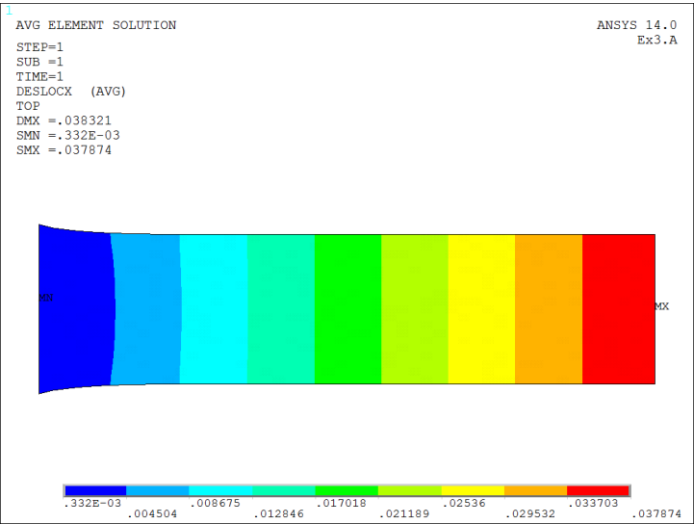
FATOR DE SEGURANÇA (TENSÃO DE ESCOAMENTO)



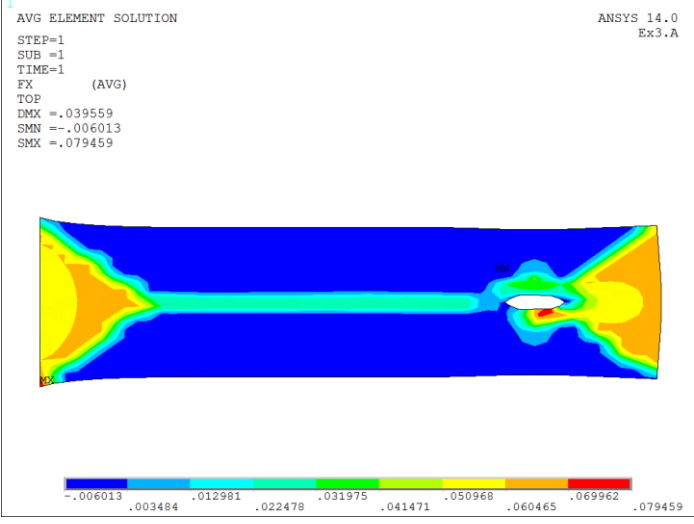
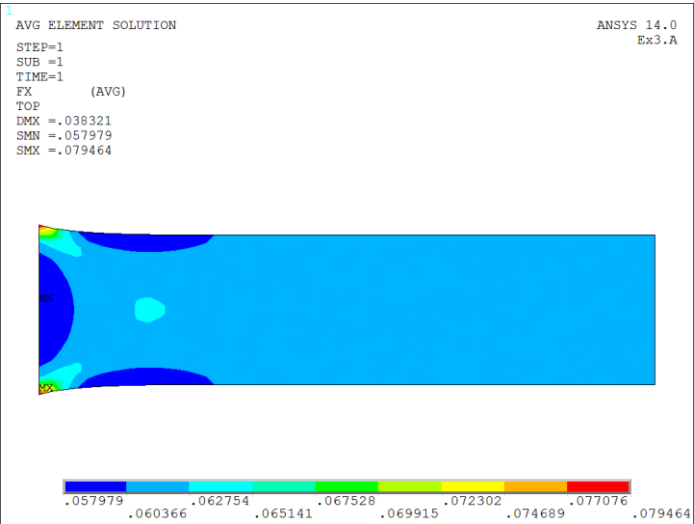
DEFORMAÇÃO AXIAL (EM X)



DESLOCAMENTO AXIAL (EM X)





FORÇA AXIAL (EM X)







## EXERCÍCIO 3.A

Análise de uma chapa tracionada – correção dos sistemas locais de coordenadas

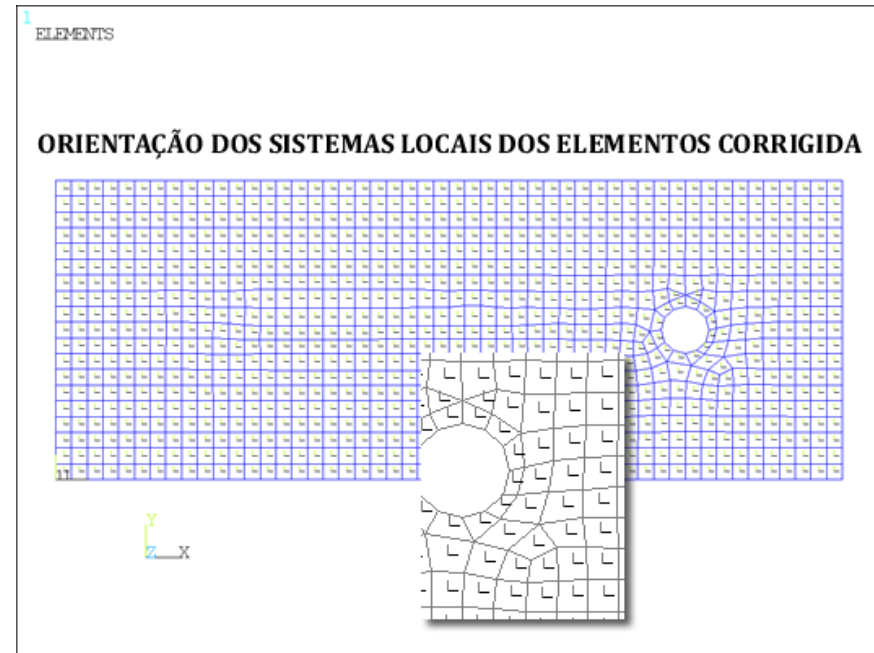
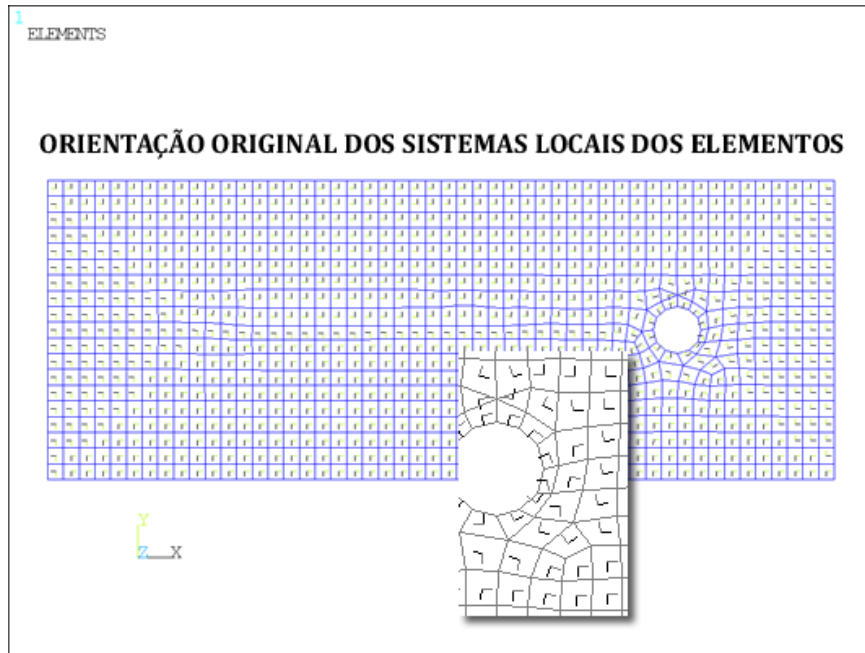
/input,'Ex3.C – APDL',mac	!! Continuar modelo do exercício 3.A	
ALLSEL /VIEW,,,,,1 /AUTO,1 EPLOT	Utility Menu → Select → Everything View Bar →  View Bar →  Utility Menu → Plot → Elements	
/DEVICE,VECTOR,ON /REPLOT	Utility Menu → PlotCtrls → Device Options... Vector mode (wireframe) = On Replot upon OK/Apply? = Replot → OK	
/PSYMB,ESYS,1 /REPLOT	Utility Menu → PlotCtrls → Symbols... Element coordinate sys = On Replot upon OK/Apply? = Replot → OK	
LOCAL,11,CART,0,0,0	Utility Menu → WorkPlane → Local Coordinate Systems → Create Local CS → At Specified Loc + → 0,0,0 → OK Ref number of new coord sys = 11 Type of coordinate system = Cartesian 0 Origin of coord system = 0 0 0 → OK	
<b>/prep7</b>	<b>Preprocessor</b>	
EMODIF,ALL,ESYS,11	Modeling → Move / Modify → Elements → Modify Attrib → Pick All → Attribute to change = Elem coord ESYS New attribute number = 11 → OK	
EPLOT	Utility Menu → Plot → Elements	
/DEVICE,VECTOR,OFF /PSYMB,ESYS,0 /REPLOT	Utility Menu → PlotCtrls → Device Options... Vector mode (wireframe) = Off Replot upon OK/Apply? = Replot → OK Utility Menu → PlotCtrls → Symbols... Element coordinate sys = On	

	Replot upon OK/Apply? = Replot → OK	
<b>/solu</b>	<b>Solution</b>	
SOLVE	Solve → Current LS → OK	
<b>/post1</b>	<b>General Postproc</b>	
SET,,1	Read Results → First Set	
ETABLE,REFL	Element Table → Define Table → Update → Close	
PLETAB,FX,AVG	Element Table → Plot Elem Table → Item to be plotted = FX Average at common nodes? = Yes - average → OK	
PATH,FURO,2,30,100 PPATH,1,,80,0,0,11 PPATH,2,,80,38,0,11	Path Operations → Define Path → By Location → Define Path Name : = FURO Number of points = 2 Number of data sets = 30 Number of divisions = 100 → OK Path point number = 1 Location in Global CS = 80, 0, 0 Interpolation CS = 11 → OK Path point number = 2 Location in Global CS = 80, 38, 0 Interpolation CS = 11 → OK	
PATH,FURO	Path Operations → Recall Path → Recall Path by Name : = FURO → OK	
PDEF,FX,ETAB,FX,NOAVG	Path Operations → Map onto Path → User label for item = FX Item to be mapped = Elem table item ; ETAB, FX Average results across element = No → OK	
PATH,PONTA,2,30,100 PPATH,1,,100,0,0,11 PPATH,2,,100,38,0,11	Path Operations → Define Path → By Location → Define Path Name : = PONTA Number of points = 2 Number of data sets = 30	

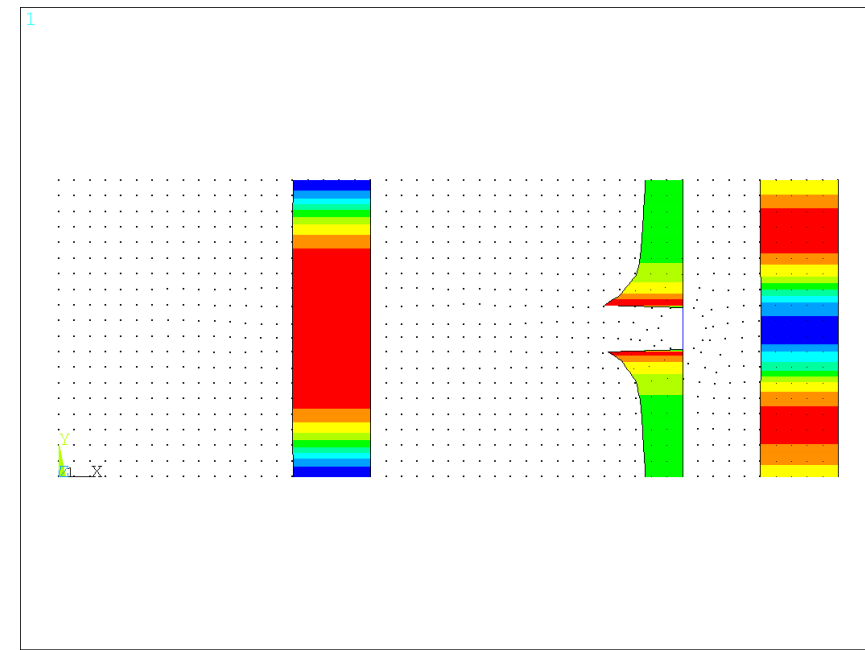
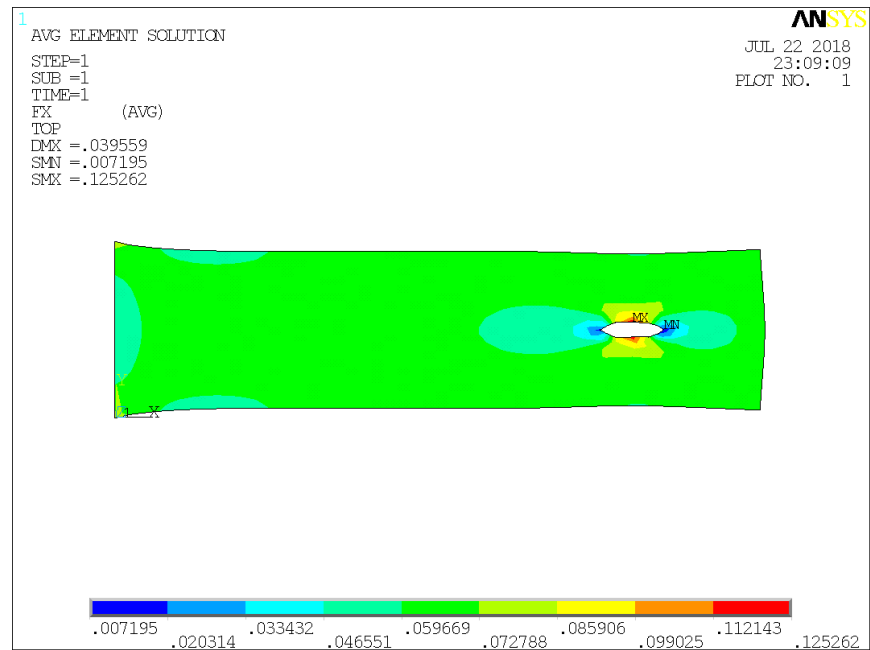
	<p>Number of divisions = 100</p> <p>→ OK</p> <p>Path point number = 1</p> <p>Location in Global CS = 100, 0, 0</p> <p>Interpolation CS = 11</p> <p>→ OK</p> <p>Path point number = 2</p> <p>Location in Global CS = 100, 38, 0</p> <p>Interpolation CS = 11</p> <p>→ OK</p>	
PATH,PONTA	<p>Path Operations → Recall Path →</p> <p>Recall Path by Name : = PONTA</p> <p>→ OK</p>	
PDEF,FX,ETAB,FX,NOAVG	<p>Path Operations → Map onto Path →</p> <p>User label for item = FX</p> <p>Item to be mapped = Elem table item ; ETAB, FX</p> <p>Average results across element = No</p> <p>→ OK</p>	
<p>PATH,MEIO,2,30,100</p> <p>PPATH,1,,40,0,0,11</p> <p>PPATH,2,,40,38,0,11</p>	<p>Path Operations → Define Path → By Location →</p> <p>Define Path Name : = MEIO</p> <p>Number of points = 2</p> <p>Number of data sets = 30</p> <p>Number of divisions = 100</p> <p>→ OK</p> <p>Path point number = 1</p> <p>Location in Global CS = 40, 0, 0</p> <p>Interpolation CS = 11</p> <p>→ OK</p> <p>Path point number = 2</p> <p>Location in Global CS = 40, 38, 0</p> <p>Interpolation CS = 11</p> <p>→ OK</p>	
PATH,MEIO	<p>Path Operations → Recall Path →</p> <p>Recall Path by Name : = MEIO</p> <p>→ OK</p>	
PDEF,FX,ETAB,FX,NOAVG	<p>Path Operations → Map onto Path →</p> <p>User label for item = FX</p> <p>Item to be mapped = Elem table item ; ETAB, FX</p>	

	Average results across element = No → OK	
ALLSEL /VIEW,,,,,1 /AUTO,1 NPLOT /NOERASE	Utility Menu → Select → Everything View Bar →  View Bar →  Utility Menu → Plot → Nodes Utility Menu → PlotCtrls → Erase Options → Erase between Plots	
PATH,PONTA	Path Operations → Recall Path → Recall Path by Name : = PONTA → OK	
PLPAGM,FX,100,NODE	Path Operations → Plot Path Item → On Geometry → Path items to be displayed = FX Scale factor offset = 100 Display options : = With nodes → OK	
PATH,FURO	Path Operations → Recall Path → Recall Path by Name : = FURO → OK	
PLPAGM,FX,100,NODE	Path Operations → Plot Path Item → On Geometry → Path items to be displayed = FX Scale factor offset = 100 Display options : = With nodes → OK	
PATH,MEIO	Path Operations → Recall Path → Recall Path by Name : = MEIO → OK	
PLPAGM,FX,100,NODE	Path Operations → Plot Path Item → On Geometry → Path items to be displayed = FX Scale factor offset = 100 Display options : = With nodes → OK	
/ERASE	Utility Menu → PlotCtrls → Erase Options → Erase between Plots	
<b>FINISH</b>	<b>Finish</b>	

## SISTEMAS LOCAIS DE EIXOS



## FORÇA AXIAL (EM X)



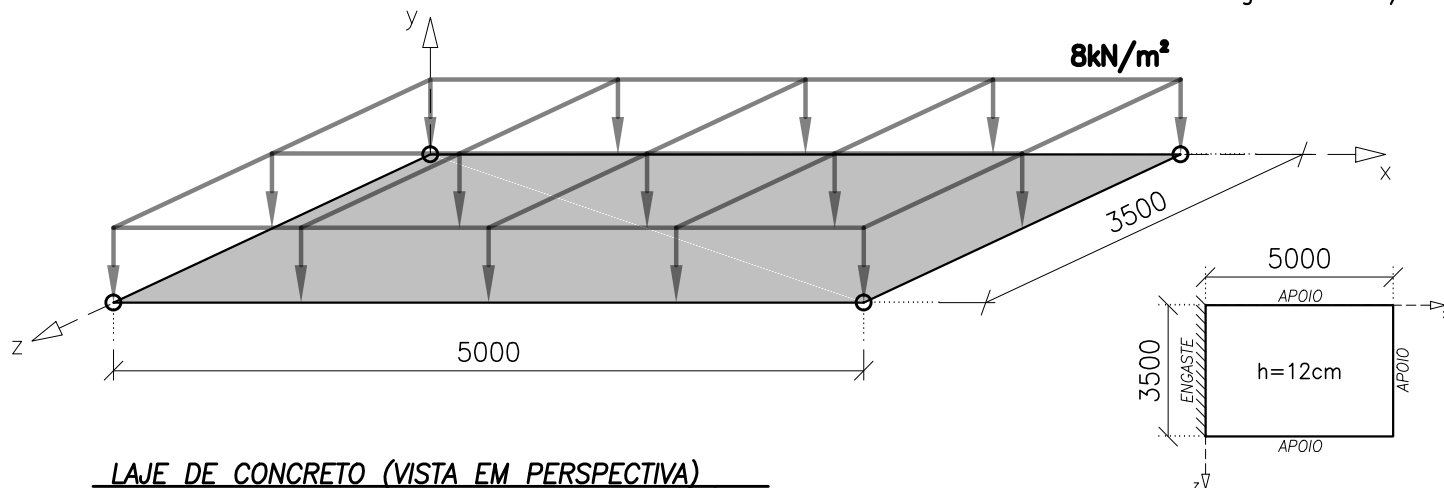
## EXERCÍCIO 3.B

### PROBLEMA:

CALCULAR A FLECHA E AS TENSÕES NA LAJE ABAIXO. CONSIDERAR O PESO PRÓPRIO DA LAJE.

### DADOS:

$E = 23.8\text{GPa}$   
 $\nu = 0.2$   
 $h = 12\text{cm}$   
 $\rho = 2500\text{kg/m}^3$   
 $g = 9.81\text{m/s}^2$



### LAJE DE CONCRETO (VISTA EM PERSPECTIVA)

ESC.: 1/50 COTAS EM MILÍMETROS

### CONDIÇÕES DE APOIO

ESC.: 1/200 COTAS EM MILÍMETROS

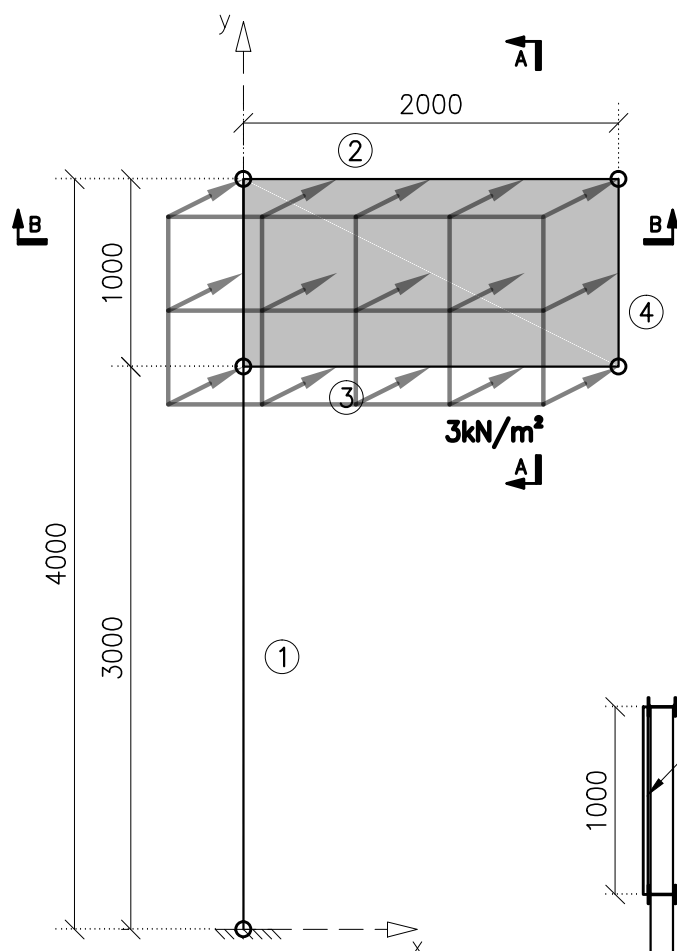
## EXERCÍCIO 3.C

### PROBLEMA:

EXIBIR DIAGRAMAS DE MOMENTO (FLETOR E TORÇOR) E FORÇA (NORMAL E CORTANTE). CALCULAR A TENSÃO EQUIVALENTE DE VON MISES EM TODOS OS ELEMENTOS.

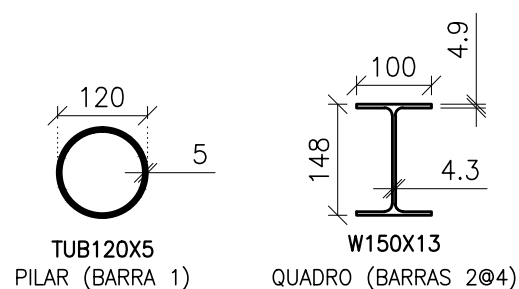
### DADOS:

$E = 200\text{GPa}$   
 $\nu = 0.3$   
 $f_y = 345\text{MPa}$   
 $t = 25\text{mm}$



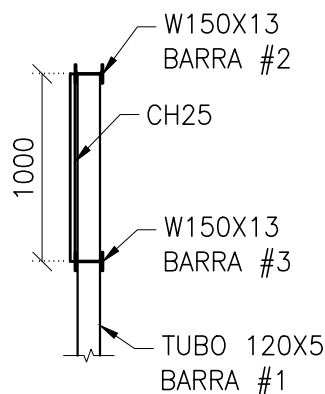
### ELEVÇÃO DO POSTE COM PLACA

ESC.: 1/40 COTAS EM MILÍMETROS



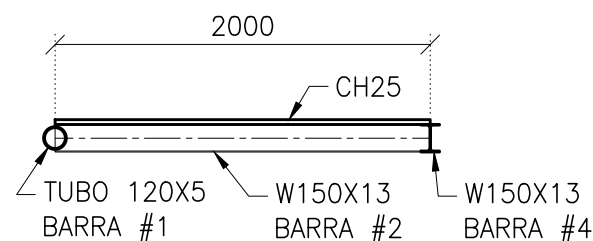
### SEÇÕES TRANSVERSAIS

ESC.: 1/10 COTAS EM MILÍMETROS



### CORTE AA

ESC.: 1/40



### CORTE BB

ESC.: 1/40