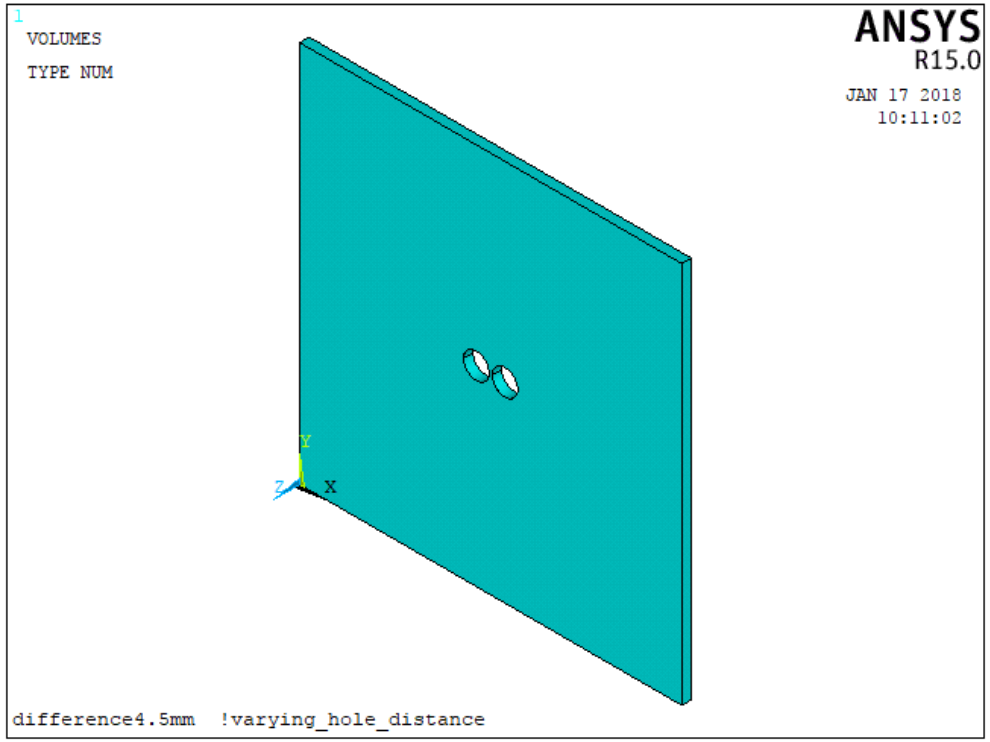
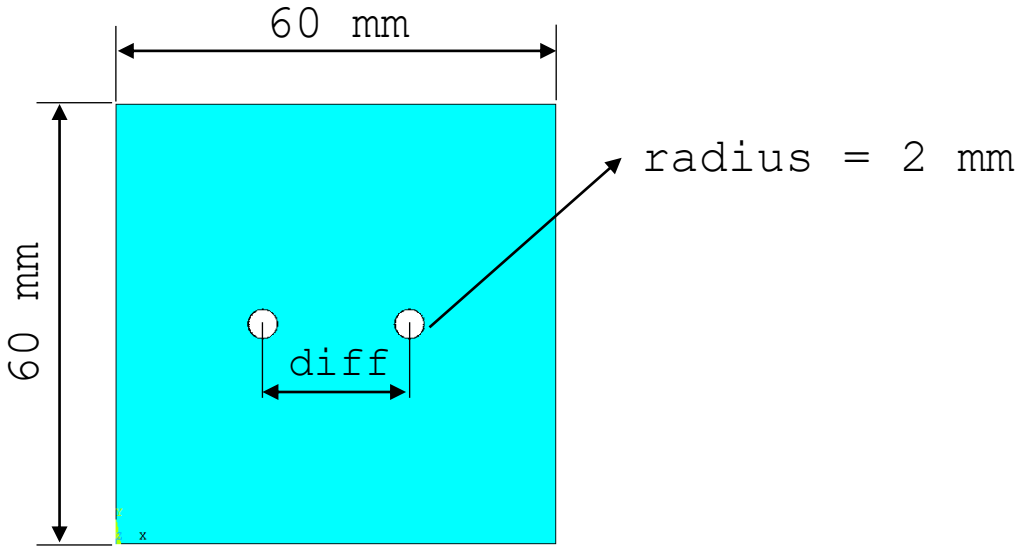
Varying hole distance

problem description

Two Circular Holes in a Plate



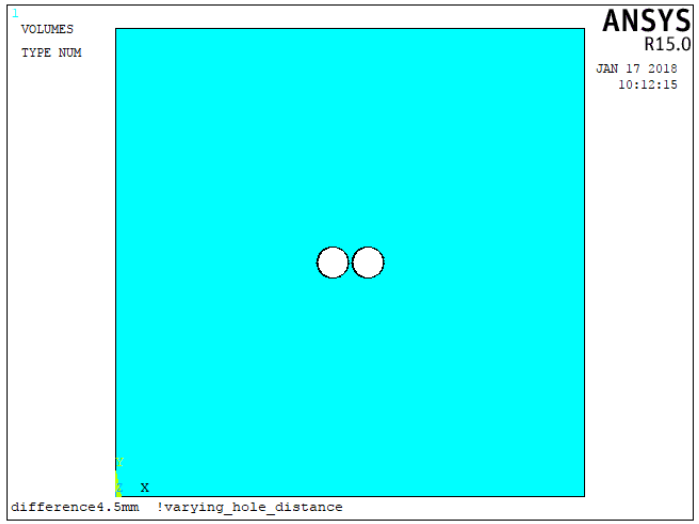


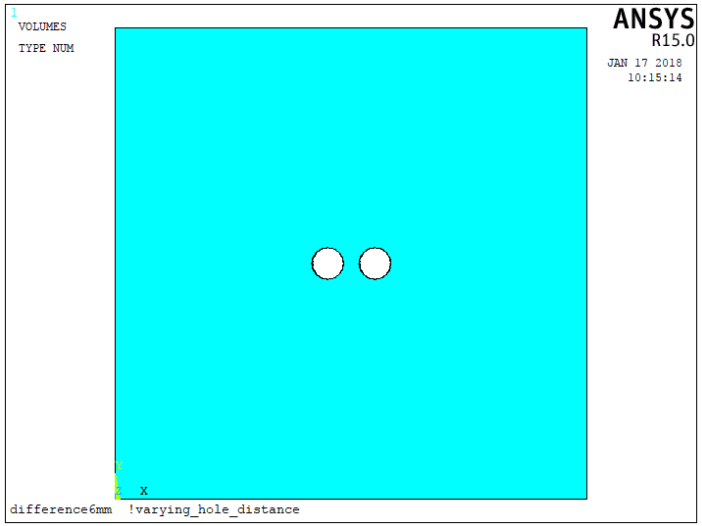
plate_thickness = depth = 1.5 mm

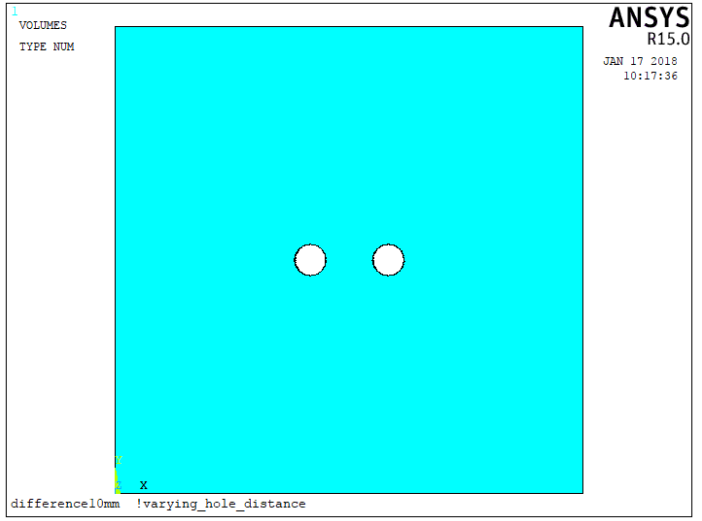
"through hole"

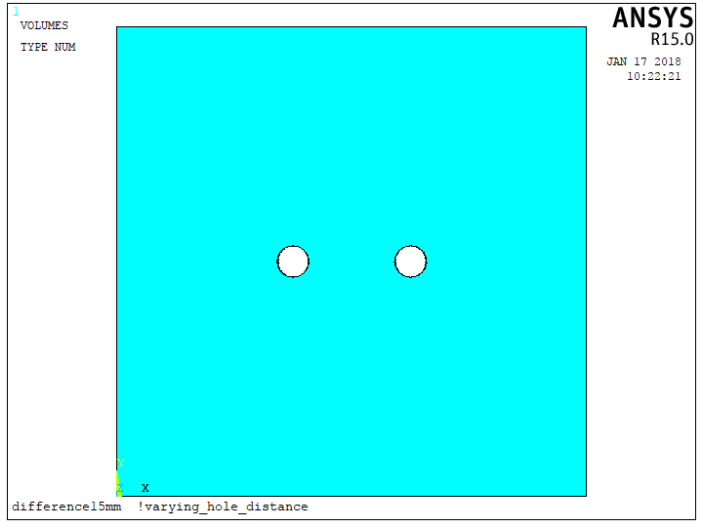
- Varying the hole distance

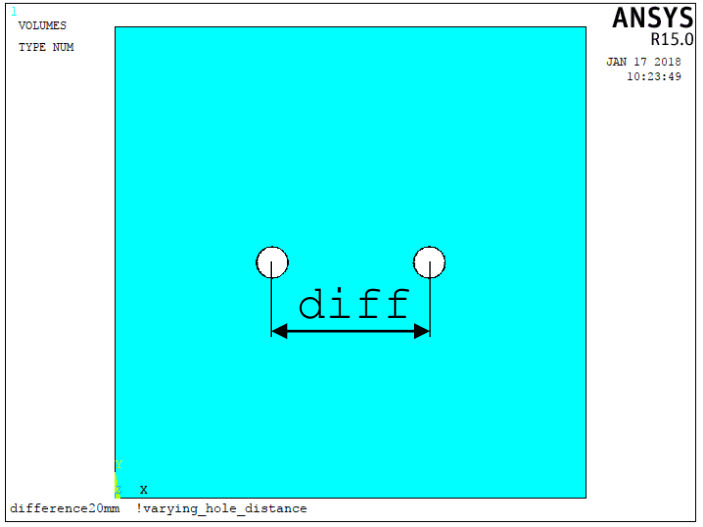
Simulation Goal





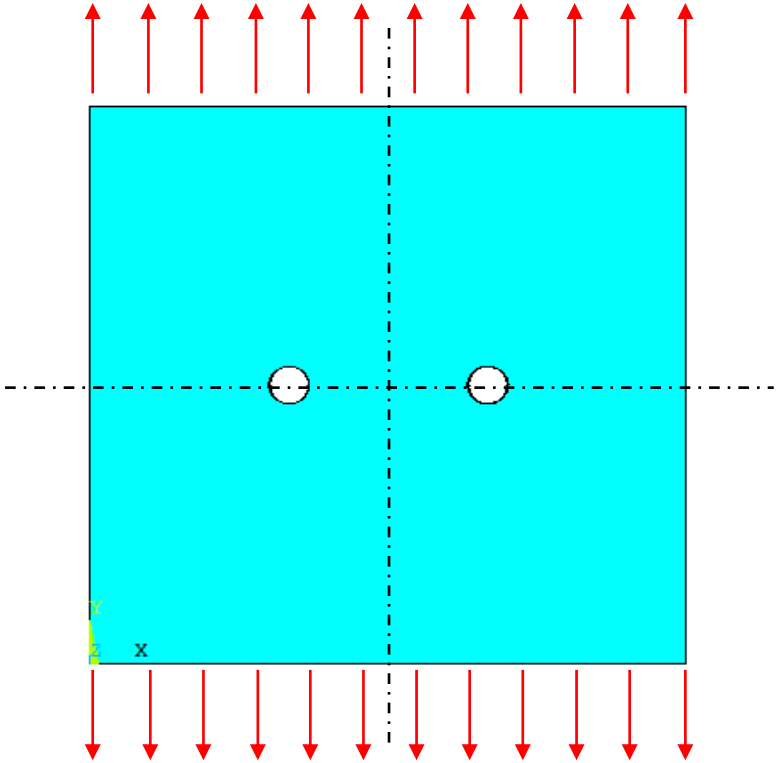




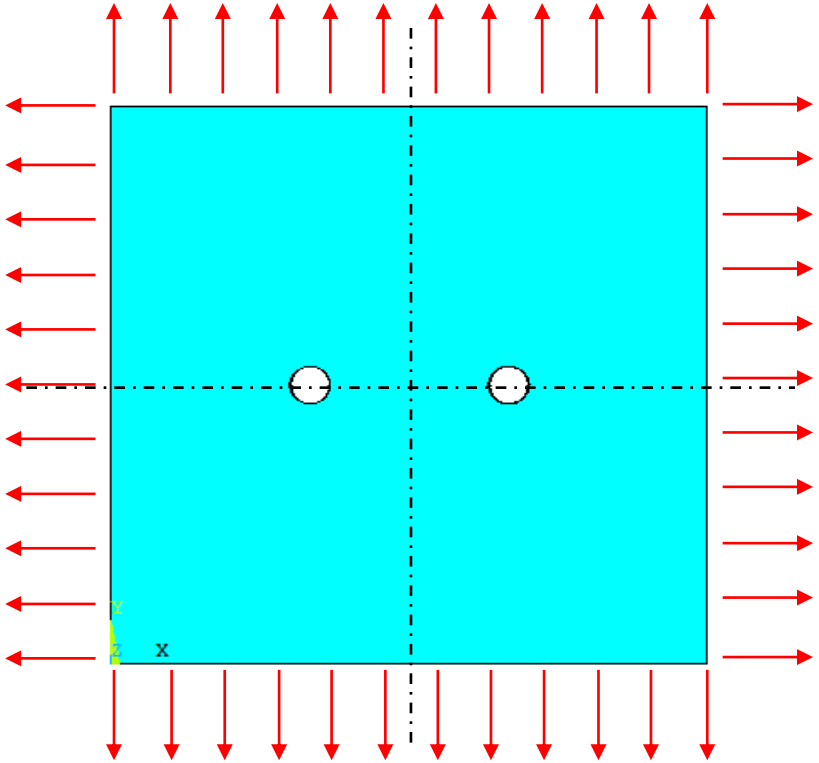



```
inicial = 4.5 !mm
final = 20 !mm
incr = 0.5 !mm

*do,diff,inicial,final,incr
        ...
        ...
*enddo
```

Types of Loads for simulation

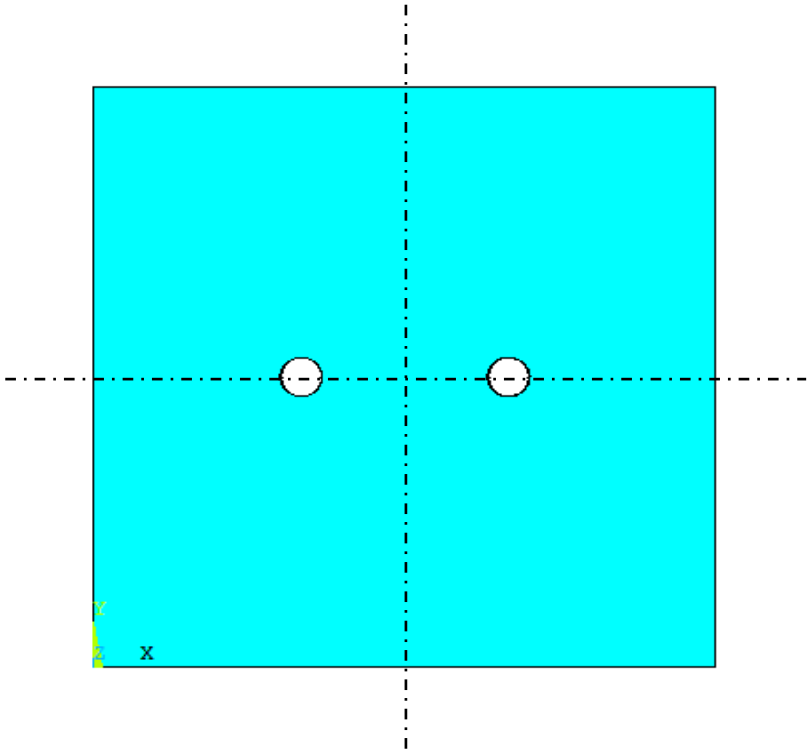


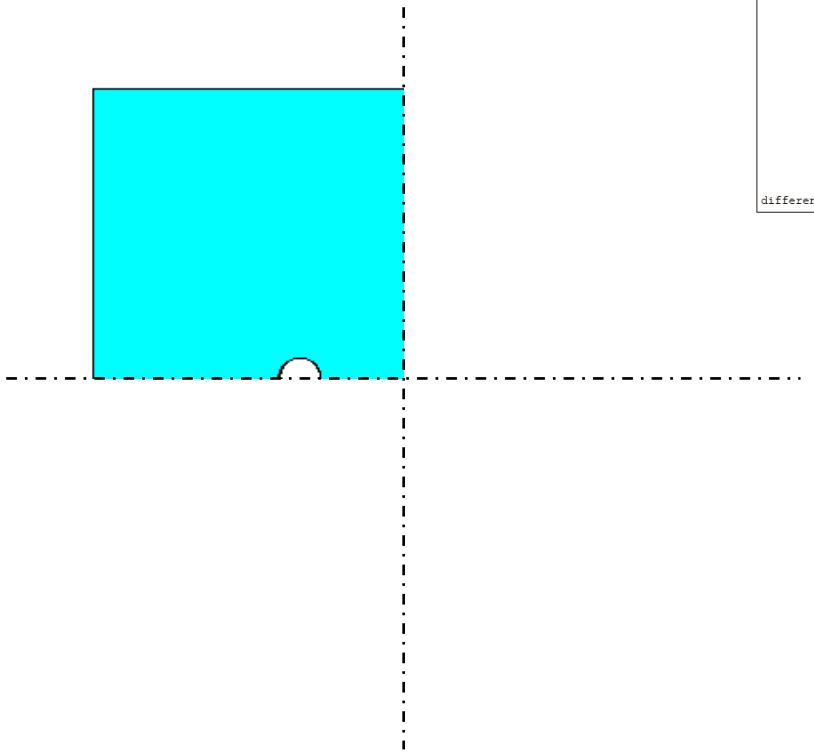
(a) Uniaxial
Transverse load

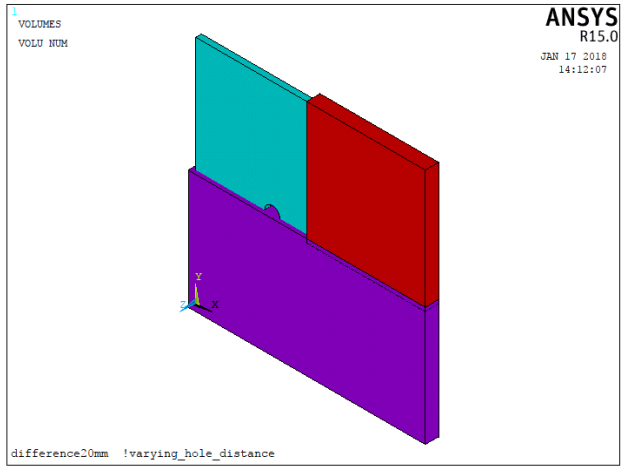


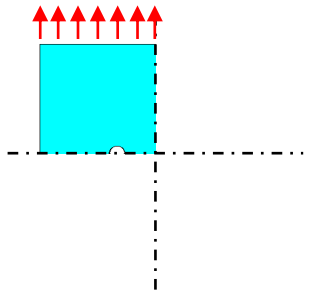
(b) Biaxial load

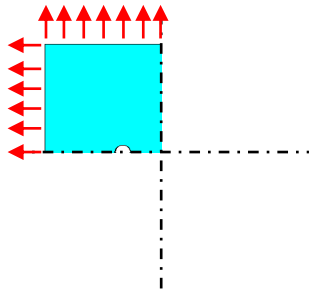
Symmetry


Y
Z
X



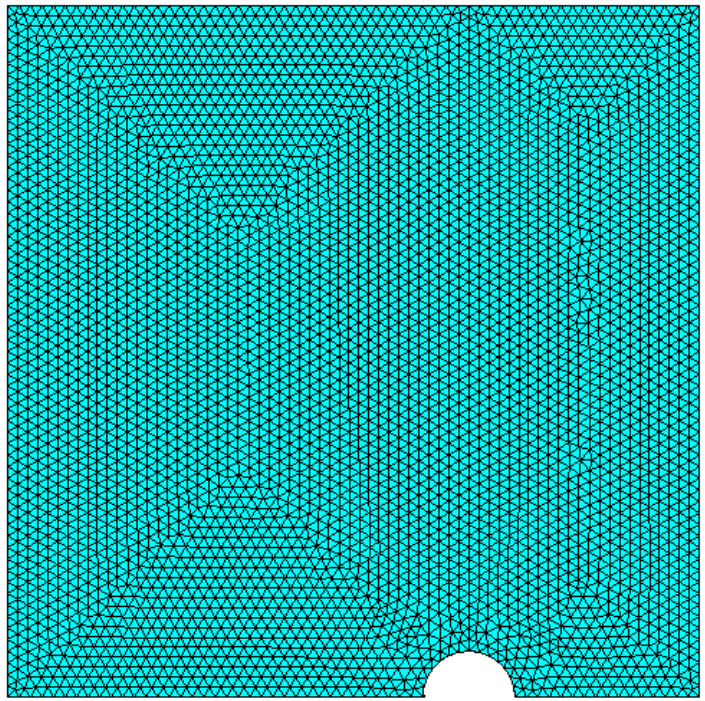

VOLUMES
VOLU NUM
ANSYS
R15.0
JAN 17 2018
14:12:07
Y
Z
X
difference20mm !varying_hole_distance

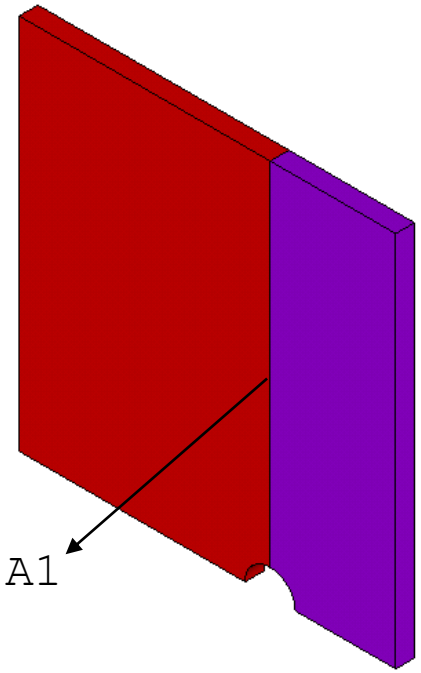


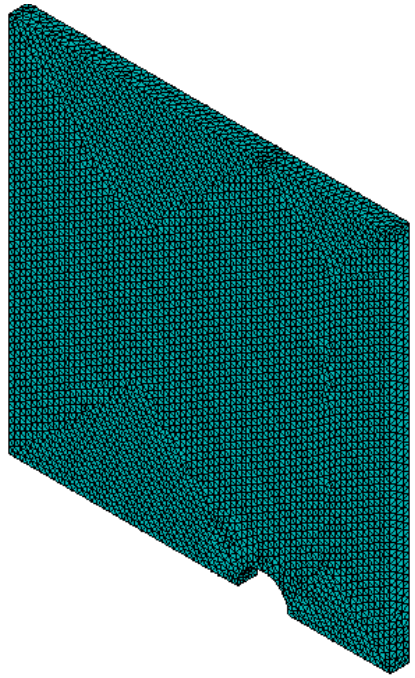


Mesh

- Duo the interest in the data from the nodes in the commom area, A1, two volumes were modeled.

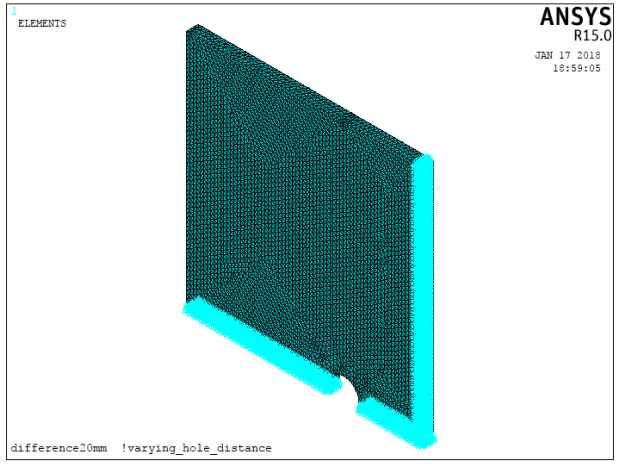






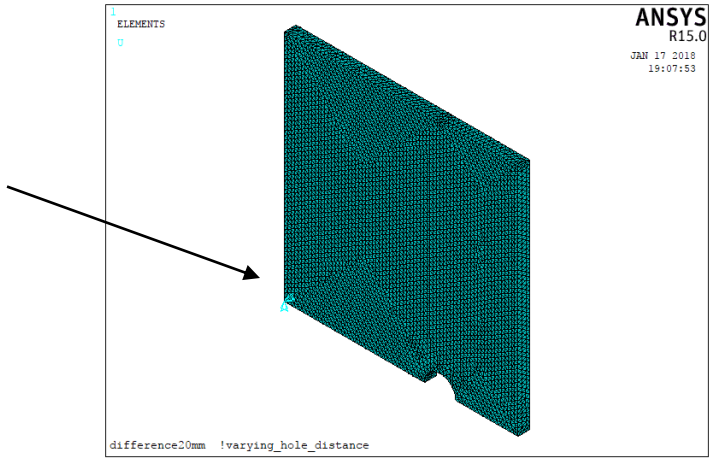
```
! Mesh
! Selection volumes
allsel

! Type element
et,1,187

! Element edge
size= 0.5
esize,size

!command
vmesh,all
eplot
```

Symmetry and Boundary Conditions




```
! Symmetry Condition

!(cross section X)
asel,s,loc,x,x2/2
nsla,s,1
dsym,symm,x,0
```

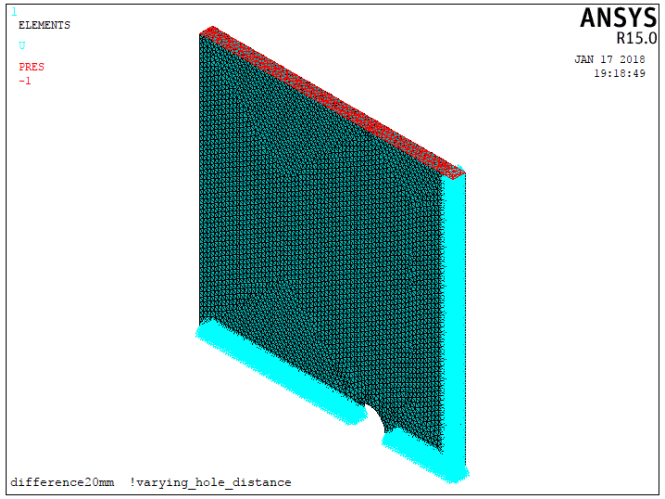
```
!(cross section Y)
asel,s,loc,y,y2/2
nsla,s,1
dsym,symm,y,0
```




```
! Boundary Condition
allsel

ksel,s,loc,x,x1
ksel,r,loc,y,y2/2
ksel,r,loc,z,z1
nslk,s
d,all,uz,0
```

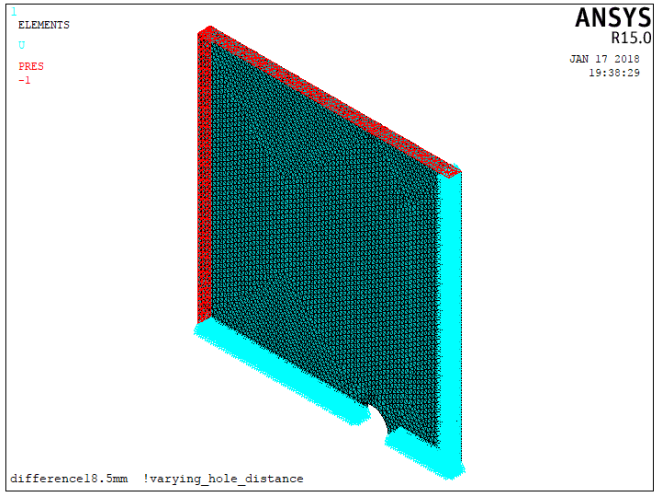
Load Conditions

(a) Uniaxial, Transverse load




```
! p = 1 Mpa

allsel
asel,s,loc,y,y2
sfa,all,1,pres,-p
asel,s,loc,y,y1
sfa,all,1,pres,-p
allsel
lswrite,1
```

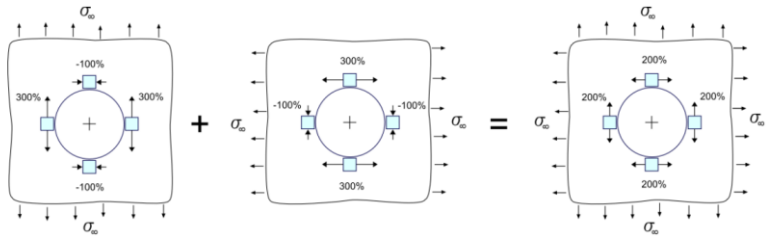
(b) Biaxial load



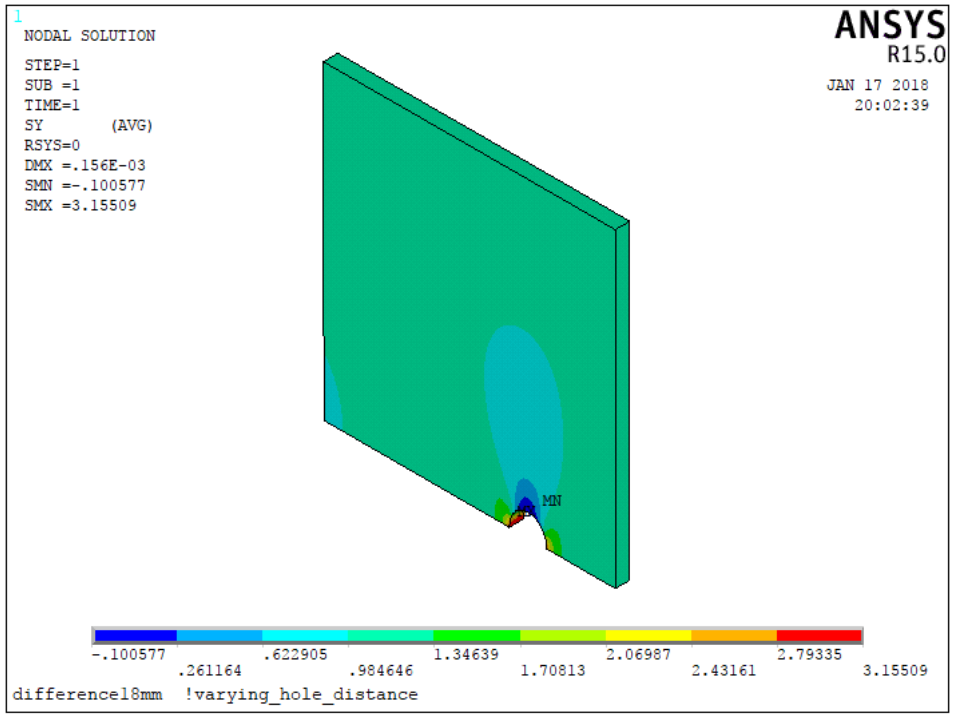

```
allsel
asel,s,loc,x,x2
sfa,all,1,pres,-p
asel,s,loc,x,x1
sfa,all,1,pres,-p
allsel

!lswrite,1
```

```
allsel
asel,s,loc,y,y2
sfa,all,1,pres,-p
asel,s,loc,y,y1
sfa,all,1,pres,-p
allsel

lswrite,2
```

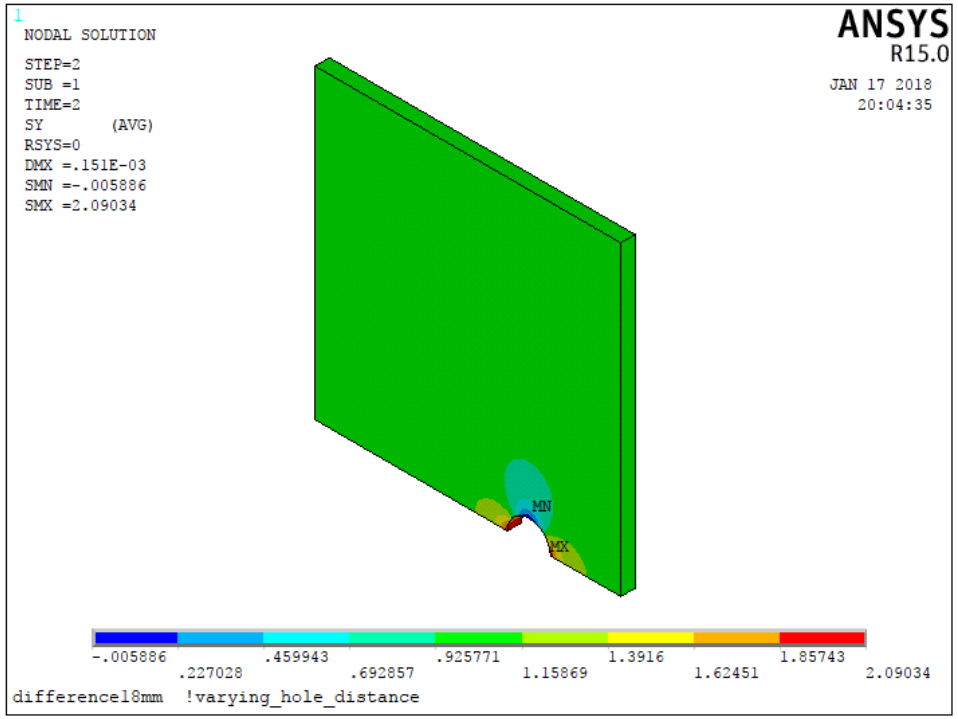
Solution



Theoretical Results



(a) Uniaxial, Transverse load

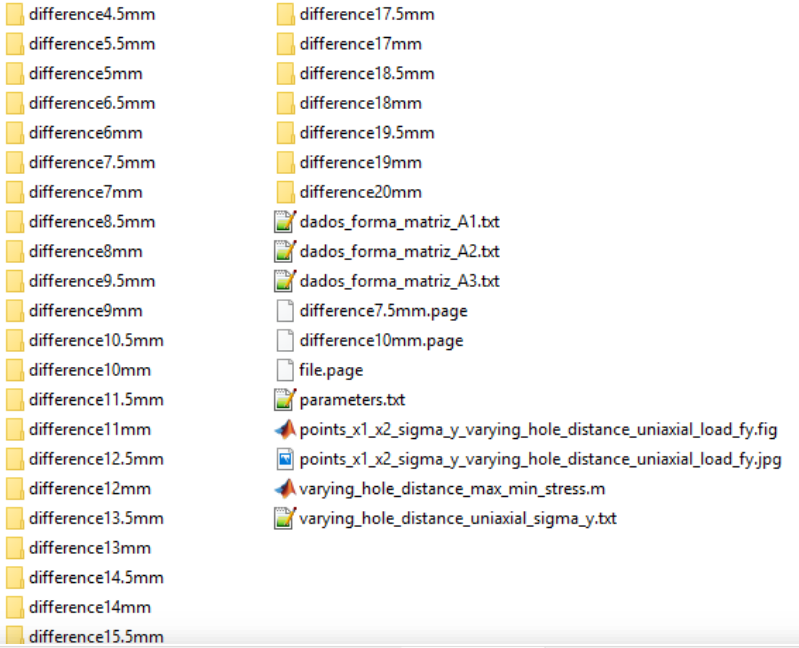


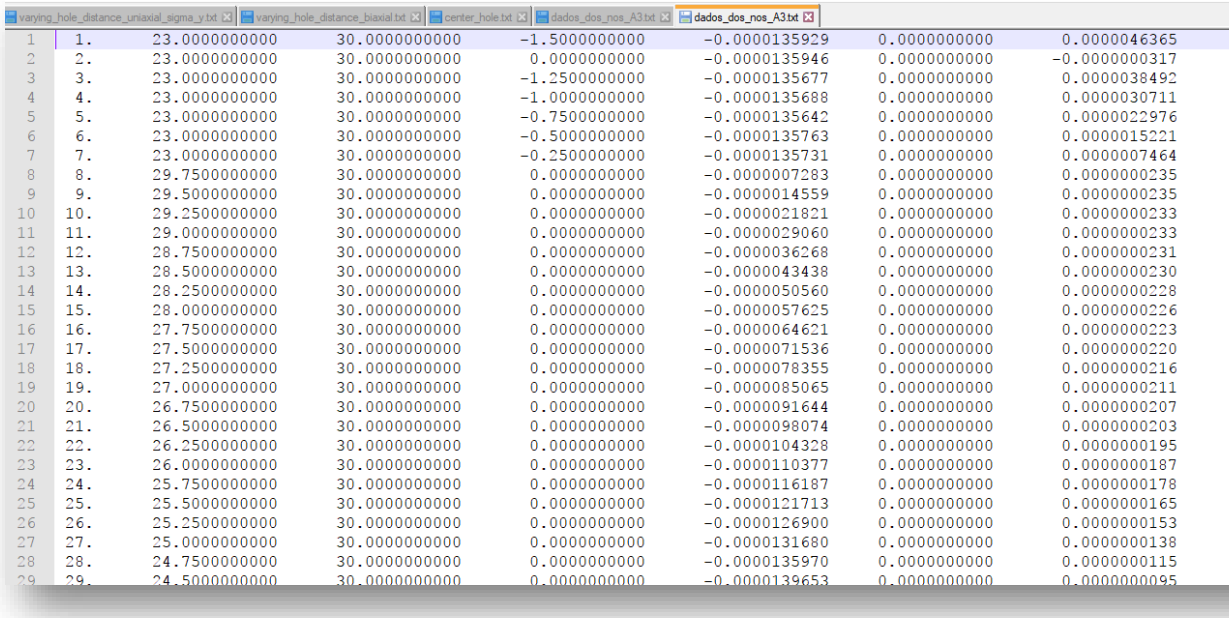
(b) Biaxial load

```
!cont=1 Uniaxial
!cont=2 Biaxial

finish
/solu
lssolve,cont
save
/post1
plnsol,s,y
```

Obtaining Data

```
/cwd,wd(1,1)

/input,dados_forma_matriz_A3,txt !(cria arquivo dados_dos_nos_A3.txt)
! ARMAZENAMENTO DE DADOS
*vget,dados_dos_nos_A3(1,1),node,menor_numero_de_nos,loc,x
*vget,dados_dos_nos_A3(1,2),node,menor_numero_de_nos,loc,y
*vget,dados_dos_nos_A3(1,3),node,menor_numero_de_nos,loc,z
*vget,dados_dos_nos_A3(1,4),node,menor_numero_de_nos,u,x
*vget,dados_dos_nos_A3(1,5),node,menor_numero_de_nos,u,y
*vget,dados_dos_nos_A3(1,6),node,menor_numero_de_nos,u,z
*vget,dados_dos_nos_A3(1,7),node,menor_numero_de_nos,s,x
*vget,dados_dos_nos_A3(1,8),node,menor_numero_de_nos,s,y
*vget,dados_dos_nos_A3(1,9),node,menor_numero_de_nos,s,z
*vget,dados_dos_nos_A3(1,10),node,menor_numero_de_nos,s,eqv


/input,dados_forma_matriz_A3,txt
```

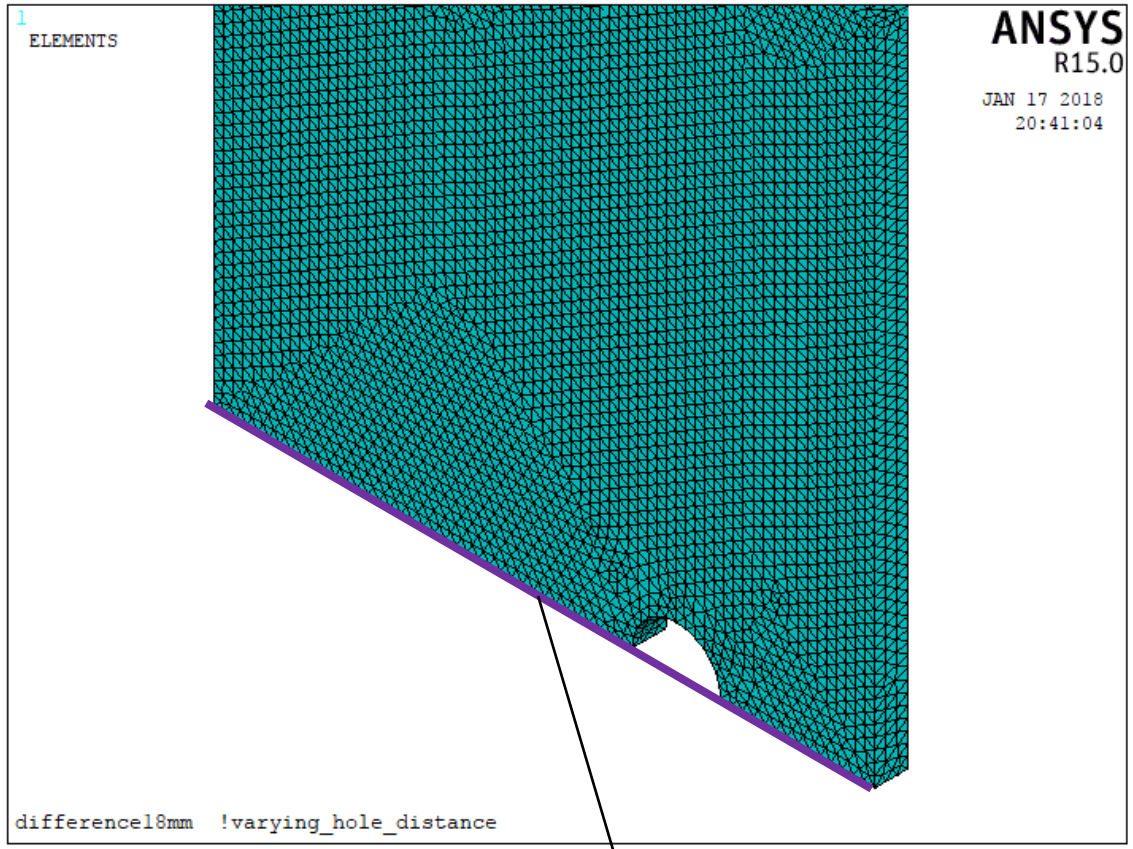




1	1.	23.0000000000	30.0000000000	-1.5000000000	-0.0000135929	0.0000000000	0.0000046365
2	2.	23.0000000000	30.0000000000	0.0000000000	-0.0000135946	0.0000000000	-0.0000000317
3	3.	23.0000000000	30.0000000000	-1.2500000000	-0.0000135677	0.0000000000	0.0000038492
4	4.	23.0000000000	30.0000000000	-1.0000000000	-0.0000135688	0.0000000000	0.0000030711
5	5.	23.0000000000	30.0000000000	-0.7500000000	-0.0000135642	0.0000000000	0.0000022976
6	6.	23.0000000000	30.0000000000	-0.5000000000	-0.0000135763	0.0000000000	0.0000015221
7	7.	23.0000000000	30.0000000000	-0.2500000000	-0.0000135731	0.0000000000	0.0000007464
8	8.	29.7500000000	30.0000000000	0.0000000000	-0.0000007283	0.0000000000	0.0000000235
9	9.	29.5000000000	30.0000000000	0.0000000000	-0.0000014559	0.0000000000	0.0000000235
10	10.	29.2500000000	30.0000000000	0.0000000000	-0.0000021821	0.0000000000	0.0000000233
11	11.	29.0000000000	30.0000000000	0.0000000000	-0.0000029060	0.0000000000	0.0000000233
12	12.	28.7500000000	30.0000000000	0.0000000000	-0.0000036268	0.0000000000	0.0000000231
13	13.	28.5000000000	30.0000000000	0.0000000000	-0.0000043438	0.0000000000	0.0000000230
14	14.	28.2500000000	30.0000000000	0.0000000000	-0.0000050560	0.0000000000	0.0000000228
15	15.	28.0000000000	30.0000000000	0.0000000000	-0.0000057625	0.0000000000	0.0000000226
16	16.	27.7500000000	30.0000000000	0.0000000000	-0.0000064621	0.0000000000	0.0000000223
17	17.	27.5000000000	30.0000000000	0.0000000000	-0.0000071536	0.0000000000	0.0000000220
18	18.	27.2500000000	30.0000000000	0.0000000000	-0.0000078355	0.0000000000	0.0000000216
19	19.	27.0000000000	30.0000000000	0.0000000000	-0.0000085065	0.0000000000	0.0000000211
20	20.	26.7500000000	30.0000000000	0.0000000000	-0.0000091644	0.0000000000	0.0000000207
21	21.	26.5000000000	30.0000000000	0.0000000000	-0.0000098074	0.0000000000	0.0000000203
22	22.	26.2500000000	30.0000000000	0.0000000000	-0.0000104328	0.0000000000	0.0000000195
23	23.	26.0000000000	30.0000000000	0.0000000000	-0.0000110377	0.0000000000	0.0000000187
24	24.	25.7500000000	30.0000000000	0.0000000000	-0.0000116187	0.0000000000	0.0000000178
25	25.	25.5000000000	30.0000000000	0.0000000000	-0.0000121713	0.0000000000	0.0000000165
26	26.	25.2500000000	30.0000000000	0.0000000000	-0.0000126900	0.0000000000	0.0000000153
27	27.	25.0000000000	30.0000000000	0.0000000000	-0.0000131680	0.0000000000	0.0000000138
28	28.	24.7500000000	30.0000000000	0.0000000000	-0.0000135970	0.0000000000	0.0000000115
29	29.	24.5000000000	30.0000000000	0.0000000000	-0.0000139653	0.0000000000	0.0000000095

Manipulating Data – Matlab Code

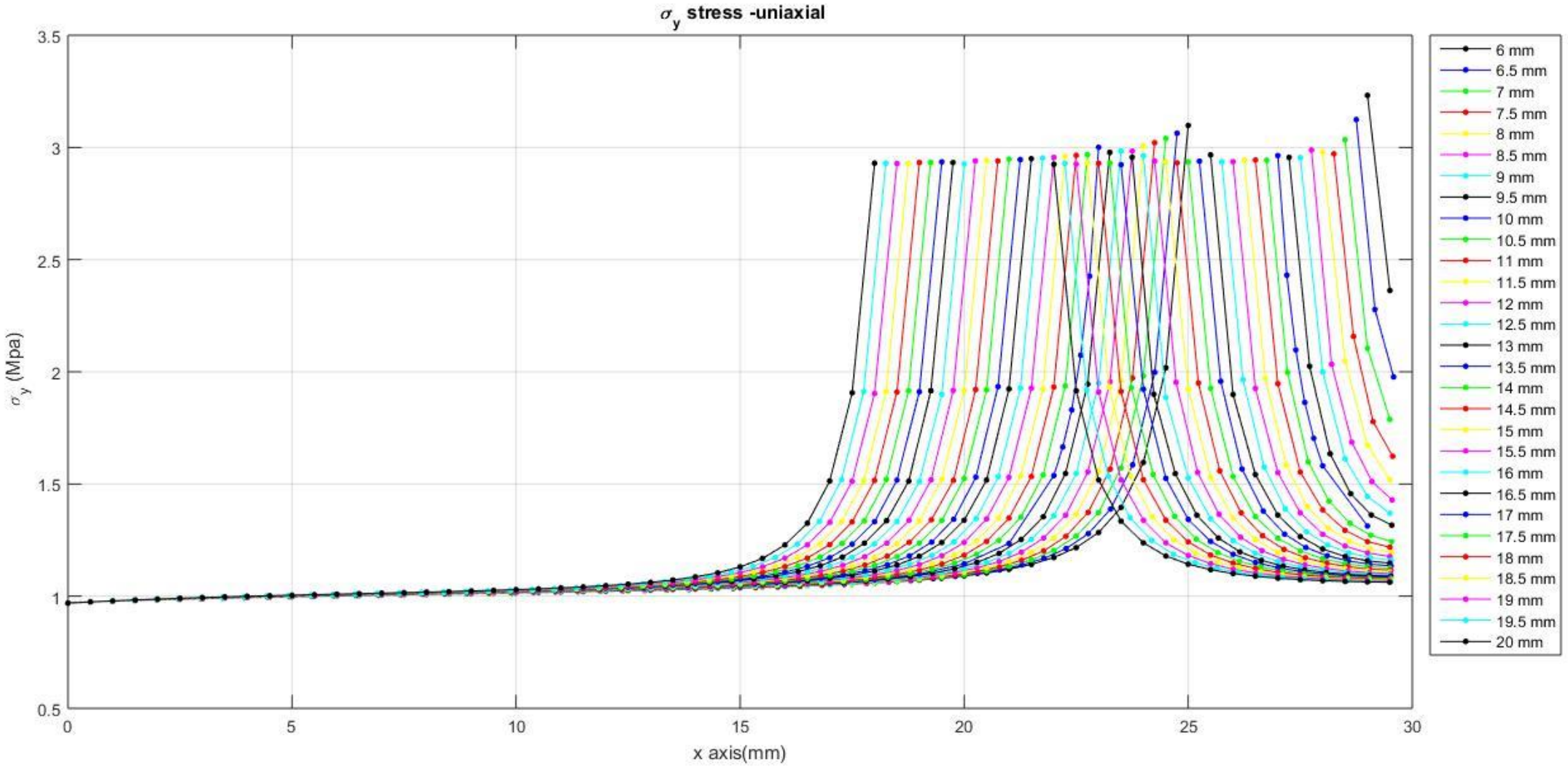
```
diff=[6:0.5:20]; %Point differences to be read
[m n] = size(diff);
r = 2; %hole radius
L = 60;
for a=1:1:n %going through each point difference
    path=['C:\Manasses\varying_hole_distance\',a
     nome='dados_dos_nos_A3.txt';%file name
     [n,xloc,yloc,zloc,ux,uy,uz,sx,sy,sz,se]=tex
     matriz=[n(:,1),xloc(:,1),yloc(:,1),zloc(:,1
     matriz=sortrows(matriz,2); %Deixa os dados
     [i,j]=find(matriz(:,4)~=0.0);%transversal l
     matriz(i,:)=[];%exclui os pontos que não es
     [i,j]=find(matriz(:,9)==0); %finds sigmax v
     matriz(i,:)=[];%exclui os valores de tensão
     [i,j]=size(matriz);
     x1 = ((L-diff(a))/2)-r;
     x2 = ((L-diff(a))/2)+r;
     [i,j]=find(matriz(:,2)==x1|matriz(:,2)==x2)

     [g h] = size(matriz);
     .
     .
     .
```



');
e(:,1)];

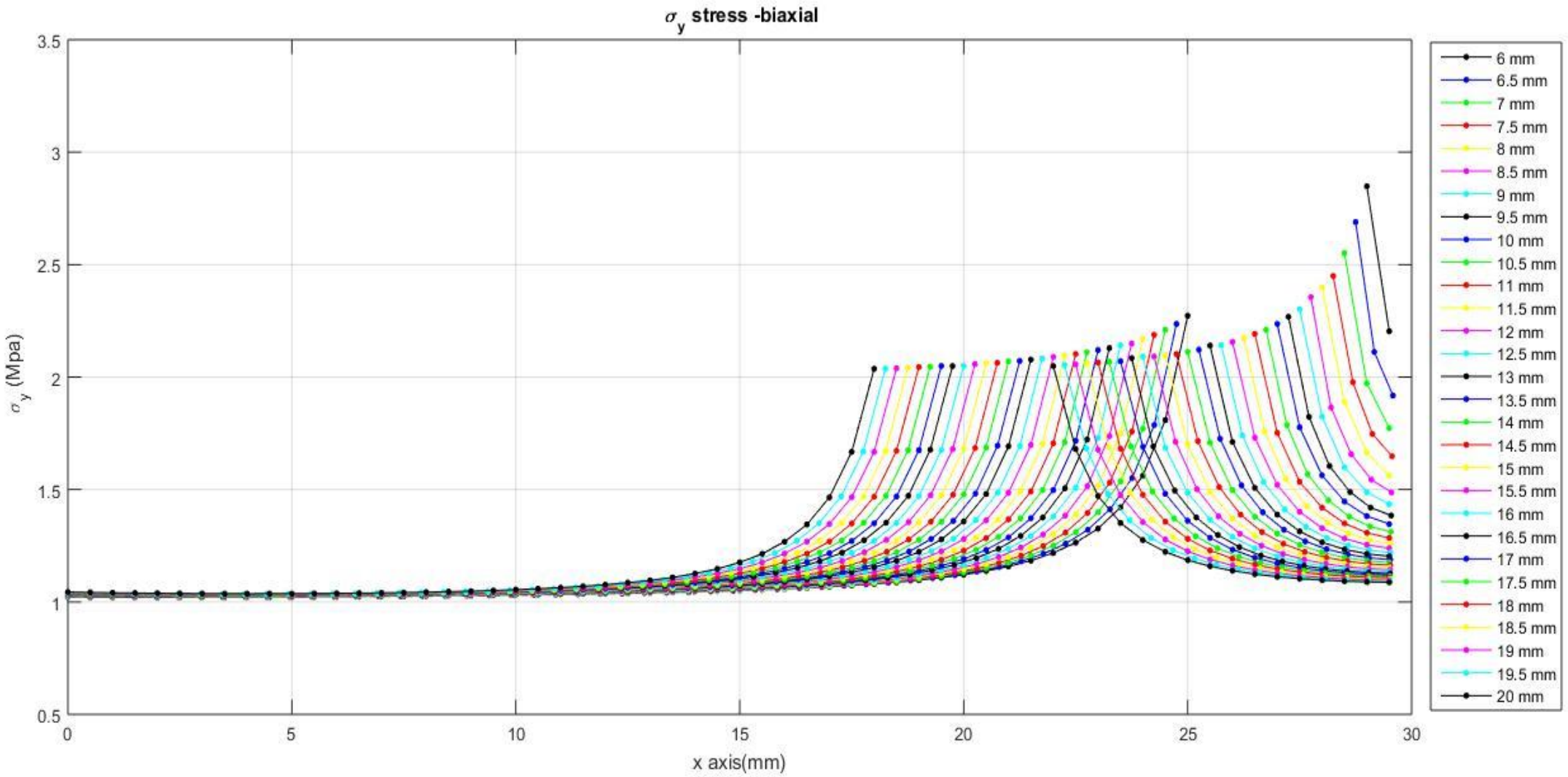
line of interest

Matlab Plots – stress profile



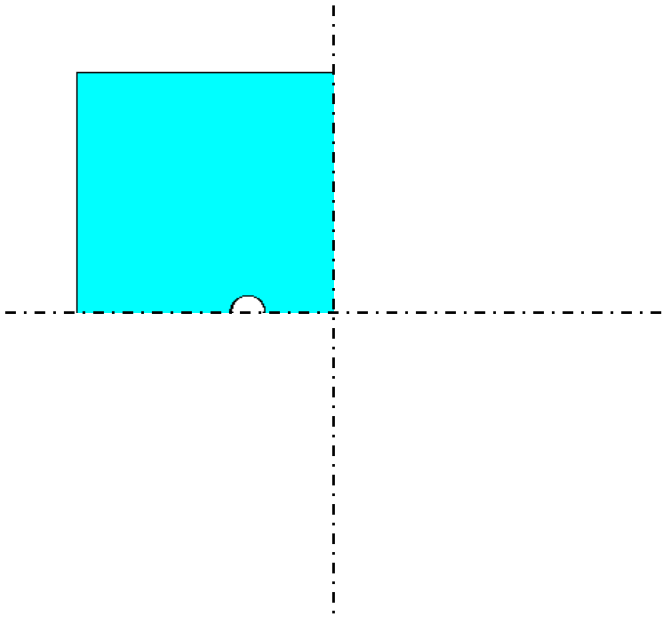
- Varying the hole distance

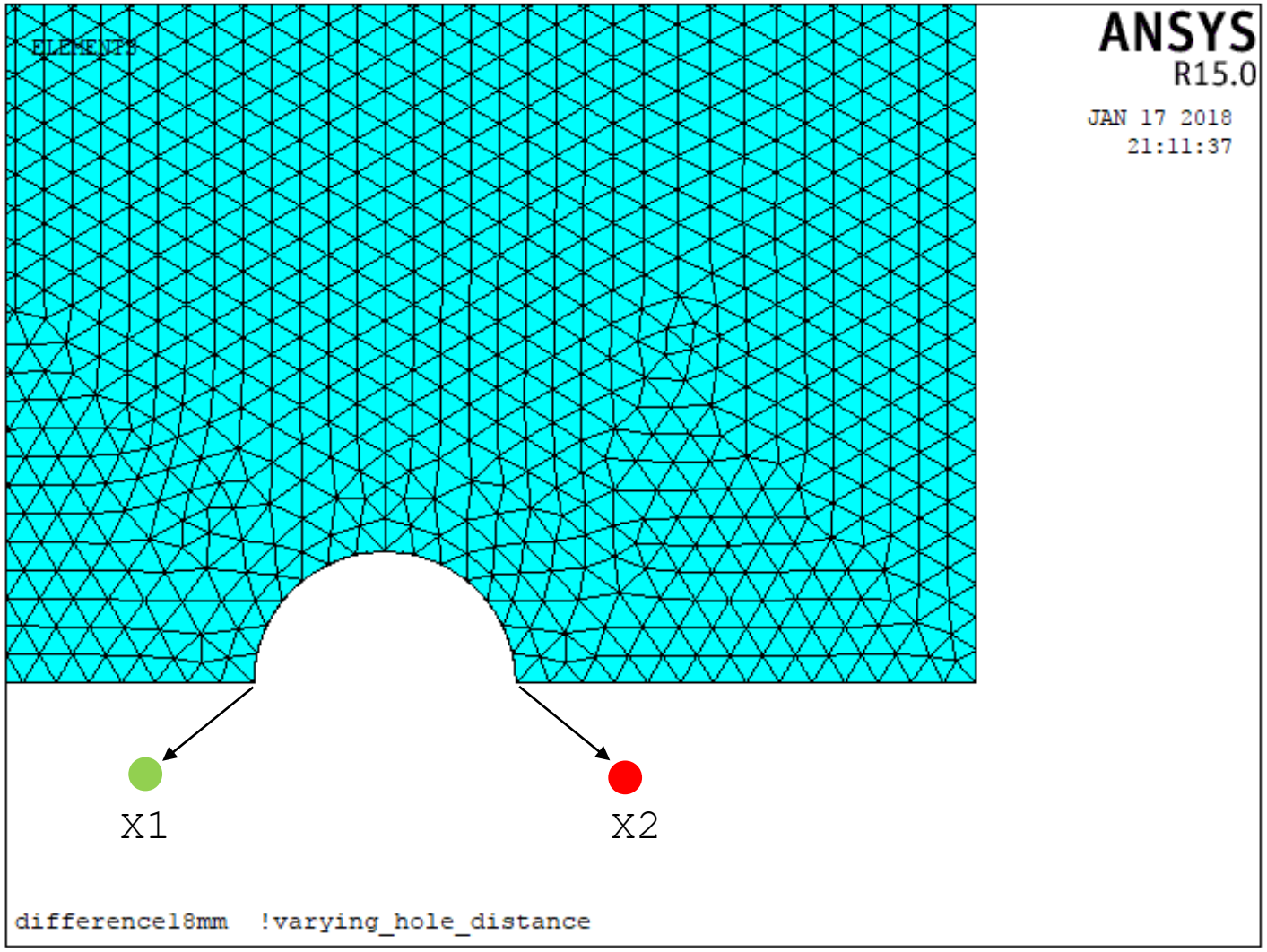
Matlab Plots – stress profile



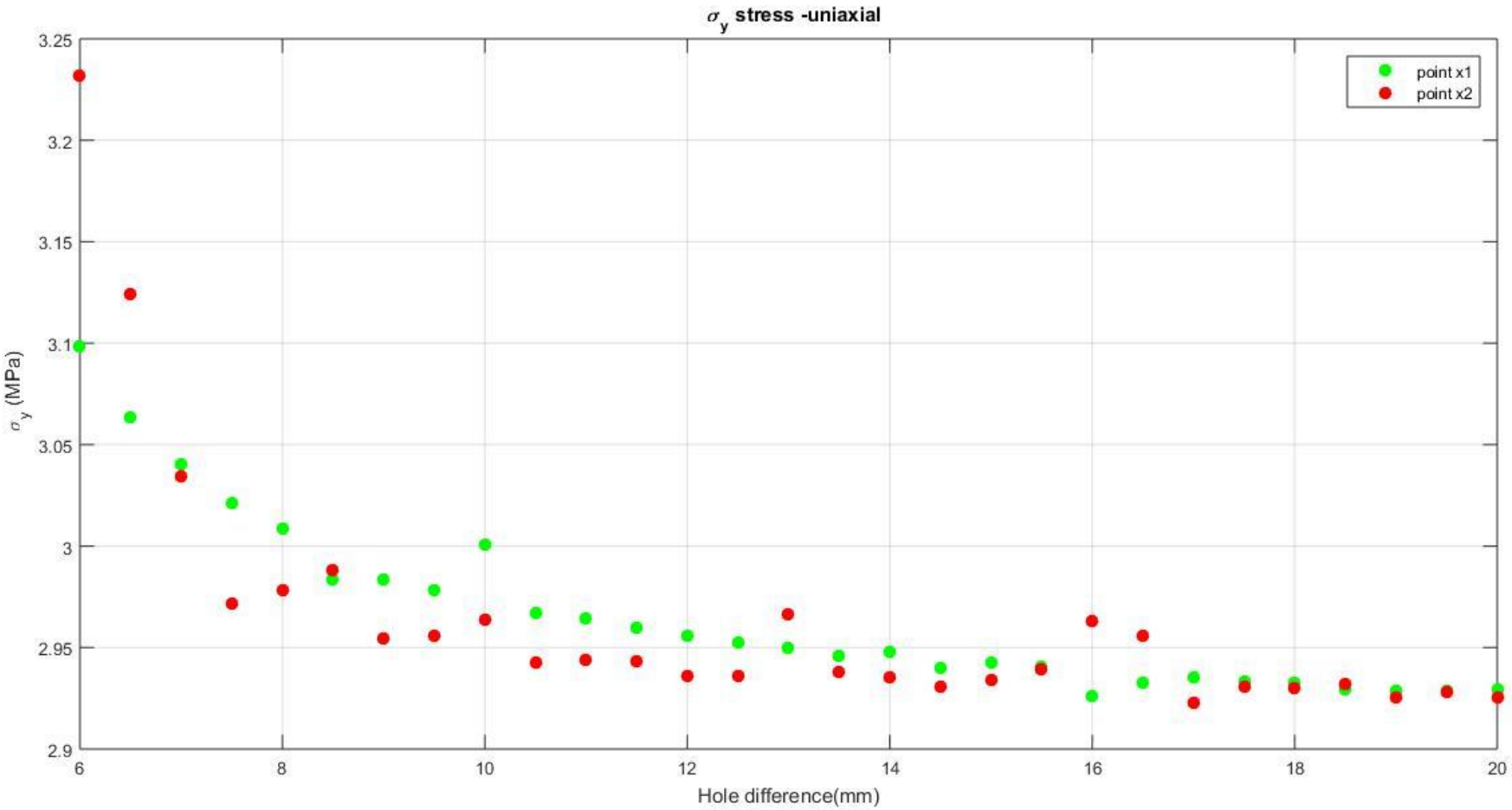
- Varying the hole distance

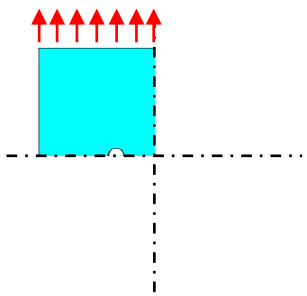
Manipulating Data – Matlab Code



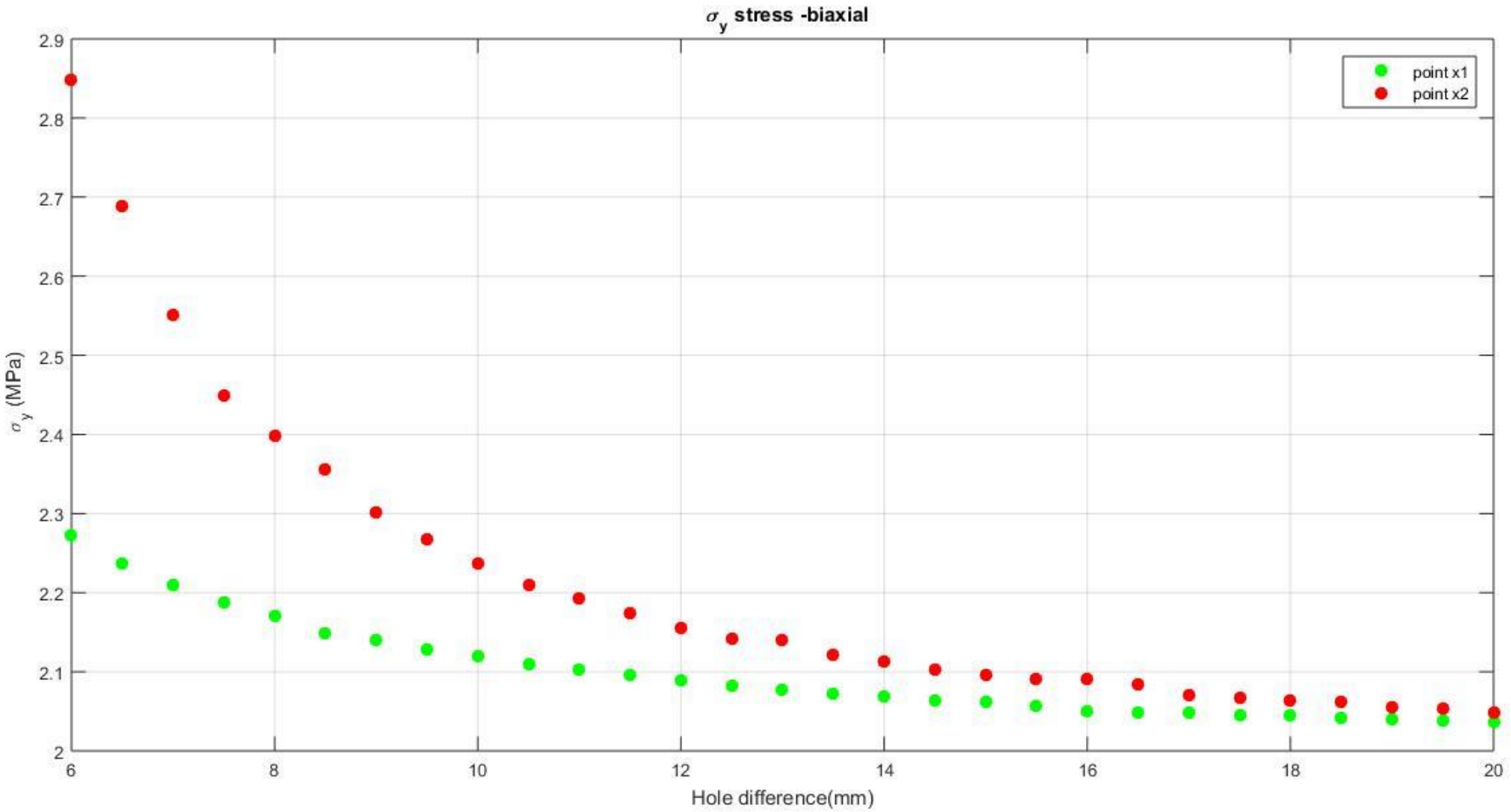


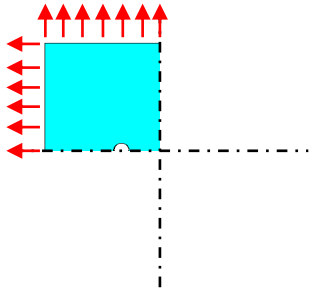
Matlab Plots – stress at points X1, X2





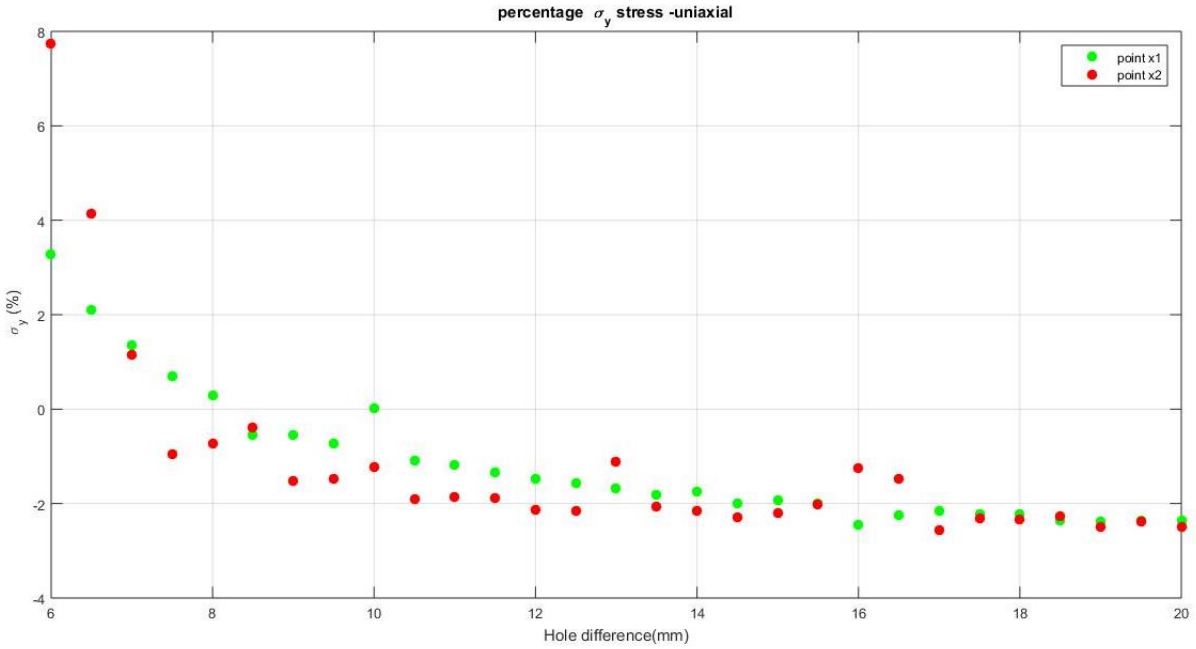
Matlab Plots – stress at points X1, X2

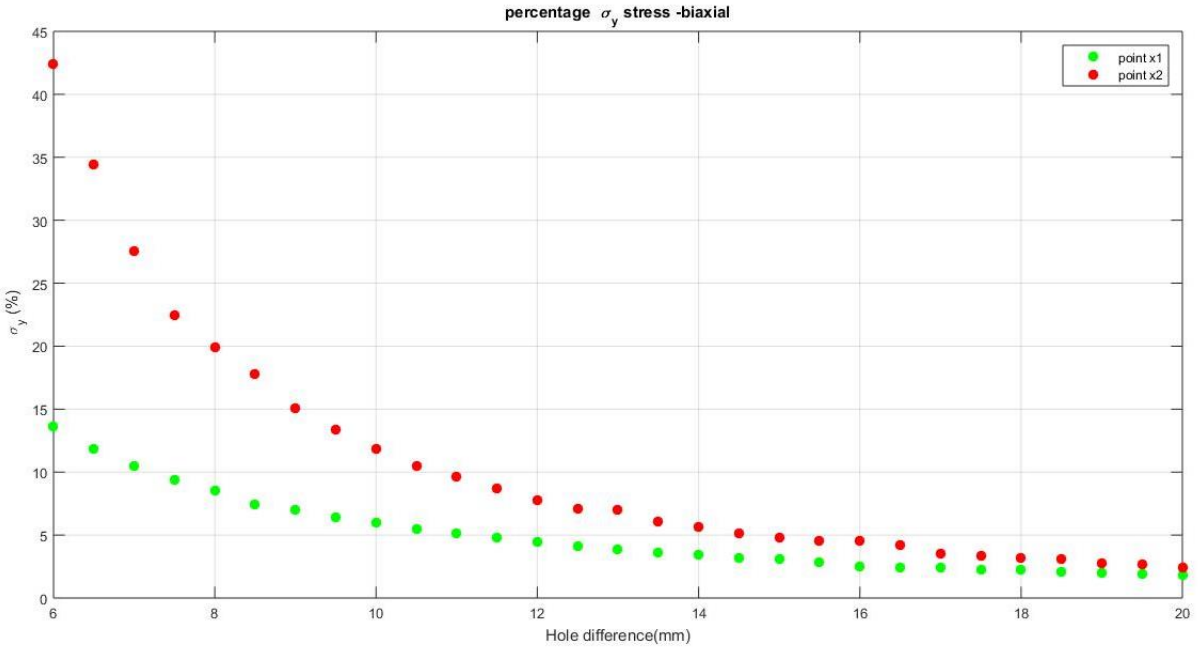


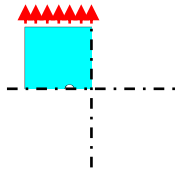


Matlab Plots – percentage, X1, X2

percentage = 100*(Sigmay(x1,x2) – sigmay_theoretical)/(sigmay_theoretical)

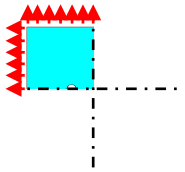






(a)Uniaxial, Transverse load

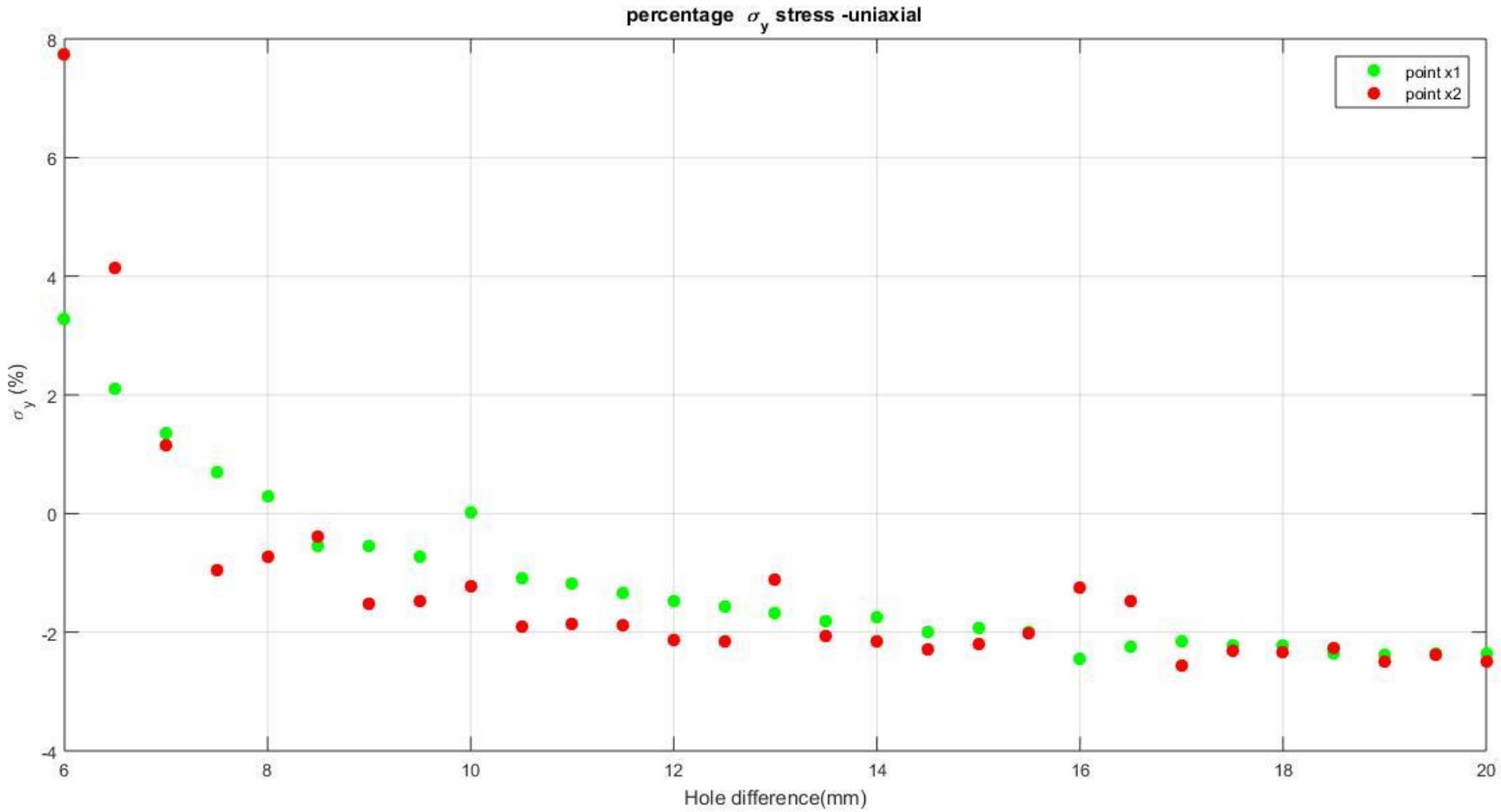
sigmay_theoretical = 3



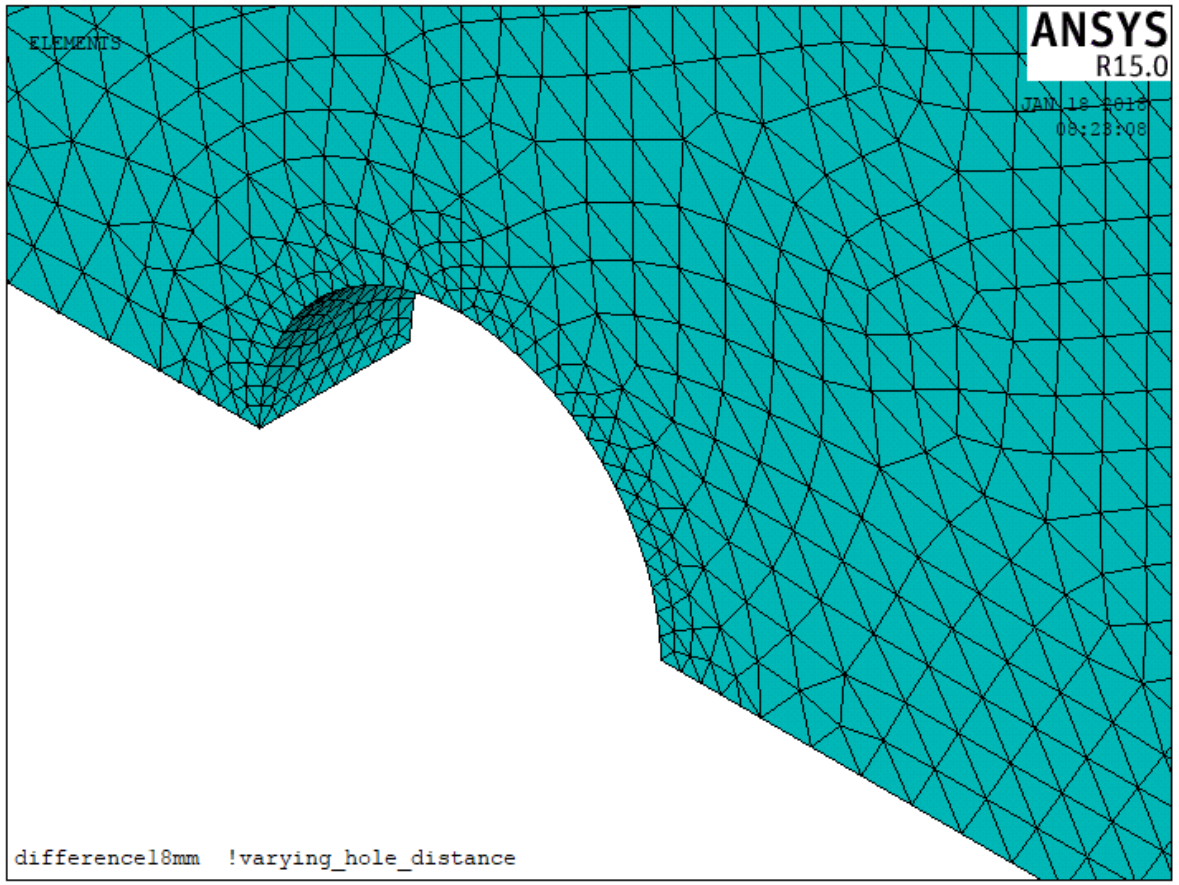
(b)Biaxial load

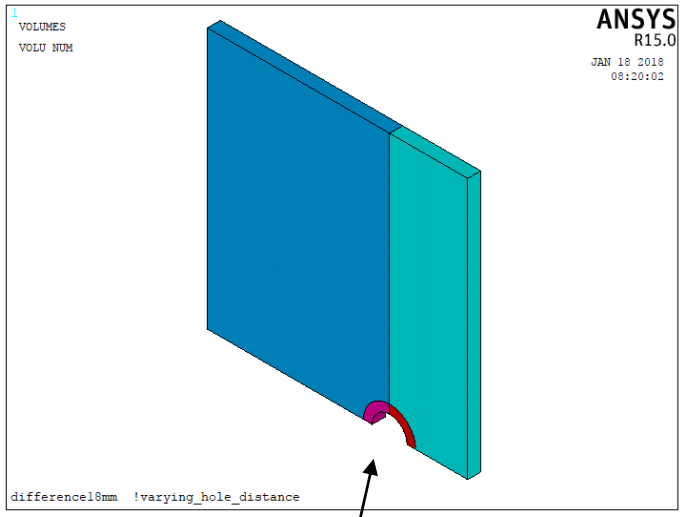
sigmay_theoretical = 2

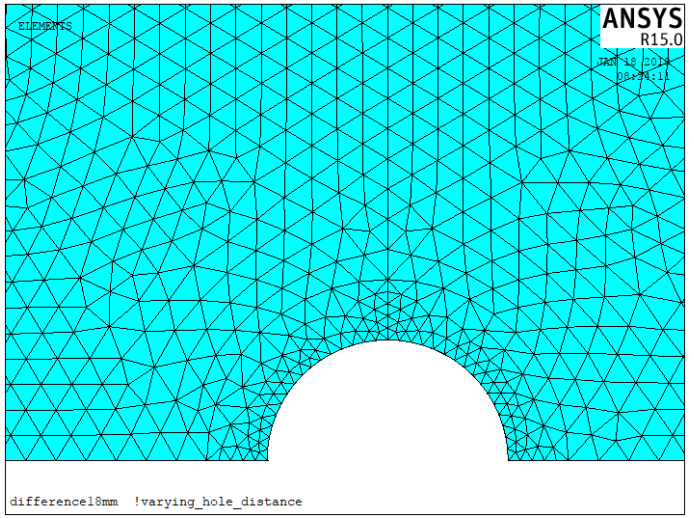
Matlab Plots – points X1, X2



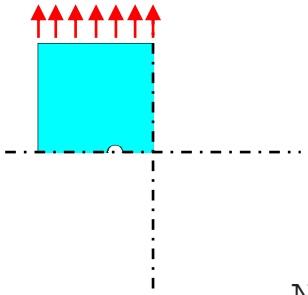
Refined Mesh Region





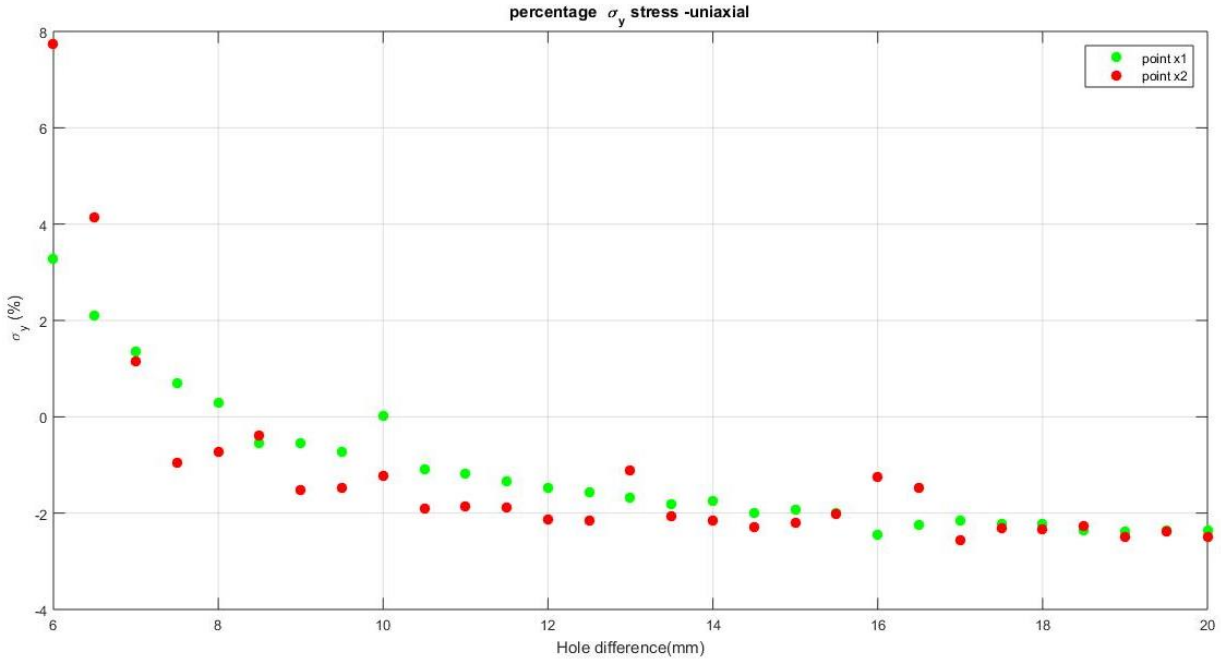



```
radius_int1=2.0
radius_ext1=3.0
cyl4,xcenter1,ycenter1,radius_int1,angle_int1,radius_ext1,angle_ext1,-depth1
```



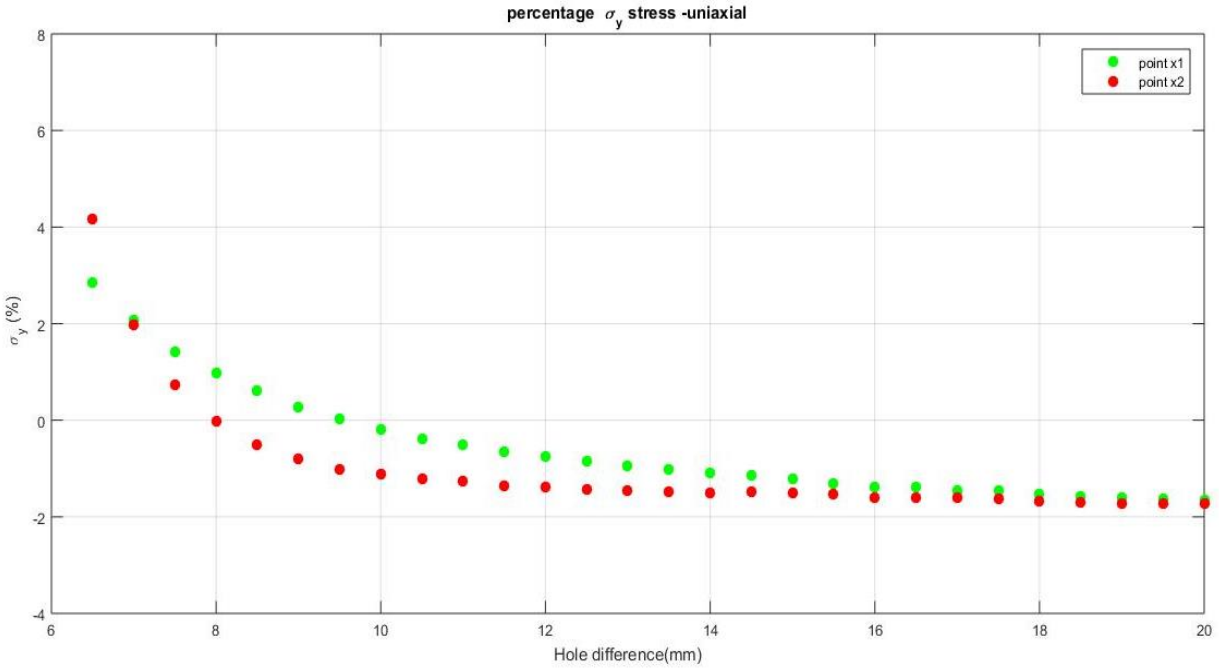
Uniaxial, Transverse load

No Refined Mesh Region




```
!mesh
esize,0.5
```

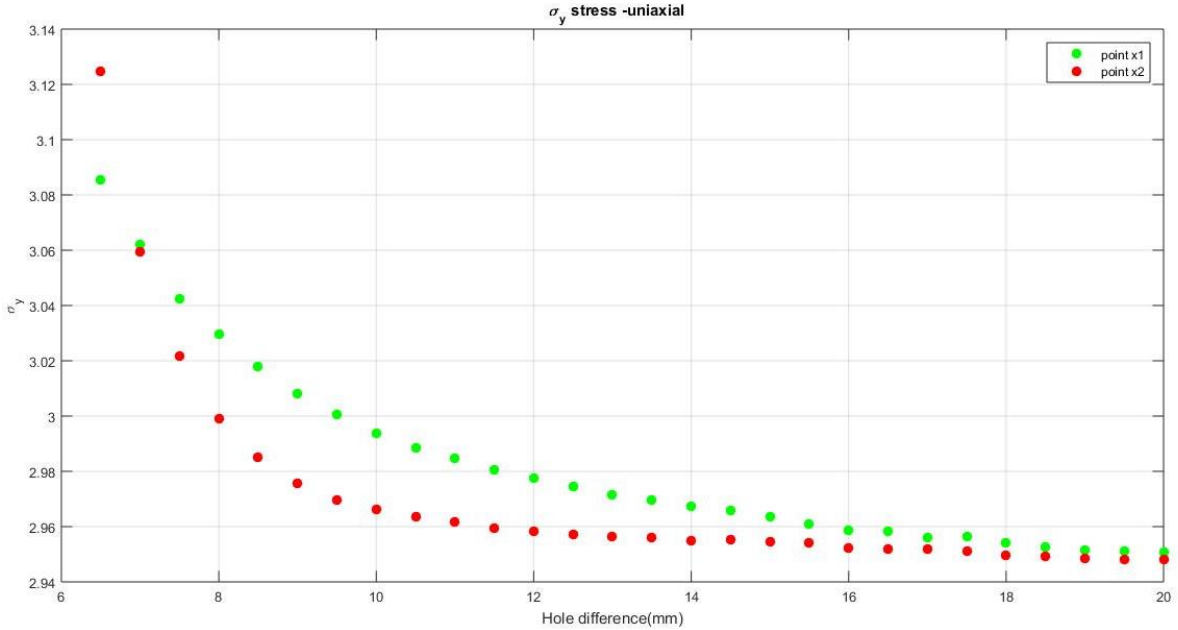
Refined Mesh Region

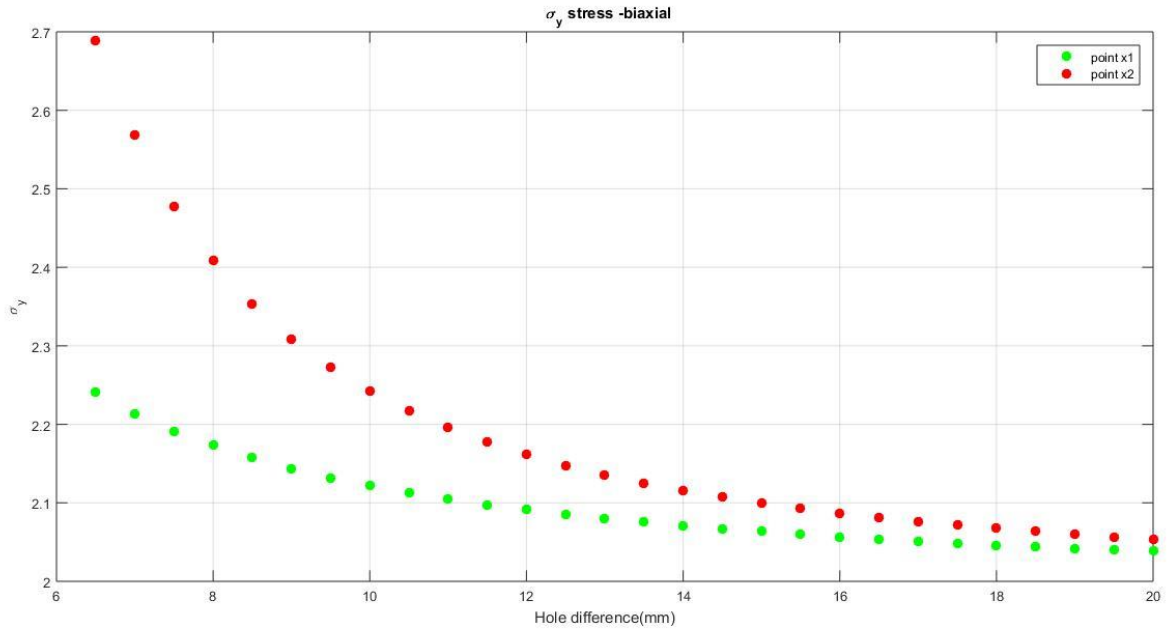



```
!coarse mesh
esize,0.5
!fine mesh
esize,0.2
```

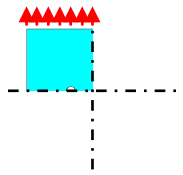
Load Comparison, X1, X2

```
!coarse mesh
esize,0.5
!fine mesh
esize,0.2
```



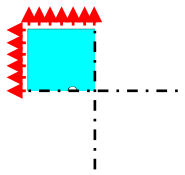


(a) Uniaxial, Transverse load

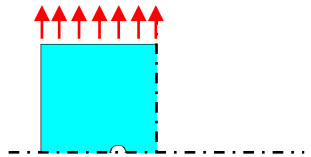


sigmay_theoretical = 3

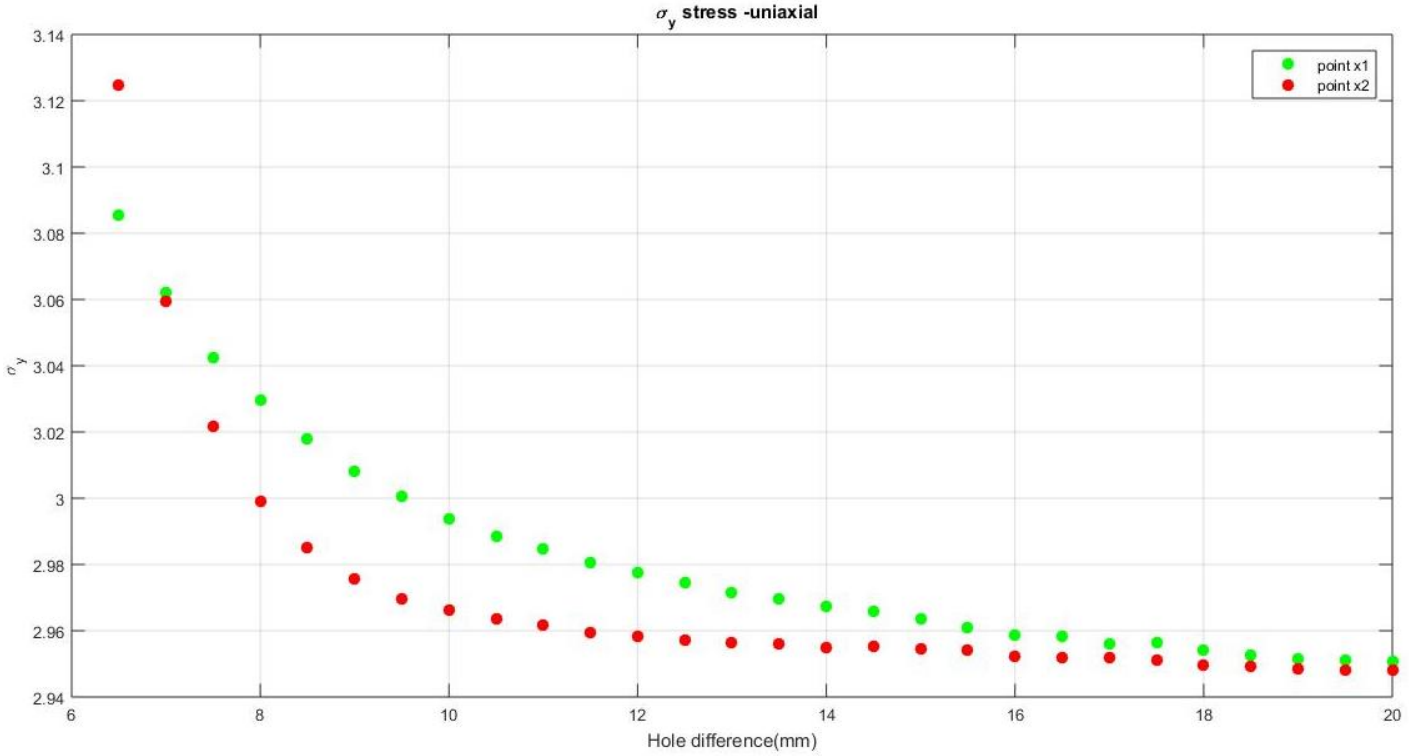
(b) Biaxial load

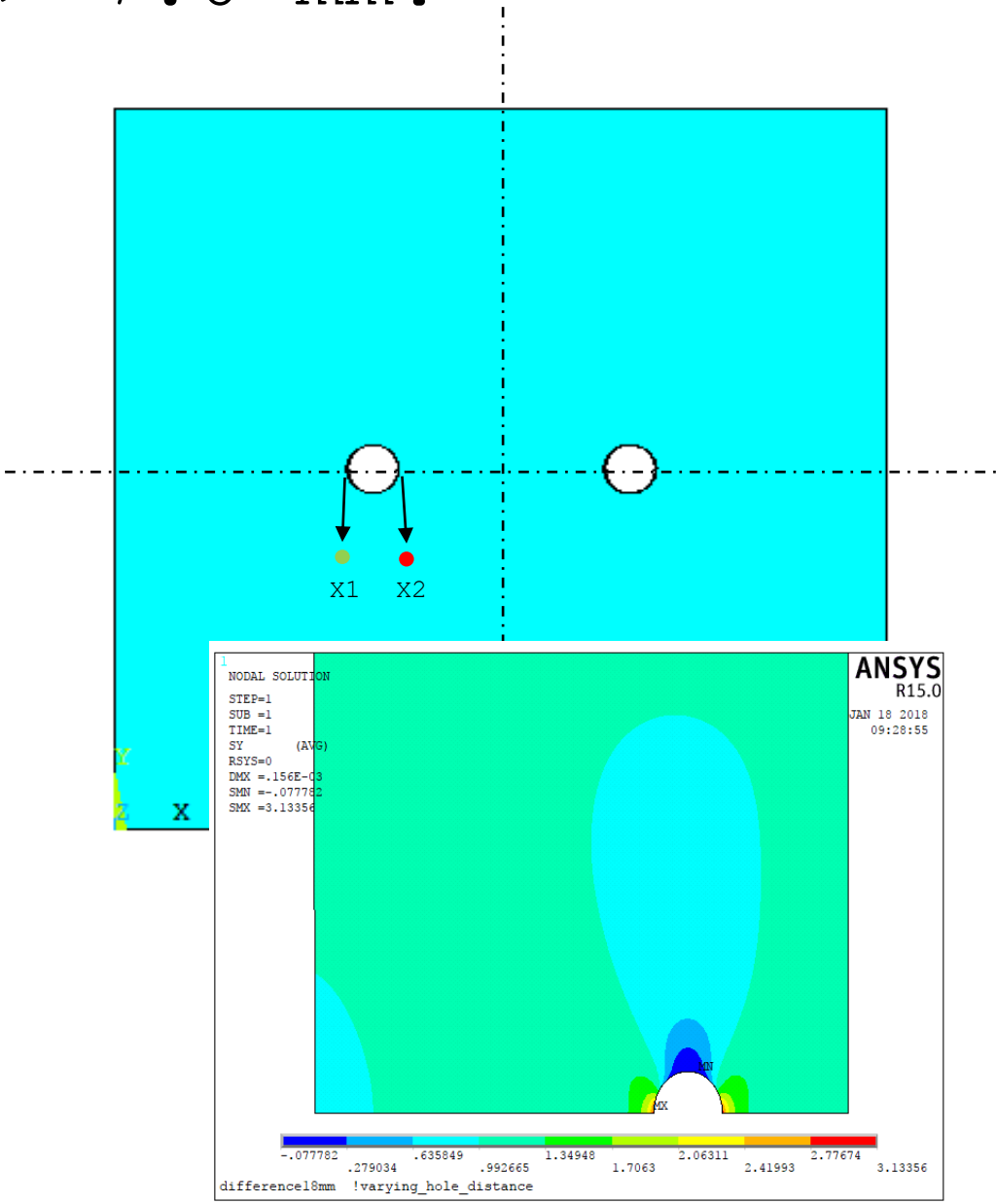


sigmay_theoretical = 2

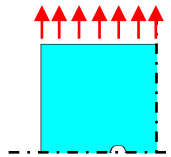


Why X1 > X2 for diff > 7.0 mm?

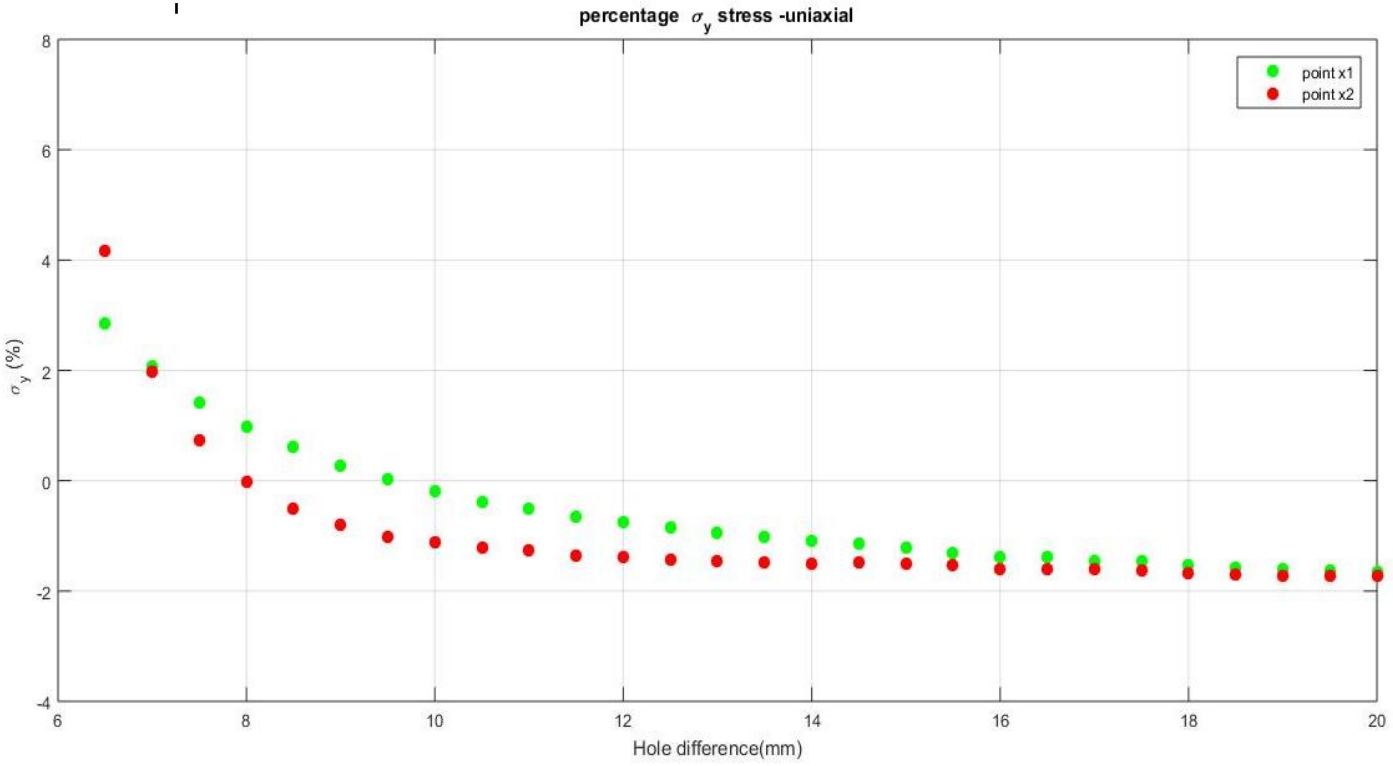


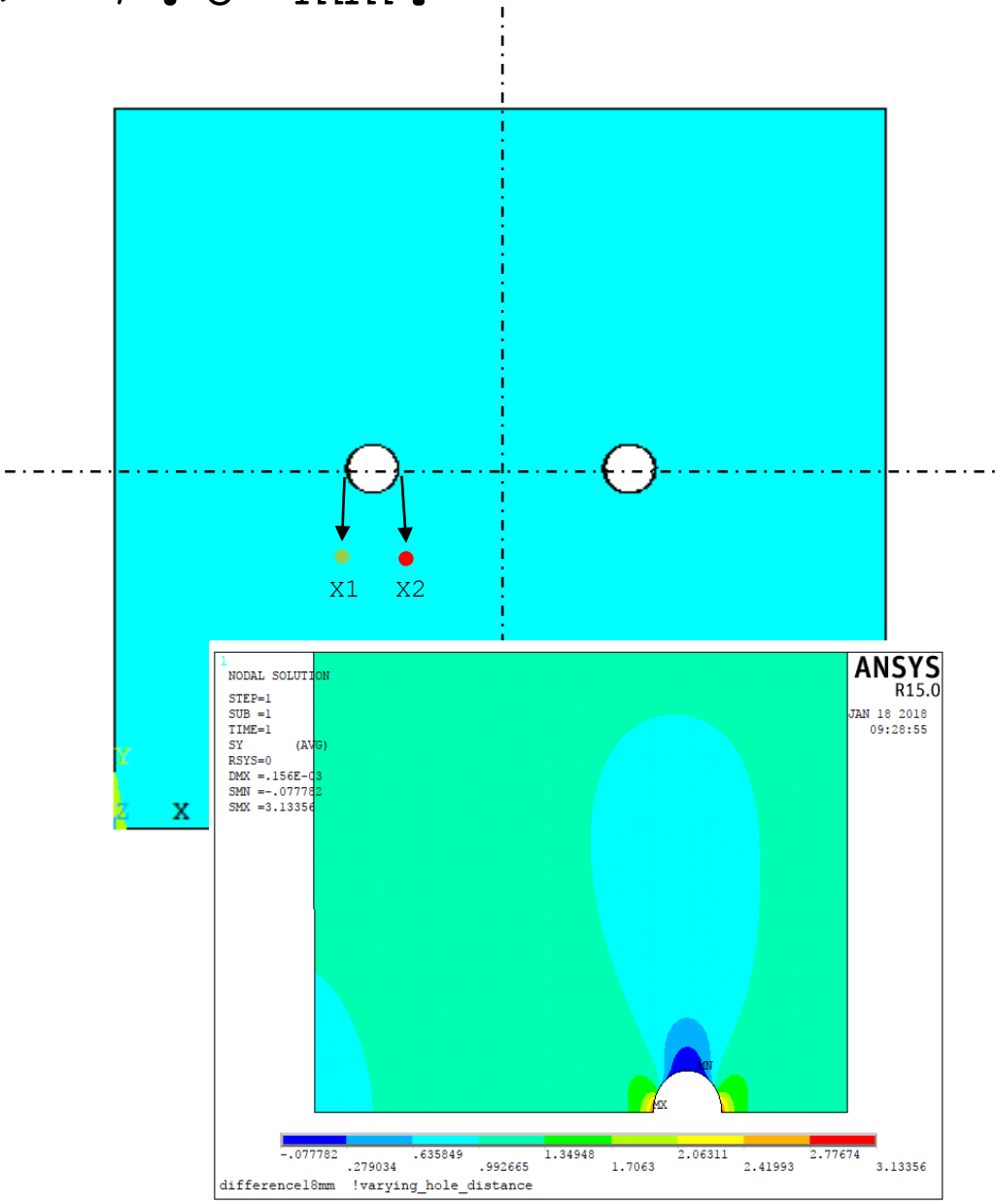



```
inicial = 6.5 !mm, minimum, duo the refined mesh region (cylinder)
final = 20 !mm
incr = 0.5 !mm

*do,diff,inicial,final,incr
          ...
*enddo
```



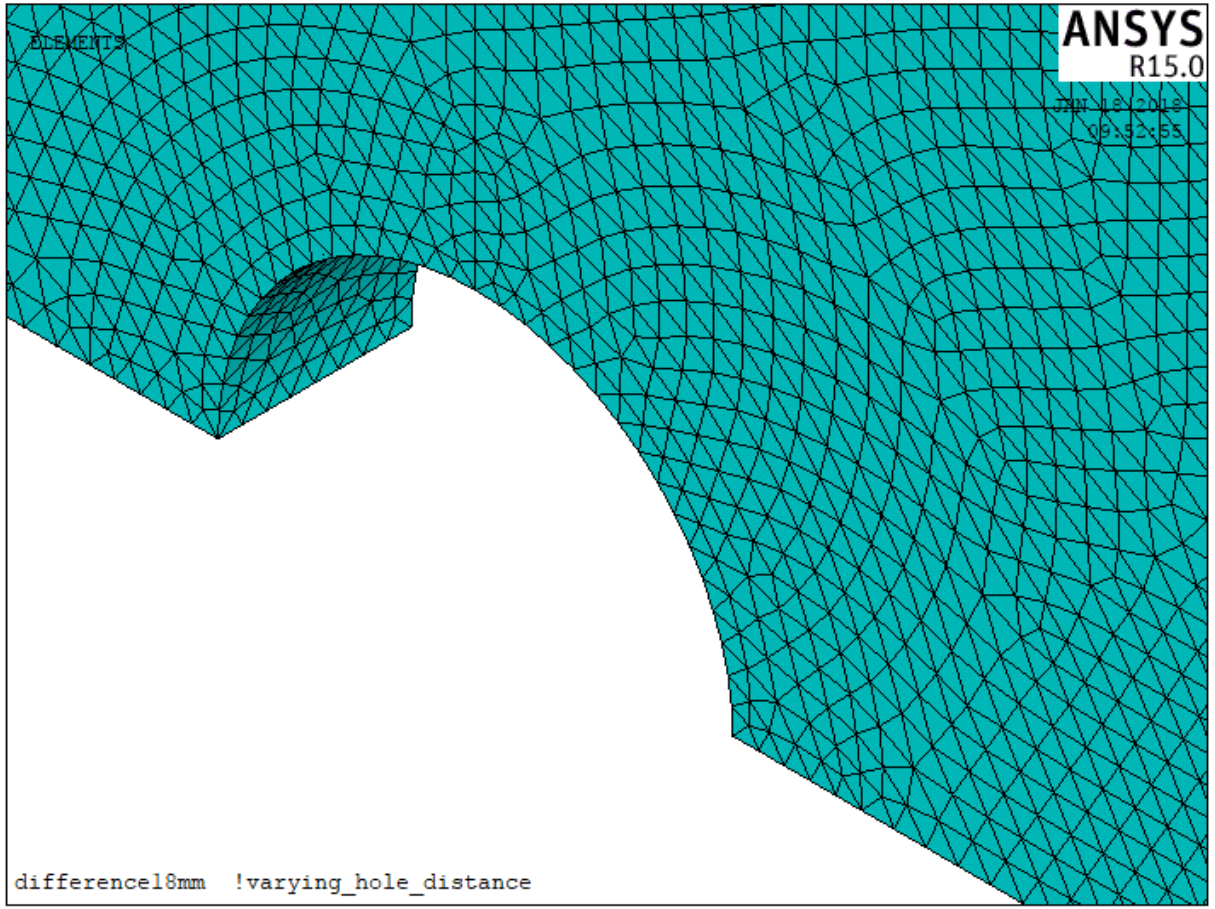
Why X1 > X2 for diff > 7.0 mm?

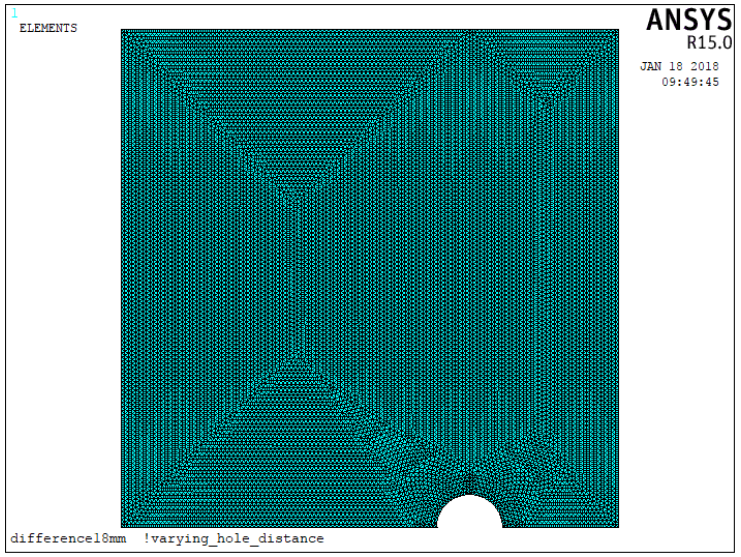


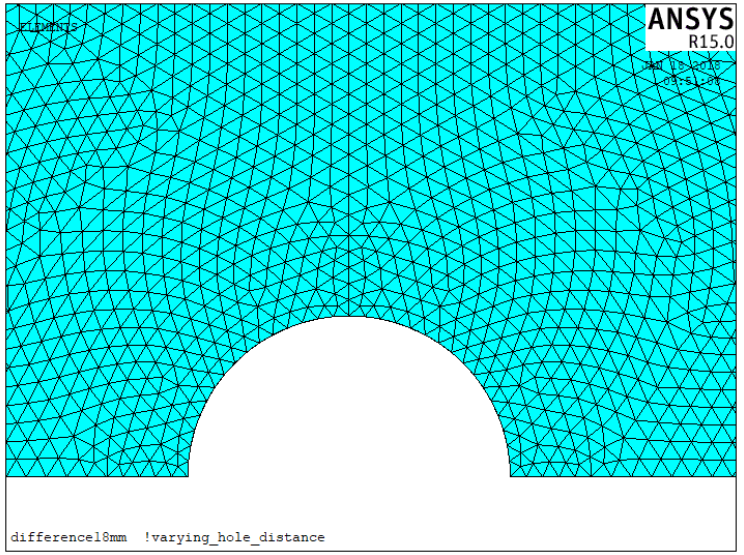



```
inicial = 6.5 !mm, minimum, duo the refined mesh region (cylinder)
final = 20 !mm
incr = 0.5 !mm

*do,diff,inicial,final,incr
          ...
*enddo
```

Even Finer Mesh Region





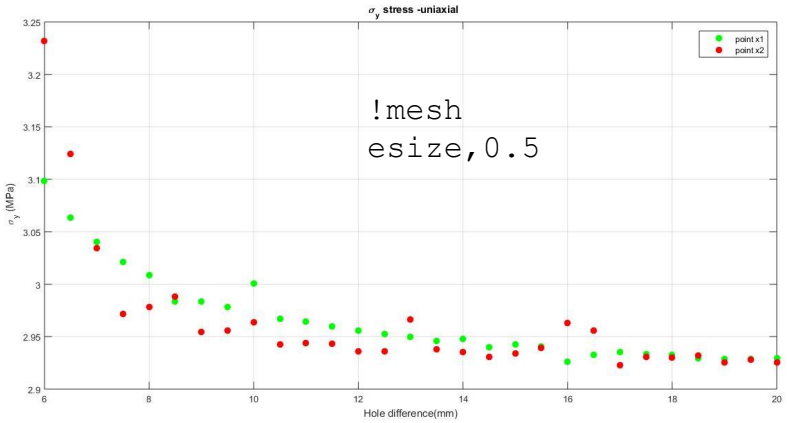


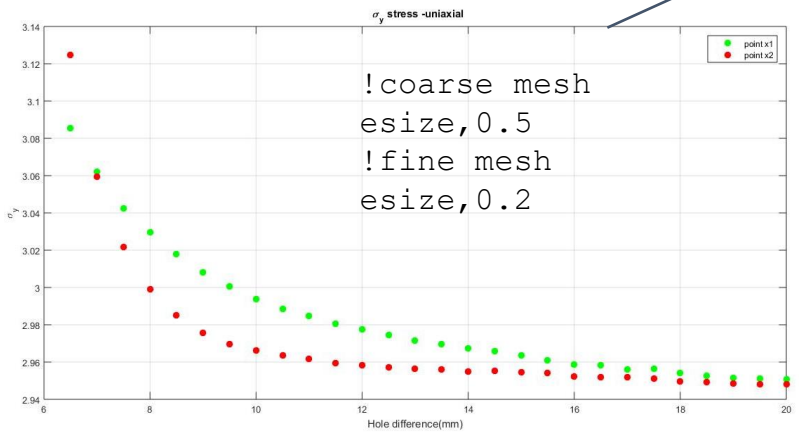

```
!coarse mesh
esize,0.25
!fine mesh
esize,0.2
```

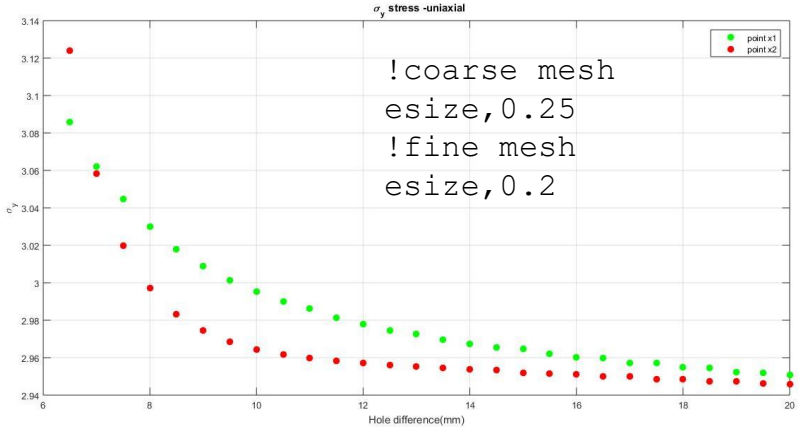
```
!Cost, just uniaxial simulation
! ~12h proccessing
! 166 GB files
```

Results

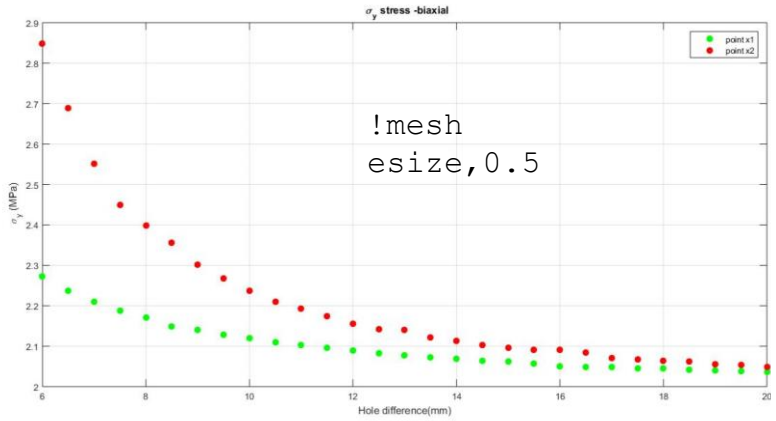
Asked this mesh with 0.5 thickness ring

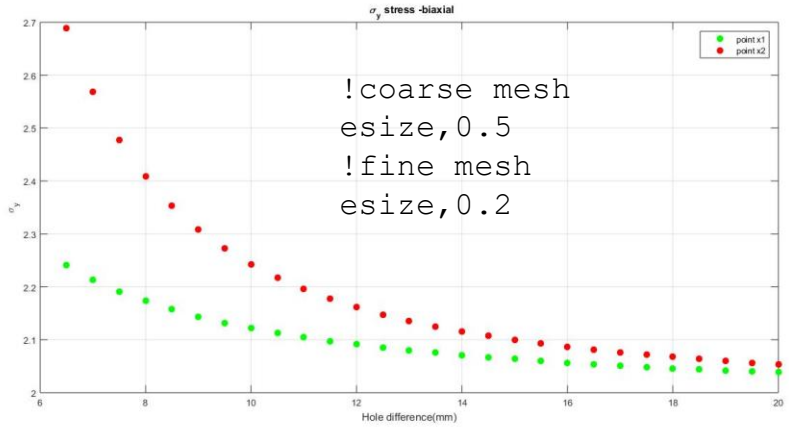




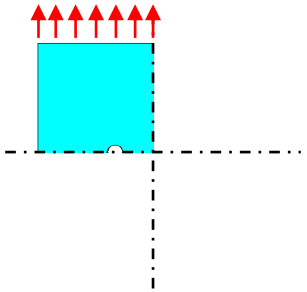


(a)Uniaxial, Transverse load



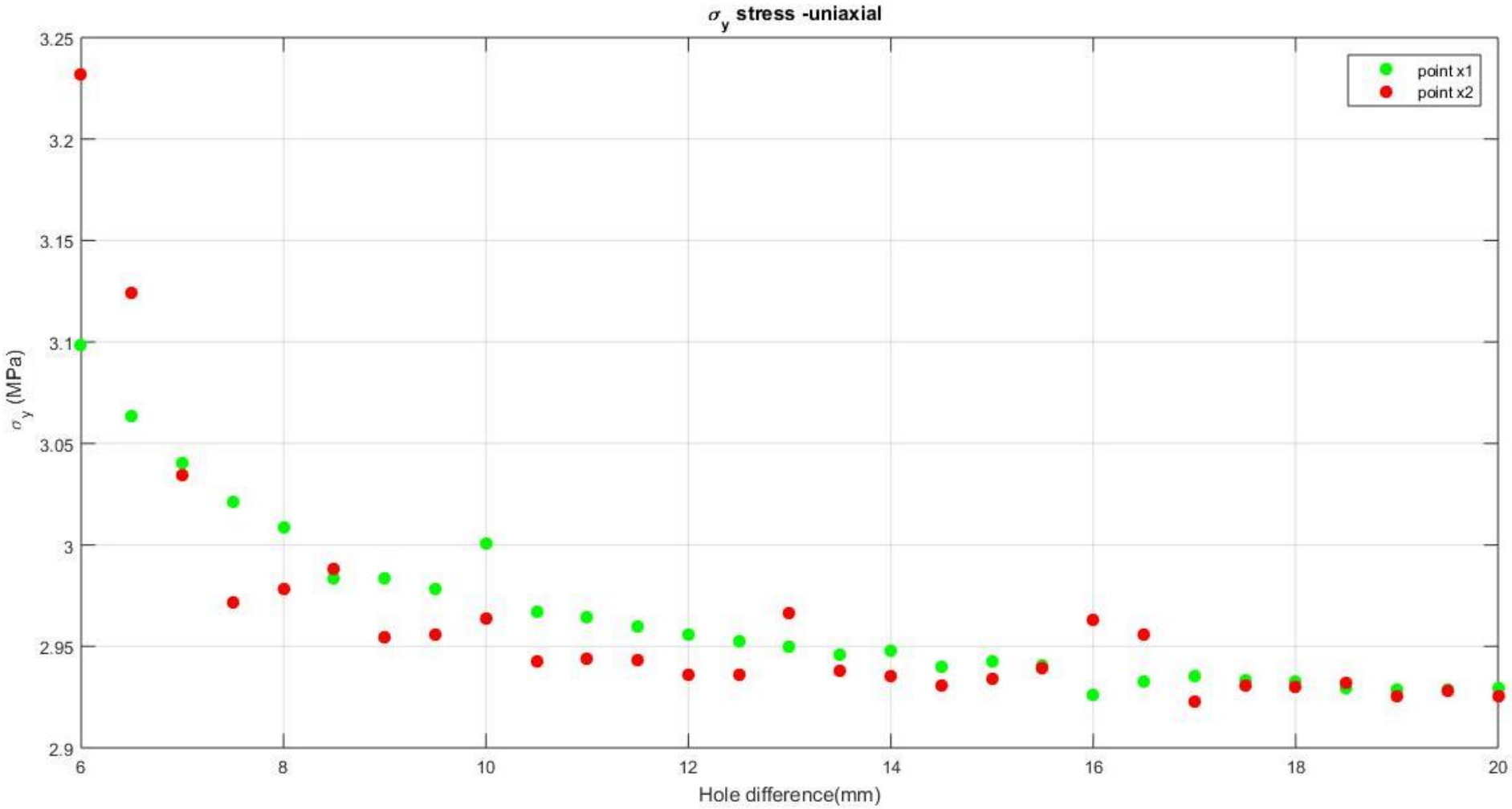


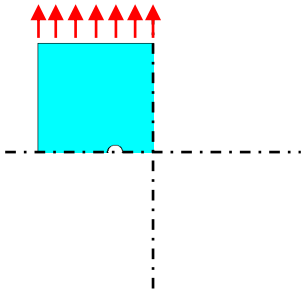
(b)Biaxial load



Uniaxial, Transverse load

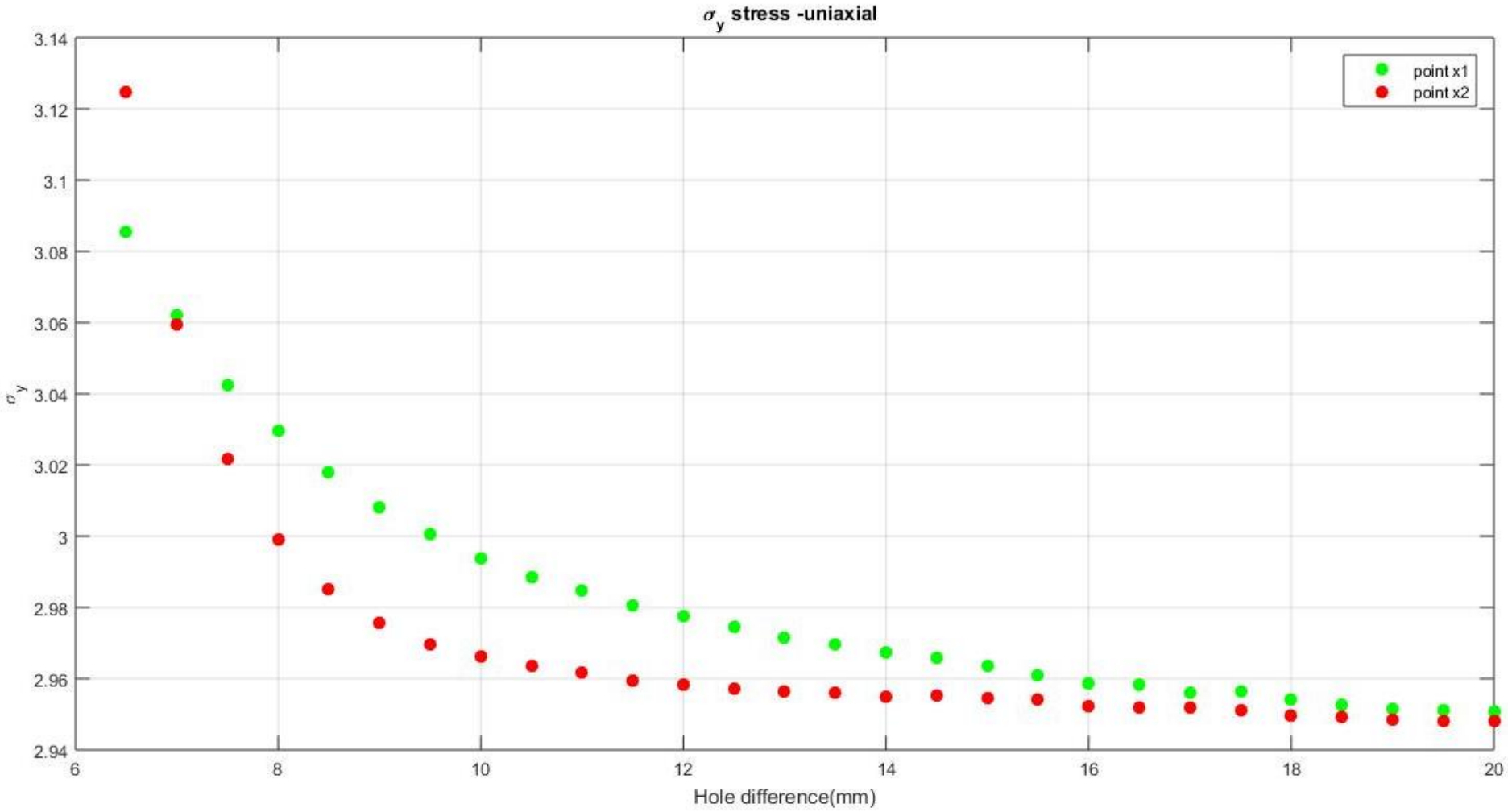
```
!mesh
esize,0.5
```

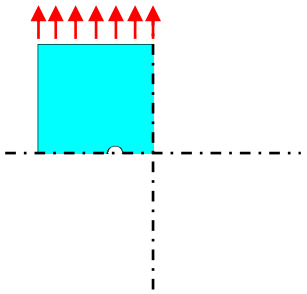




Uniaxial, Transverse load

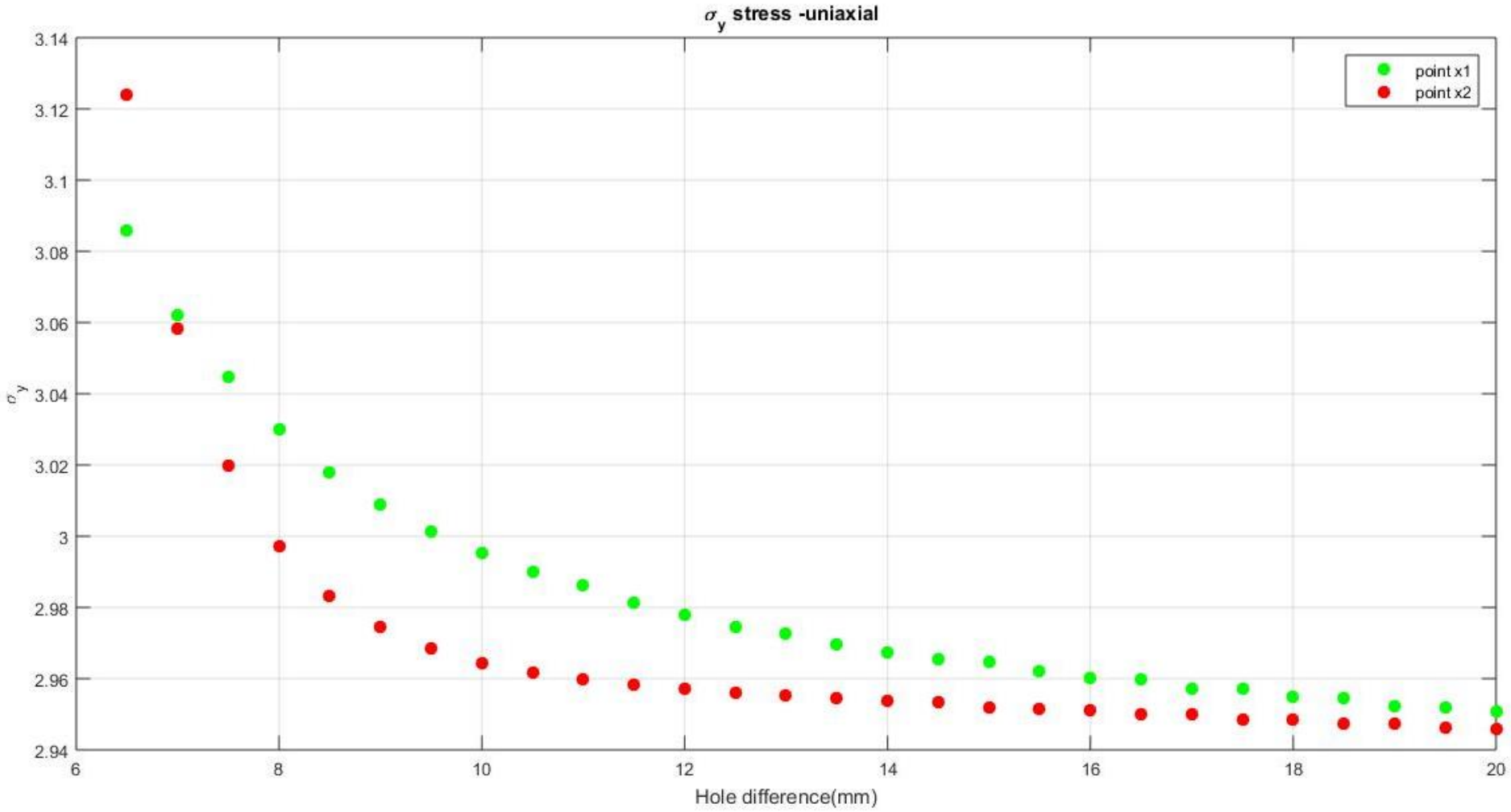
```
!coarse mesh
esize,0.5
!fine mesh
esize,0.2
```





Uniaxial, Transverse load

```
!coarse mesh
esize,0.25
!fine mesh
esize,0.2
```



Theoretical Result

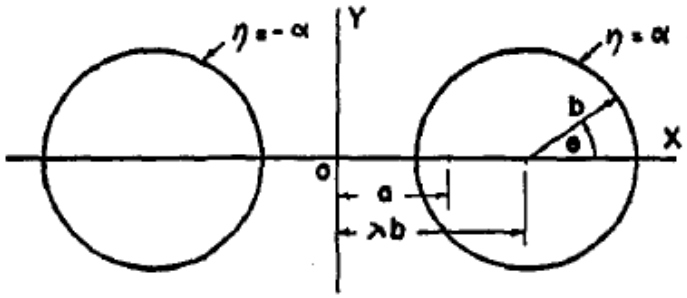


FIG. 1. Two equal holes.

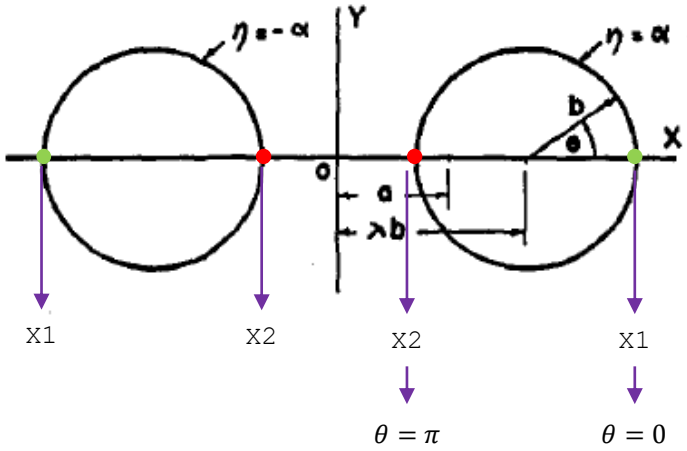


TABLE I. The maximum stresses ($T=1$).

λ	(1) All-around tension $\theta=0$	(1) All-around tension $\theta=\pi$	(2) Longitudinal tension $\theta=\pm\pi/2$	(3) Transverse tension $\theta=0$	(3) Transverse tension $\theta=\pi$
1	2.894	∞	2.569	3.869	∞
1.5	2.255	2.887	2.623	3.151	3.264
2	2.158	2.411	2.703	3.066	3.020
3	2.080	2.155	2.825	3.020	2.992
5	2.033	2.049	2.927	3.004	2.997
8	2.014	2.018	2.970	3.001	2.999
∞	2.000	2.000	3.000	3.000	3.000

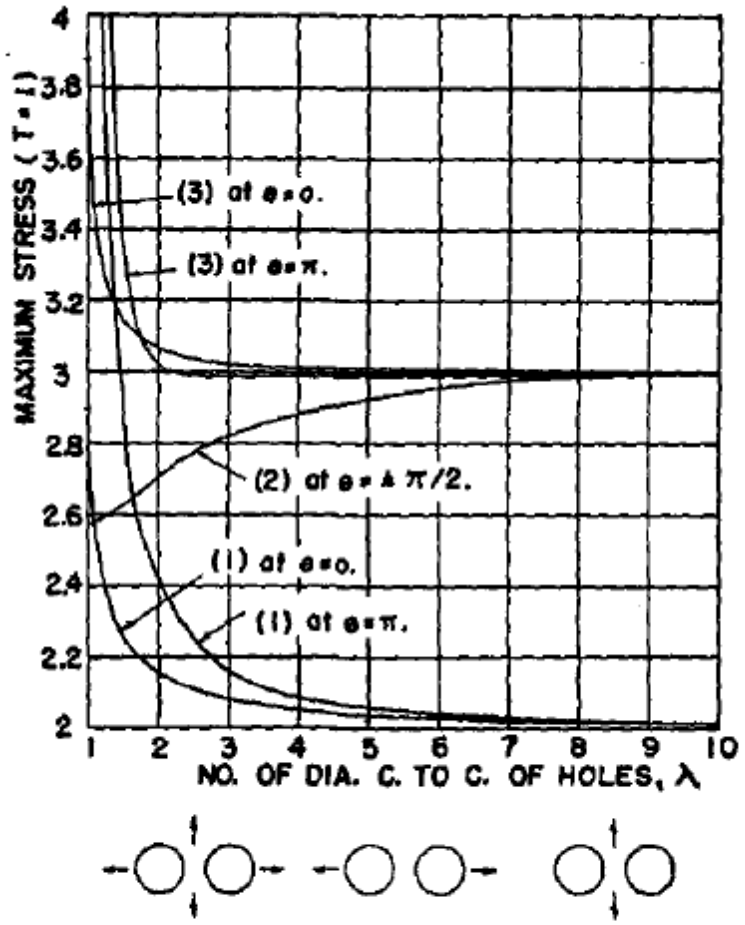
On the Stresses in a Plate Containing Two Circular Holes

CHIH-BING LING
Guggenheim Laboratory, California Institute of Technology, Pasadena 4, California
(Received May 29, 1947)

This note gives a theoretical solution to a plate containing two circular holes of equal size. The method of solution is to add to the given stress system a suitable biharmonic function which gives no stress at infinity. The parametric coefficients involved in the solution are adjusted so as to satisfy the boundary conditions at the edges of the holes. Bipolar coordinates are used in the solution, by means of which explicit expressions are obtained for the parametric coefficients. Three fundamental stress systems are discussed in some detail, namely, the all-around tension case, the longitudinal tension case, and the transverse tension case. Formulas of the stress along the edges of holes are derived and, in particular, values of maximum stress are calculated. The limiting case in which the holes are tangential is also discussed.

THE general solution of the stresses in a perforated plate, of infinite size, containing a group of circular holes was obtained by Howland and Knight,[1] and Green.[2] Naturally, such general solutions do not give much information as to the numerical aspect of the problem unless particular cases are worked out separately. In both solutions, it may be mentioned that the Jeffery's, will be given, corresponding to several fundamental stress systems acting in the plate. The parametric coefficients involved in the solution are obtained in explicit forms in terms of bipolar coordinates. Finally, the maximum stresses in the plate are calculated and plotted against the distance between the holes.

Theoretical Result



(1) All-around tension case (2) Longitudinal tension case (3) Transverse tension case

FIG. 2. The maximum stress.

TABLE I. The maximum stresses ($T=1$).

λ	(1) All-around tension $\theta=0$	(1) All-around tension $\theta=\pi$	(2) Longitudinal tension $\theta=\pm\pi/2$	(3) Transverse tension $\theta=0$	(3) Transverse tension $\theta=\pi$
1	2.894	∞	2.569	3.869	∞
1.5	2.255	2.887	2.623	3.151	3.264
2	2.158	2.411	2.703	3.066	3.020
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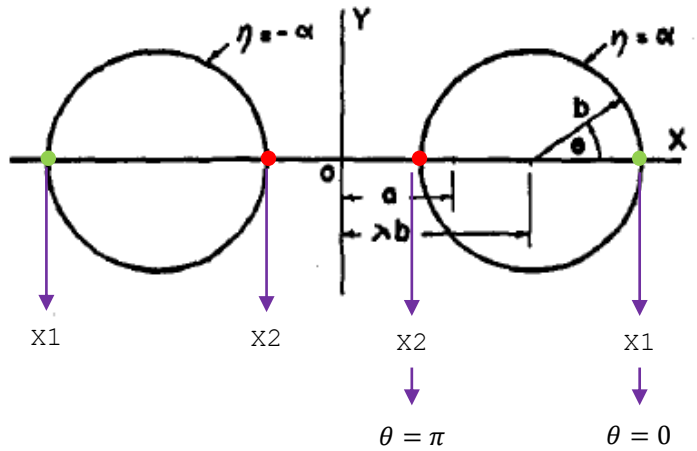
5	2.033	2.049	2.927	3.004	2.997
8	2.014	2.018	2.970	3.001	2.999
∞	2.000	2.000	3.000	3.000	3.000



Theoretical Result

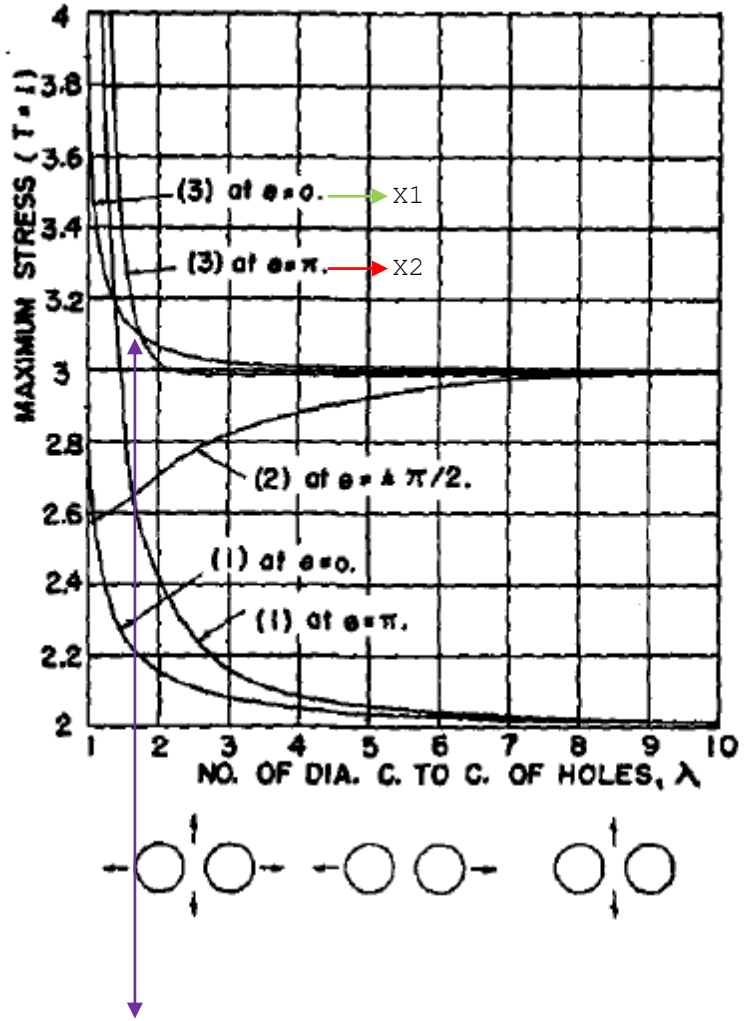


TABLE I. The maximum stresses ($T=1$).

λ	(1) All-around tension $\theta=0$	(1) All-around tension $\theta=\pi$	(2) Longitudinal tension $\theta=\pm\pi/2$	(3) Transverse tension $\theta=0$	(3) Transverse tension $\theta=\pi$
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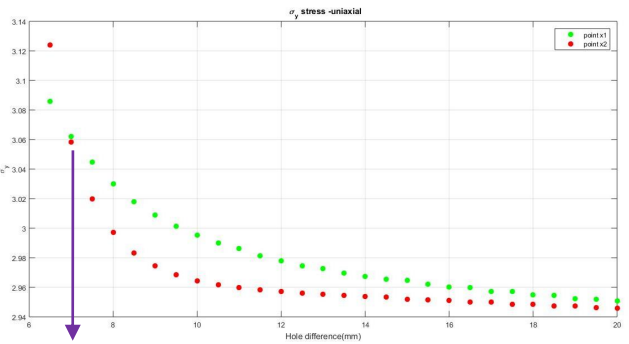
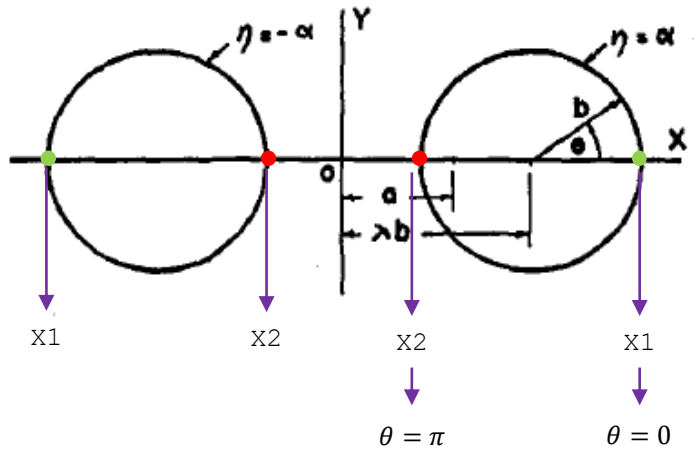
5	2.033	2.049	2.927	3.004	2.997
8	2.014	2.018	2.970	3.001	2.999
∞	2.000	2.000	3.000	3.000	3.000



7 mm



$\lambda \simeq 1.75 \quad \rightarrow \quad b = 2\ mm \quad \rightarrow \quad diff = 2 * \lambda * b = 7\ mm$

How to explain the physical phenomena ?

$$\frac{\widehat{\xi\xi}_\alpha}{T}=2(\cosh\alpha-\cos\xi)\left\{K\sinh\alpha\left(1+4\sum_{n=1}^{\infty}\frac{\sinh n\alpha\cos n\xi}{\sinh 2n\alpha+n\sinh 2\alpha}\right)\right.$$

$$\left.\mp 2\sum_{n=1}^{\infty}\frac{n(n\sinh n\alpha\sinh\alpha-\cosh n\alpha\cosh\alpha)\cos n\xi}{\sinh 2n\alpha+n\sinh 2\alpha}\right\}. \quad (34)$$

TABLE I. The maximum stresses ($T=1$).

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1	2.894	∞	2.569	3.869	∞
1.5	2.255	2.887	2.623	3.151	3.264
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8	2.014	2.018	2.970	3.001	2.999
∞	2.000	2.000	3.000	3.000	3.000

and (3) in the transverse tension case at $\xi=0$,

$$\frac{\widehat{\xi\xi}_0}{T}=4(\alpha^2K)\int_0^{\infty}\frac{\sinh\phi\,d\phi}{\sinh 2\phi+2\phi}$$

$$+2\int_0^{\infty}\frac{\phi(\phi\sinh\phi-\cosh\phi)d\phi}{\sinh 2\phi+2\phi}. \quad (40)$$

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Guggenheim Laboratory, California Institute of Technology, Pasadena 4, California
(Received May 29, 1947)

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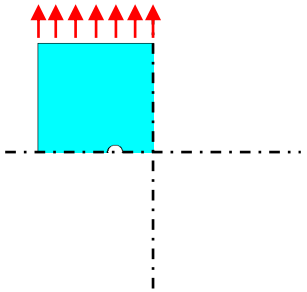
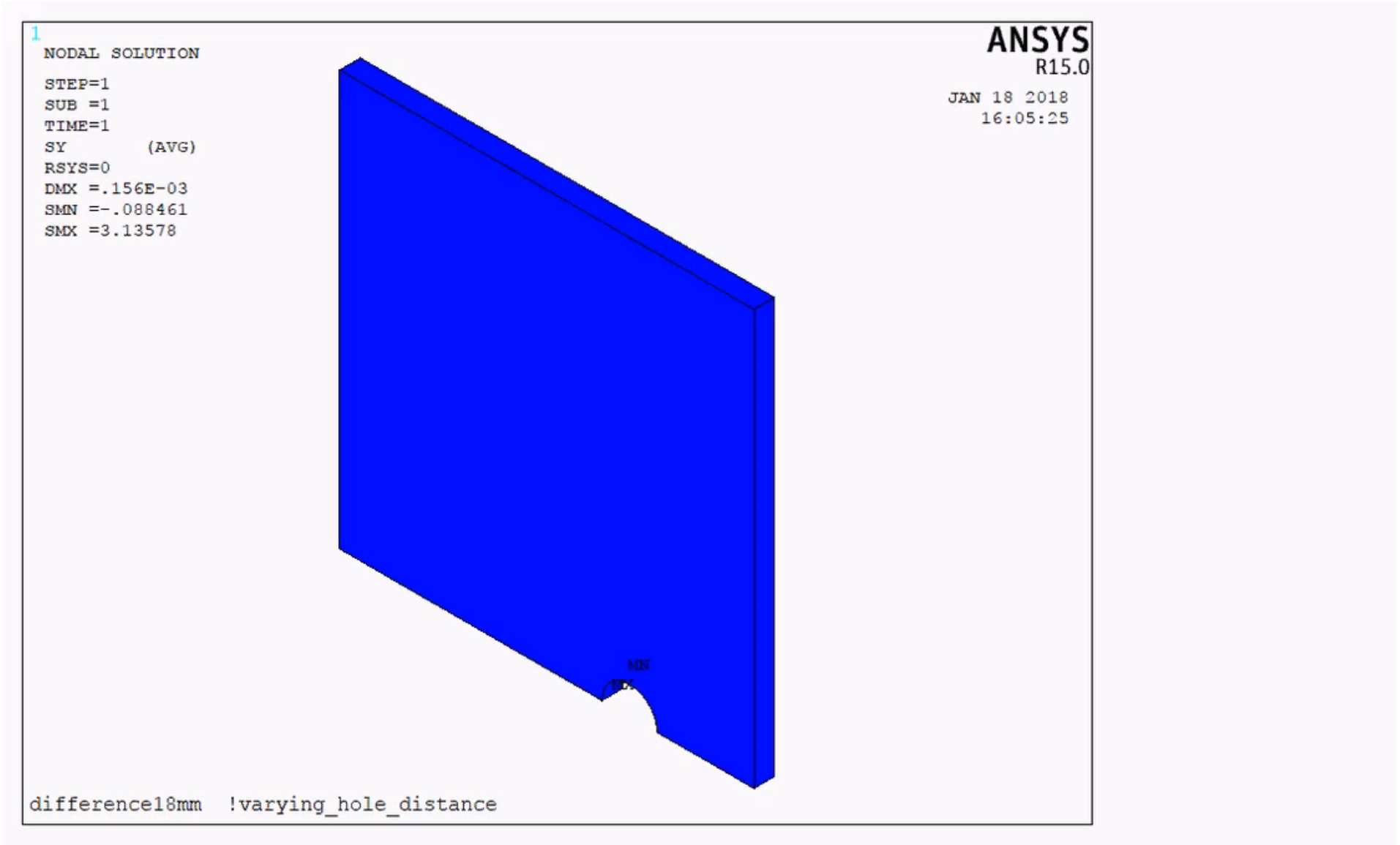
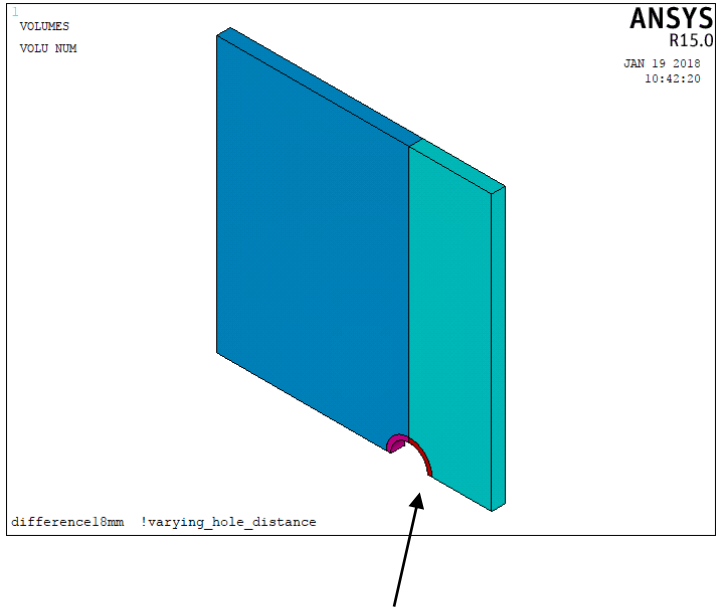
THE general solution of the stresses in a perforated plate, of infinite size, containing a group of circular holes was obtained by Howland and Knight,[1] and Green.[2] Naturally, such general solutions do not give much information as to the numerical aspect of the problem unless Jeffery's, will be given, corresponding to several fundamental stress systems acting in the plate. The parametric coefficients involved in the solution are obtained in explicit forms in terms of bipolar coordinates. Finally, the maximum stresses in the plate are calculated and plotted against



Uniaxial, Transverse load

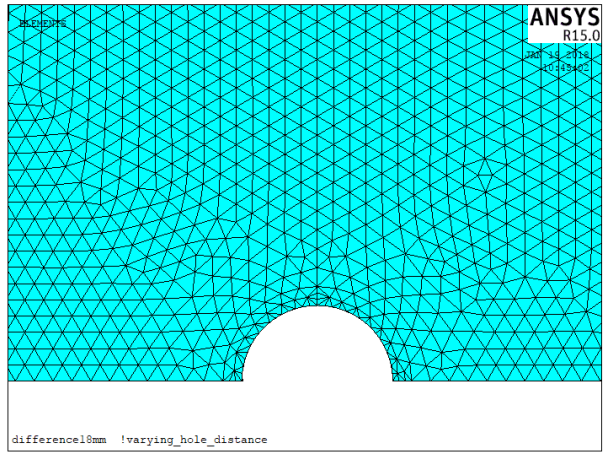


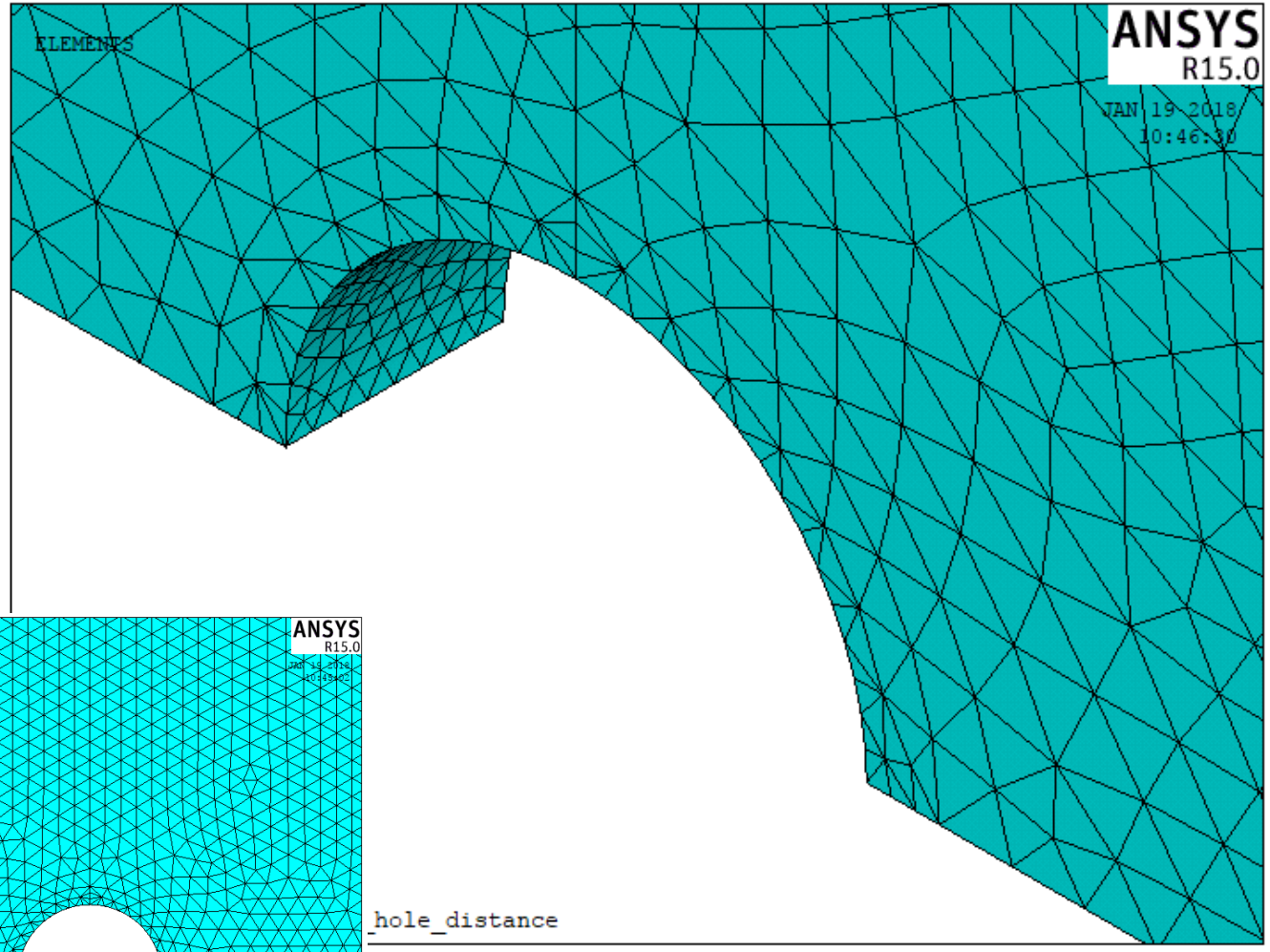
varying_hole_distance_with_refined_mesh_region_and_different_ring_thickness



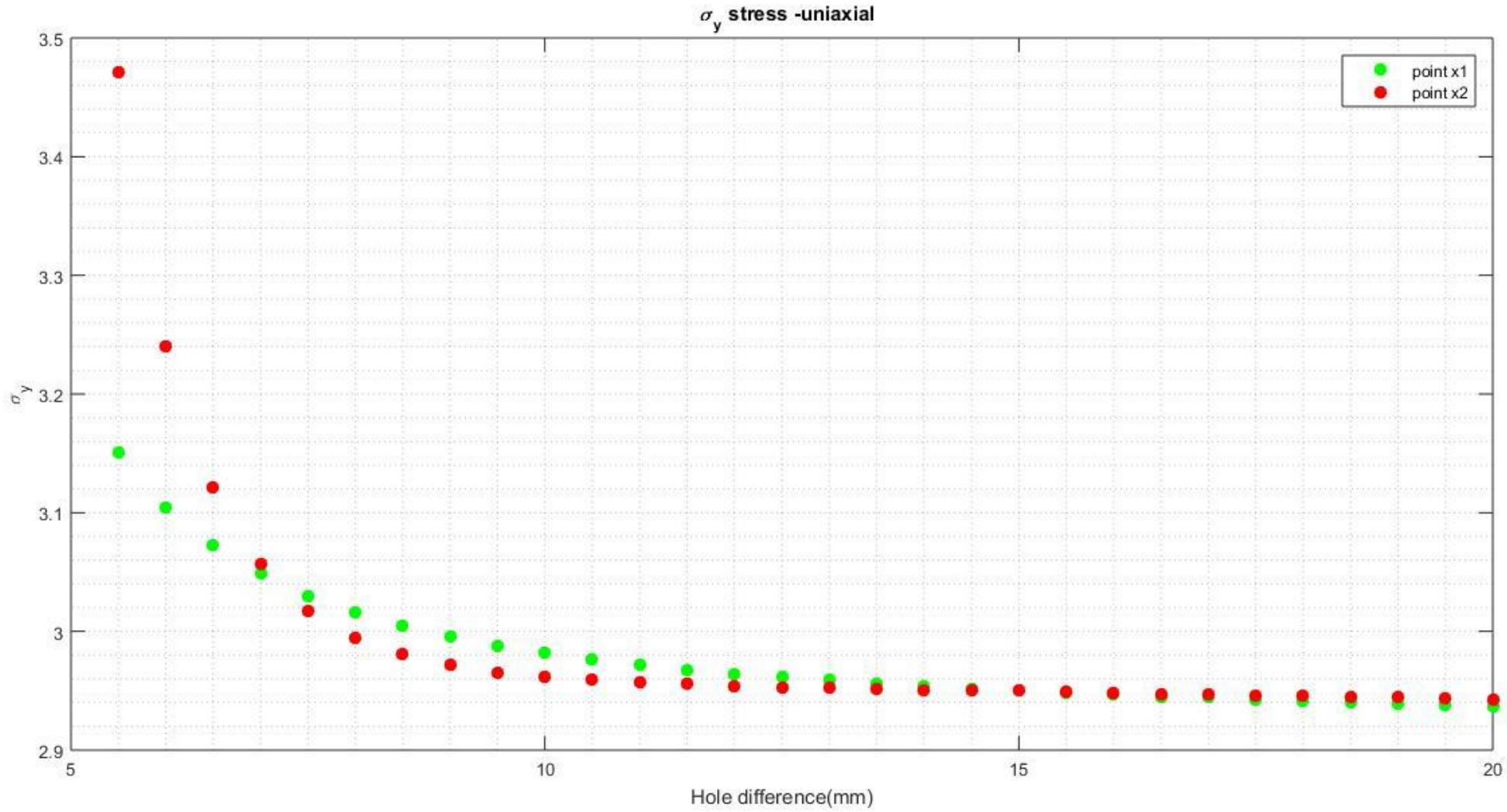
radius_int1=2.0
radius_ext1=2.5

ring_thickness = 0.5



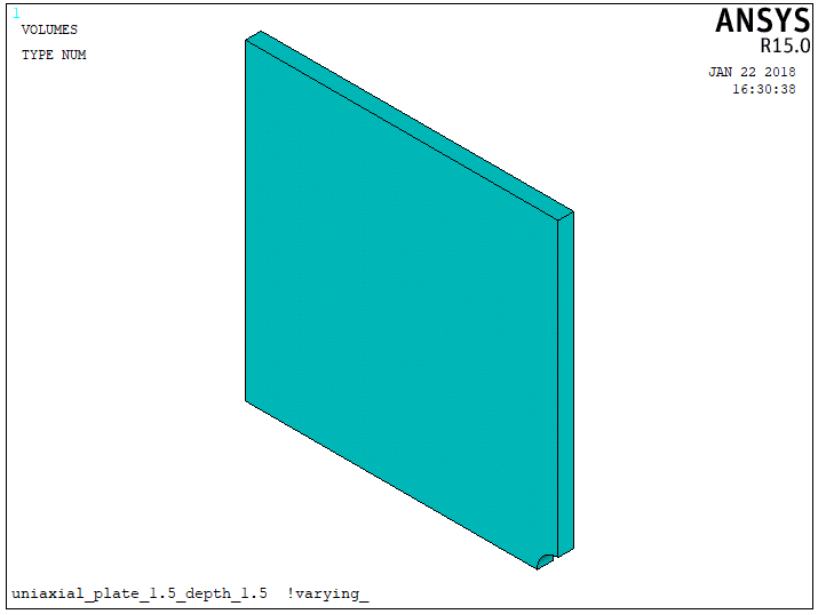


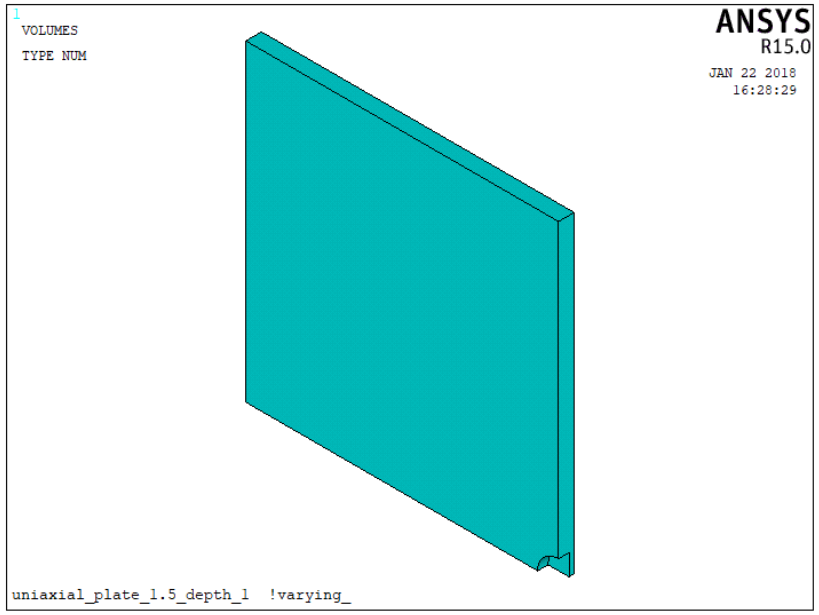
Results for uniaxial (only)

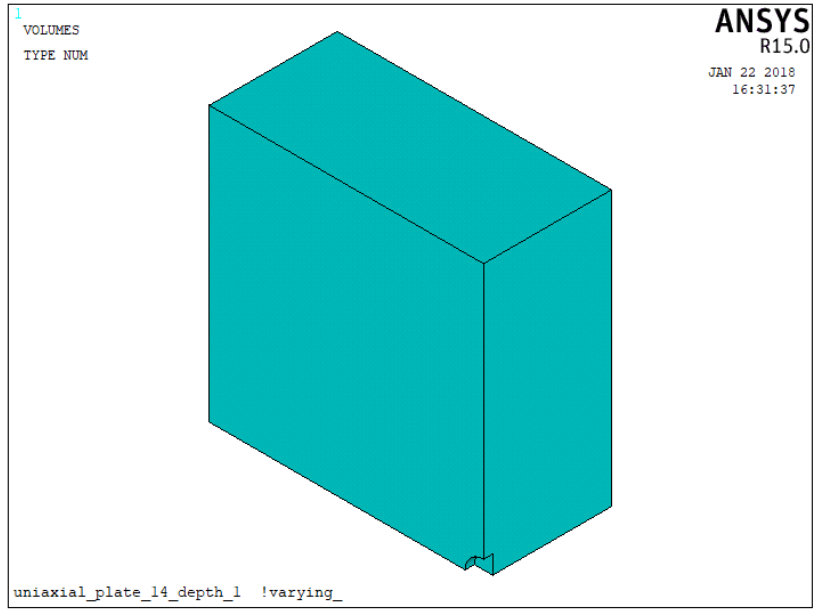


varying_hole_distance_with_refined_mesh_region_and_different_ring_thickness

Center Hole



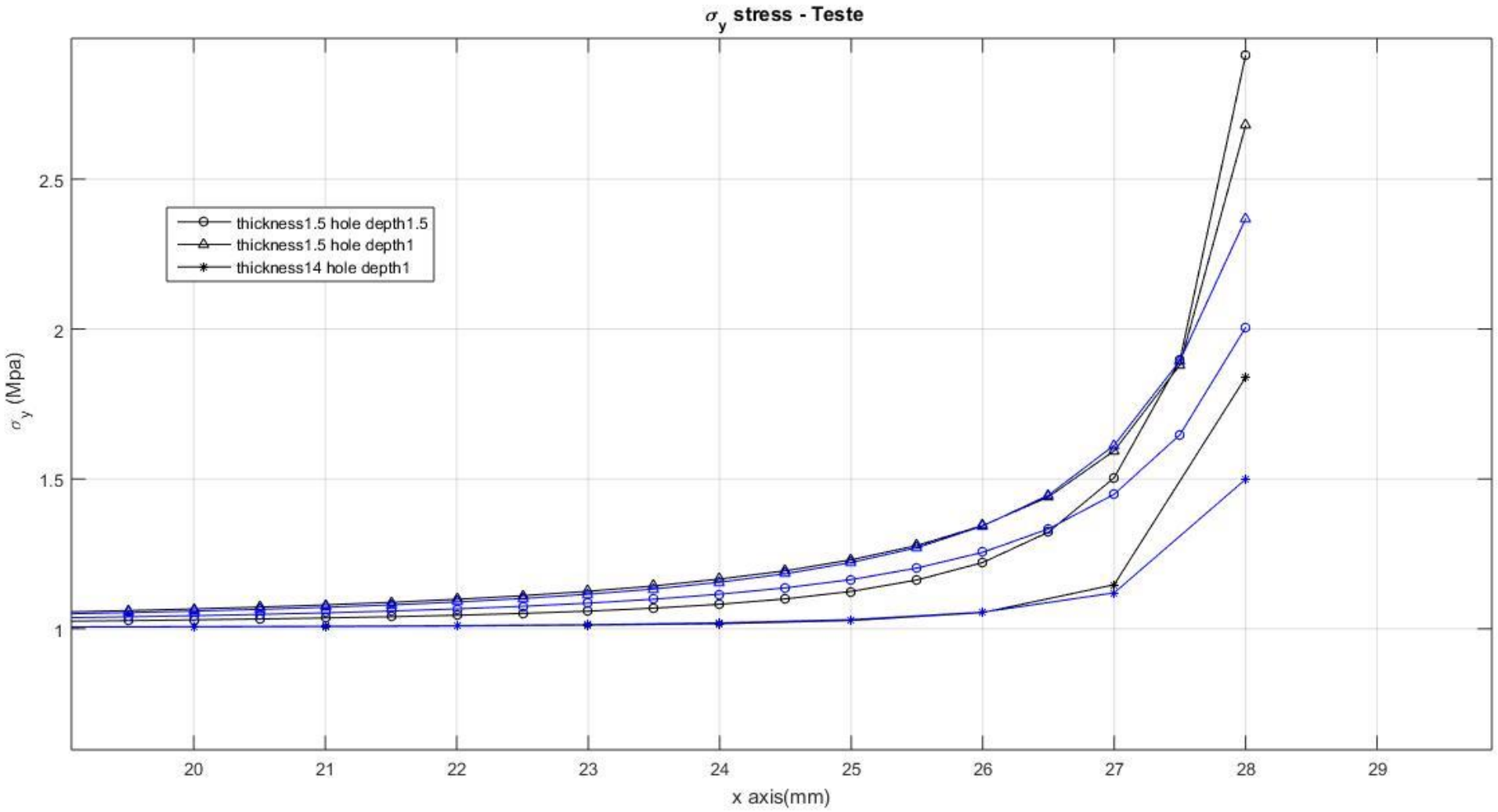




Uniaxial → plate_1.5_depth_1.5
Uniaxial → plate_1.5_depth_1
Uniaxial → plate_14_depth_1

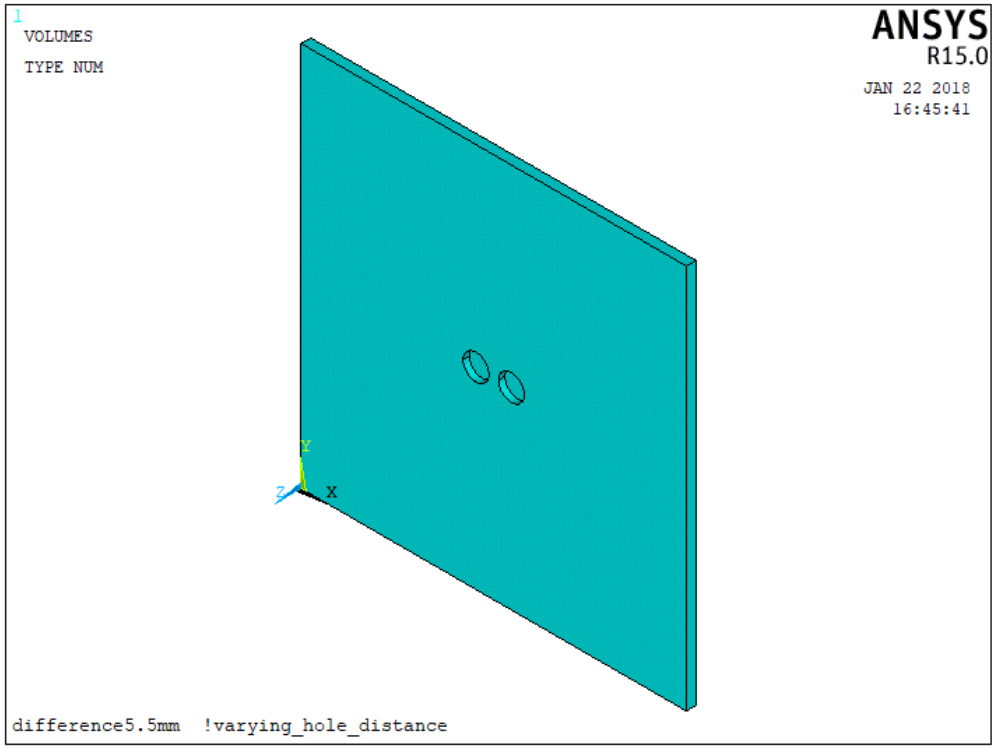
Biaxial → plate_1.5_depth_1.5
Biaxial → plate_1.5_depth_1
Biaxial → plate_14_depth_1

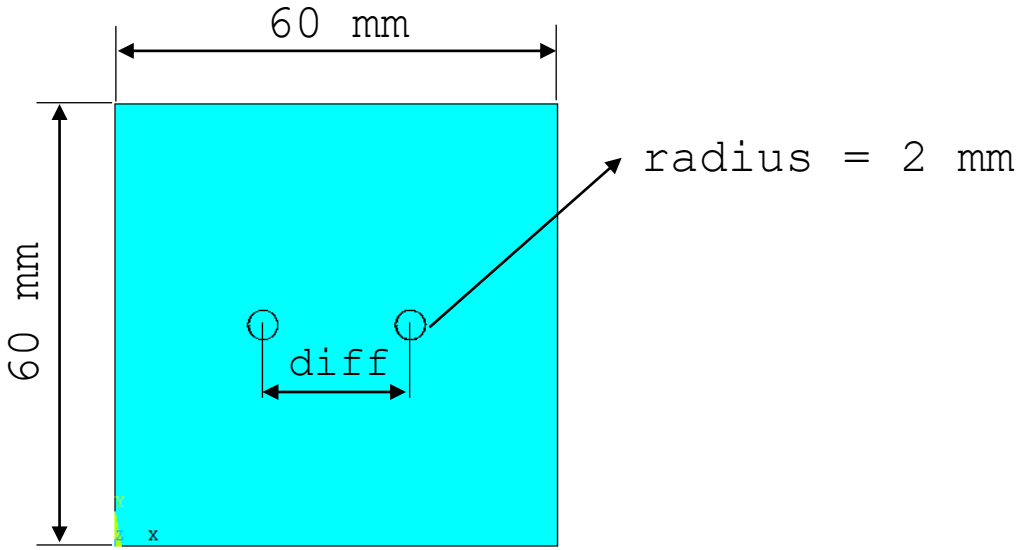
Center Hole



center_hole_uniaxial-black_and_biaxial-blue_three_geometries

A 1.5 mm plate and two Circular Holes with 1 mm depth





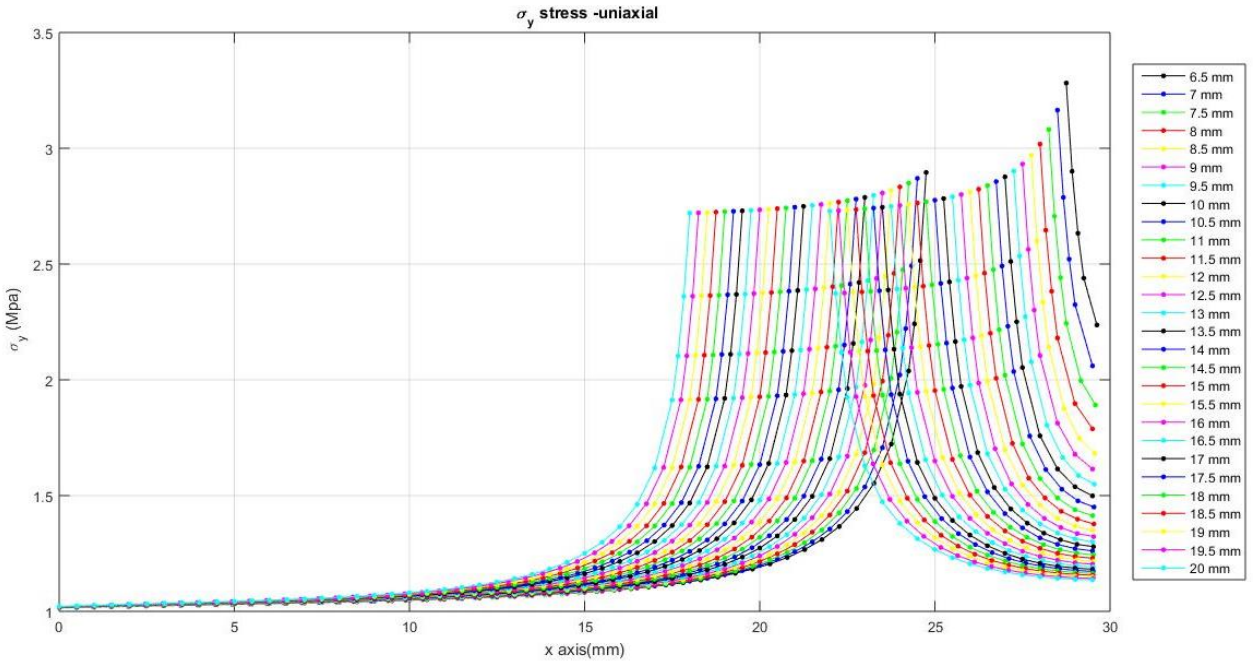
- Varying the hole distance

plate_thickness = 1.5 mm

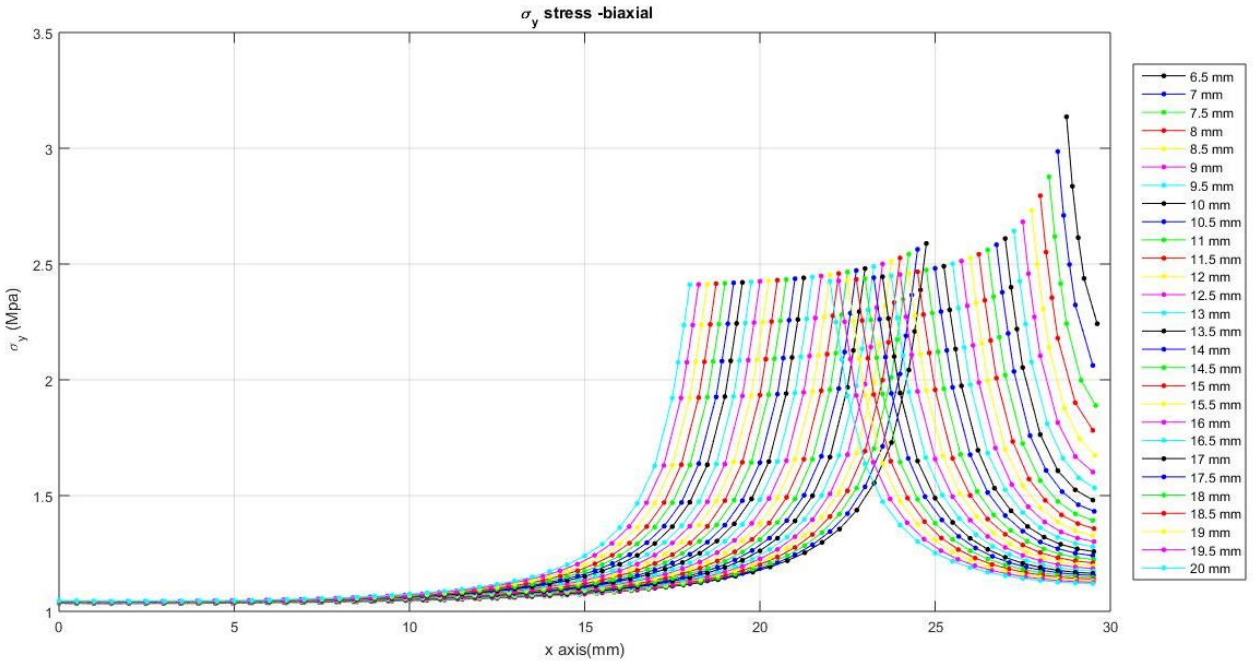
depth = 1.0 mm

"cylindrical hole"

A 1.5 mm plate and two Circular Holes with 1 mm depth

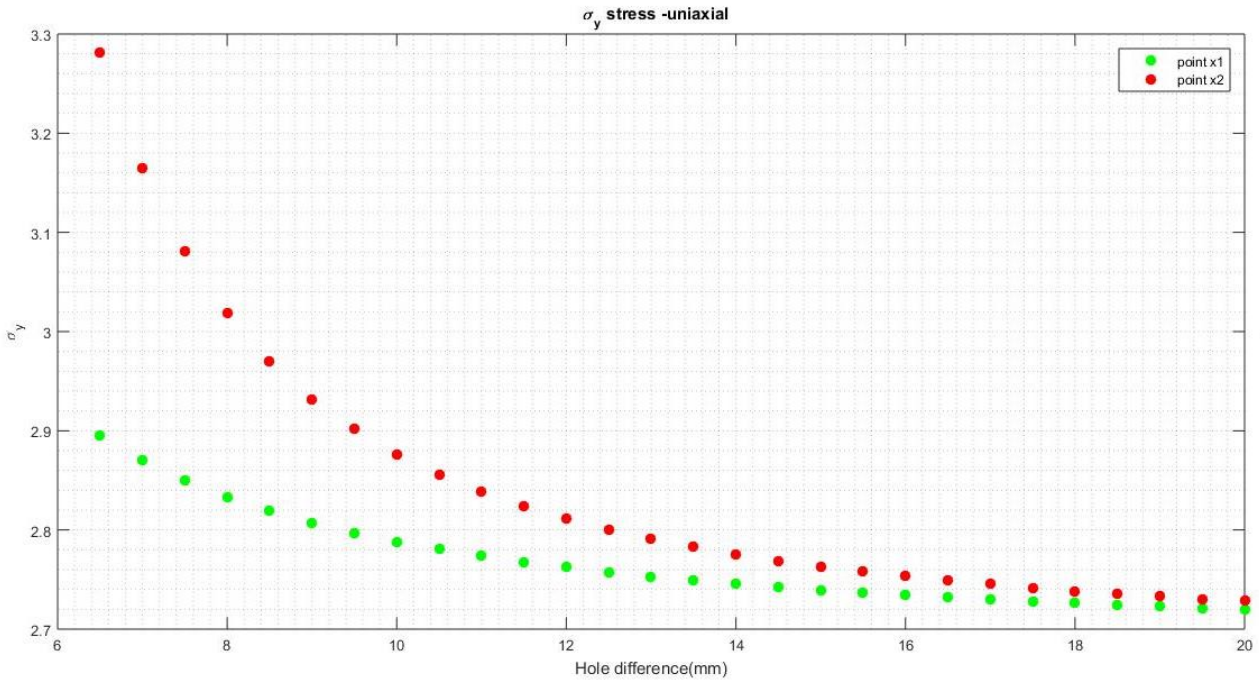


(a)Uniaxial, Transverse load

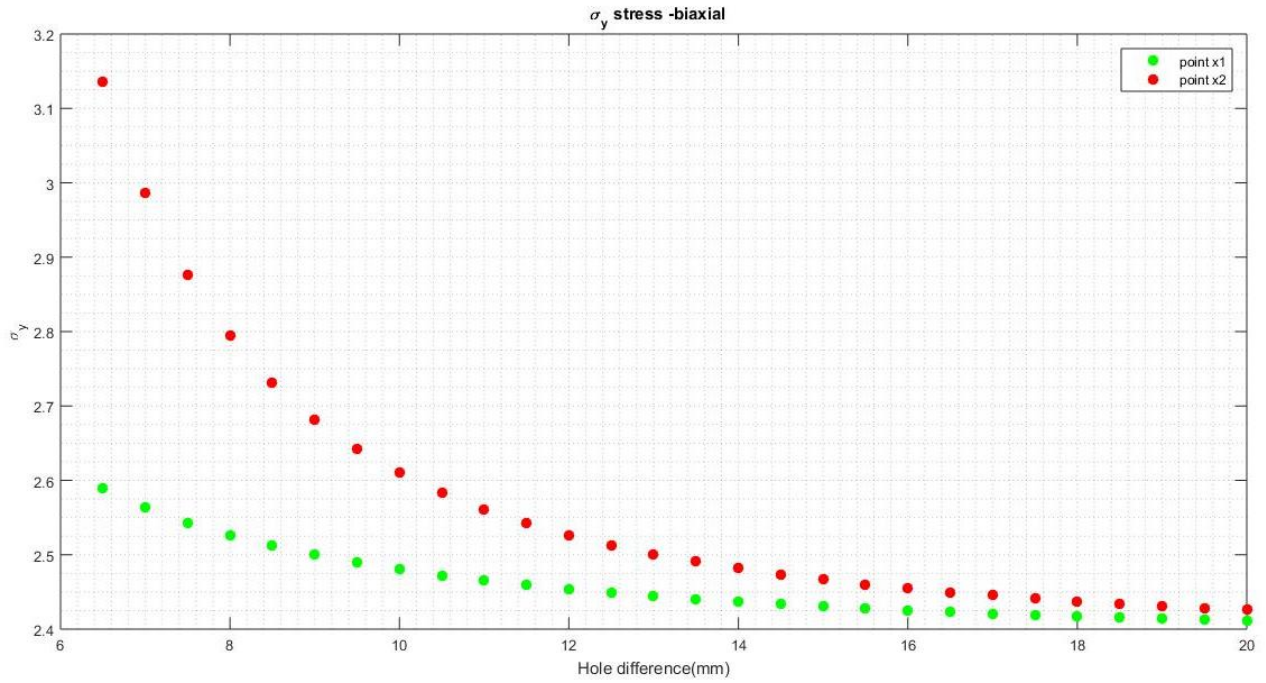


(b)Biaxial load

A 1.5 mm plate and two Circular Holes with 1 mm depth

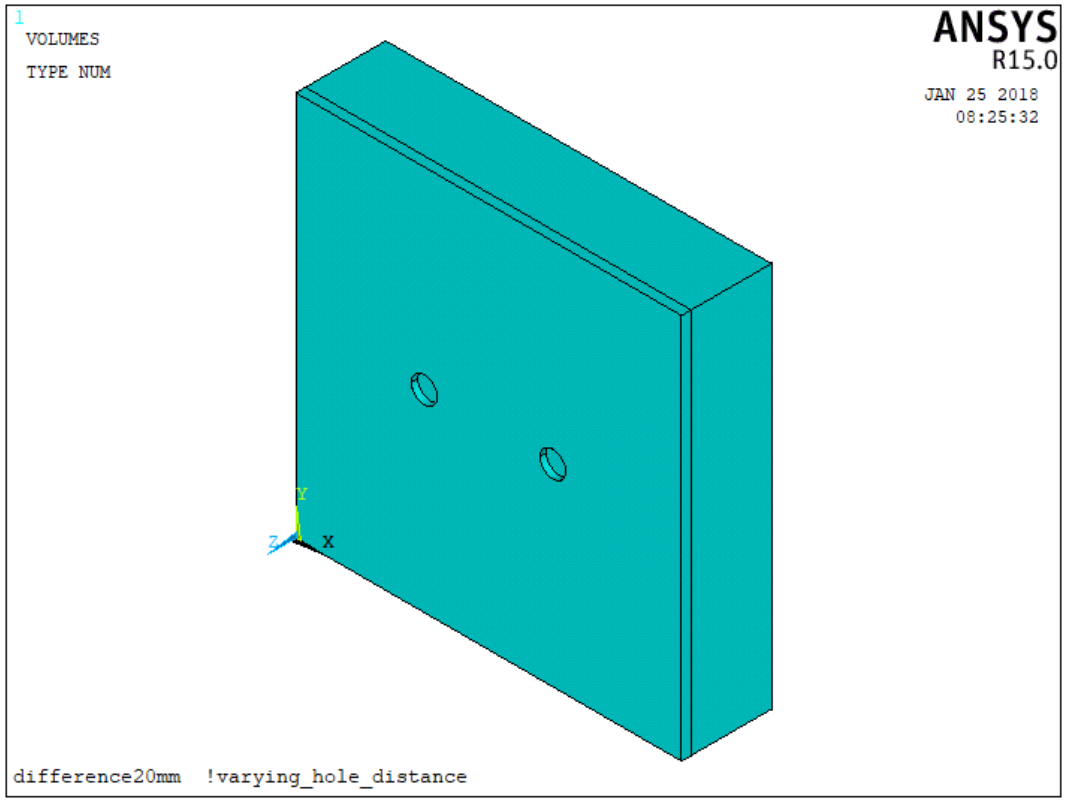


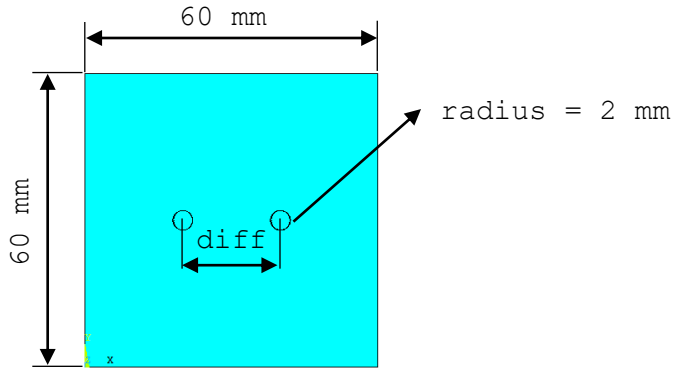
(a)Uniaxial, Transverse load



(b)Biaxial load

A 14 mm plate and two Circular Holes with 1 mm depth

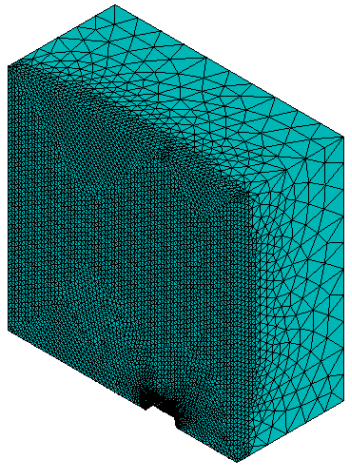




plate_thickness = 14 mm

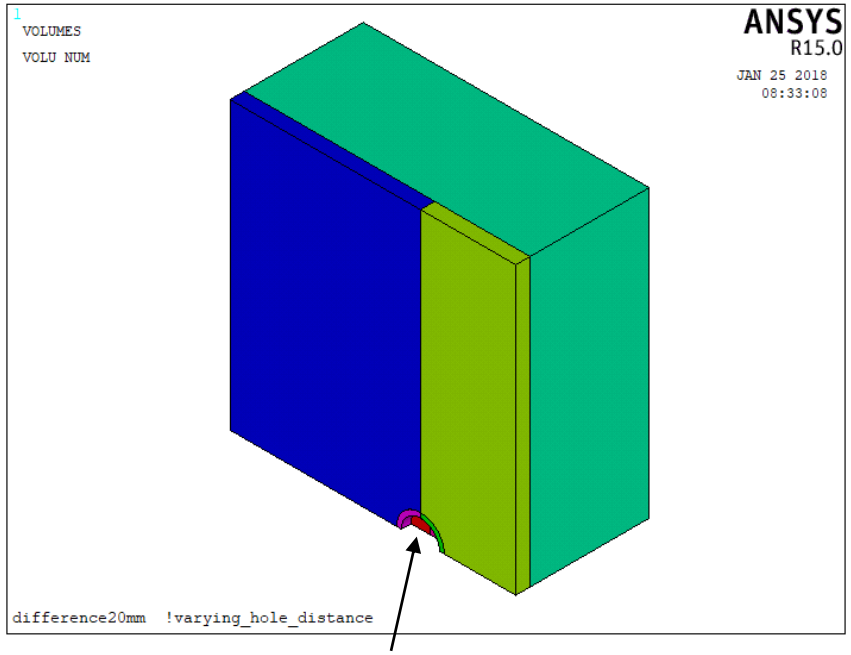
depth = 1.0 mm

"cylindrical hole"

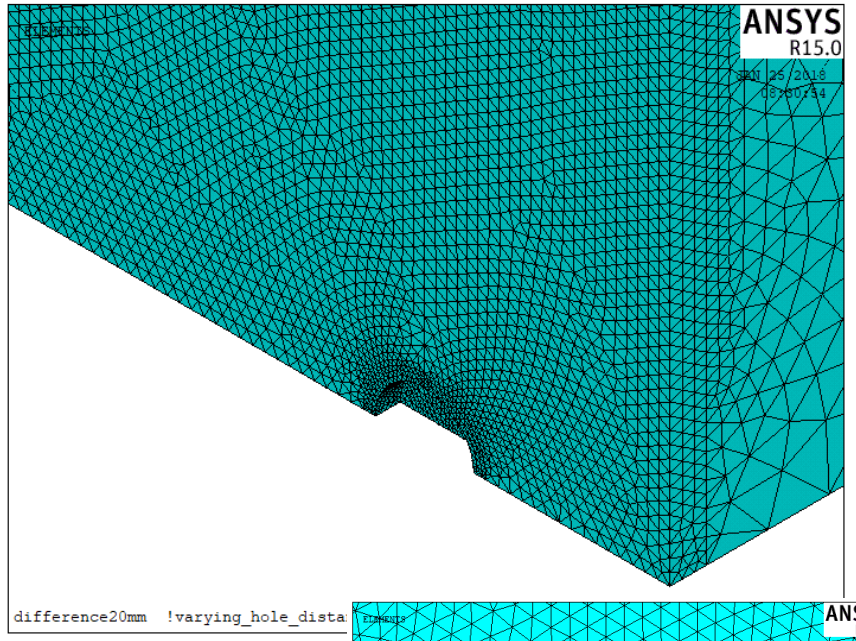


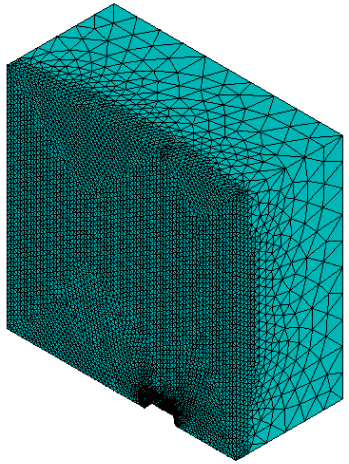
- Varying the hole distance

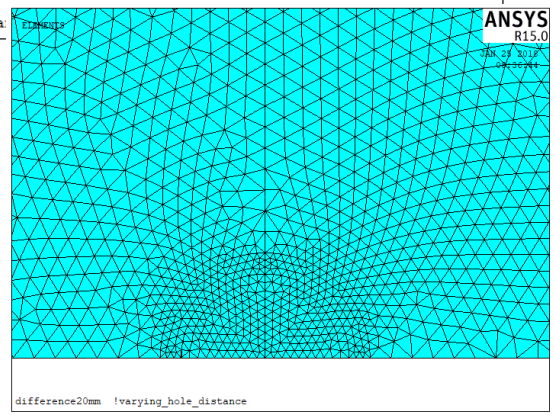
varying_hole_distance_plate_14_depth_1_refined_mesh_region_ring




```
size_refined= 0.2
esize,size_refined

size_coarse2= 0.5
esize,size_coarse2

size_coarse1=3.0
esize,size_coarse1
```

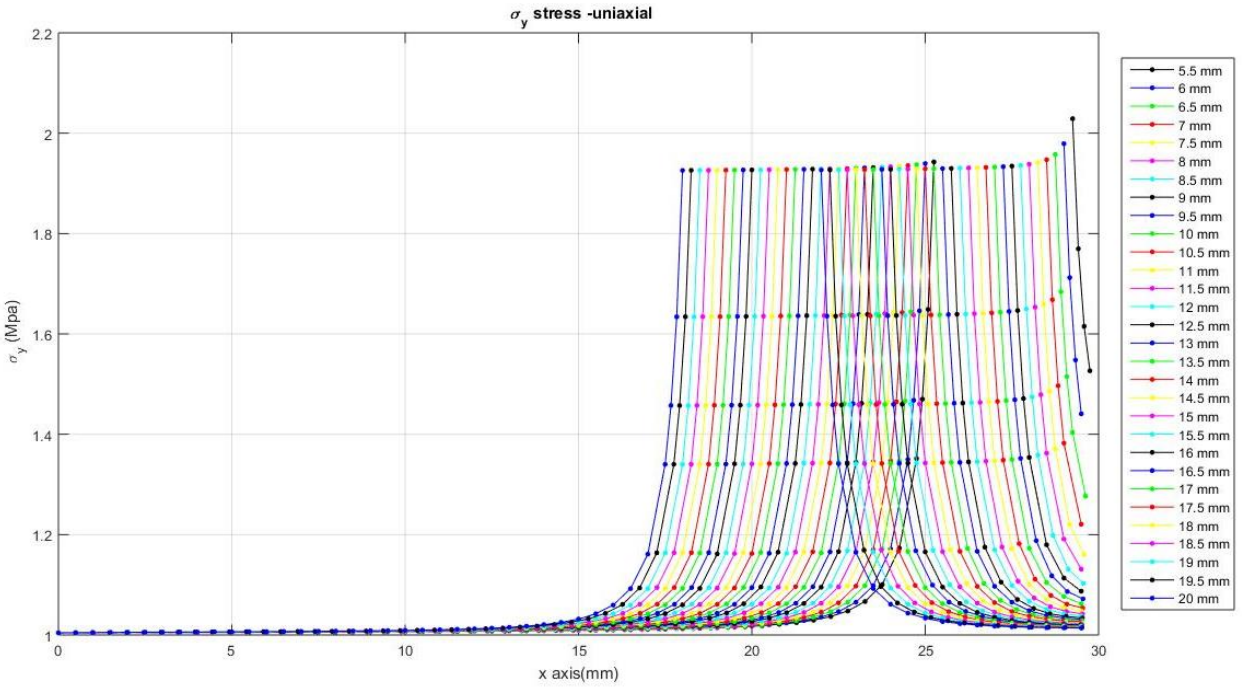




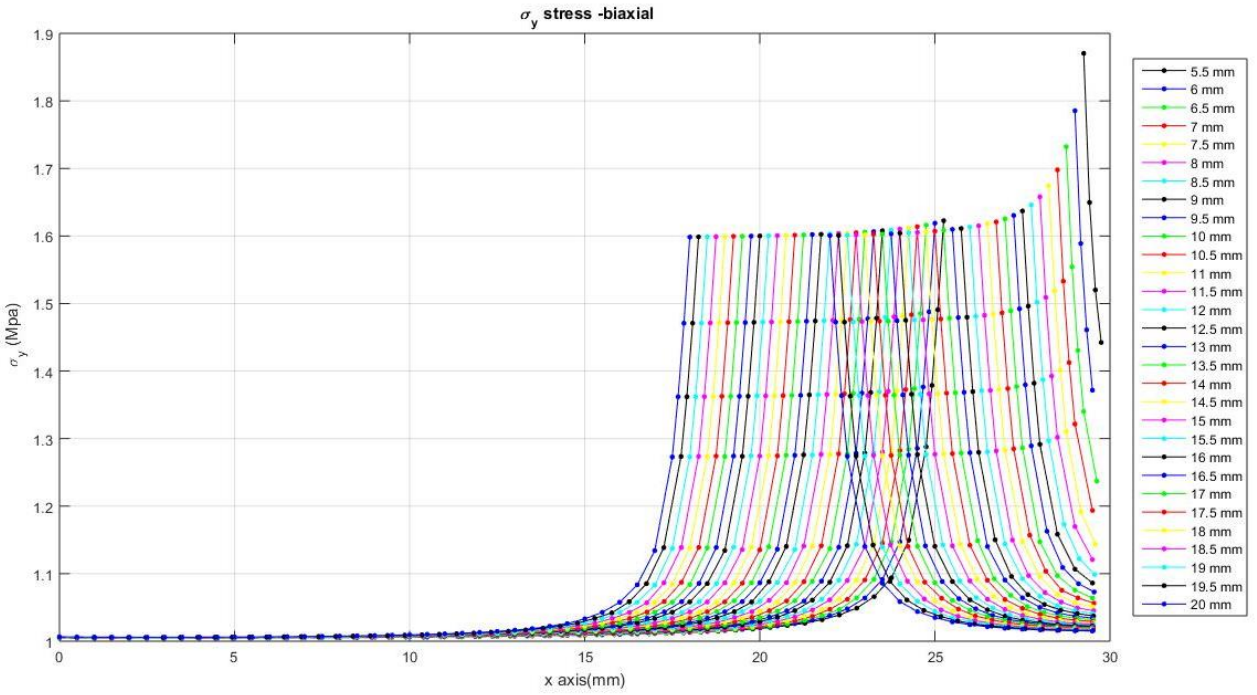



```
radius_int1=2.0
radius_ext1=2.5

ring_thickness = 0.5
```

A 14 mm plate and two Circular Holes with 1 mm depth

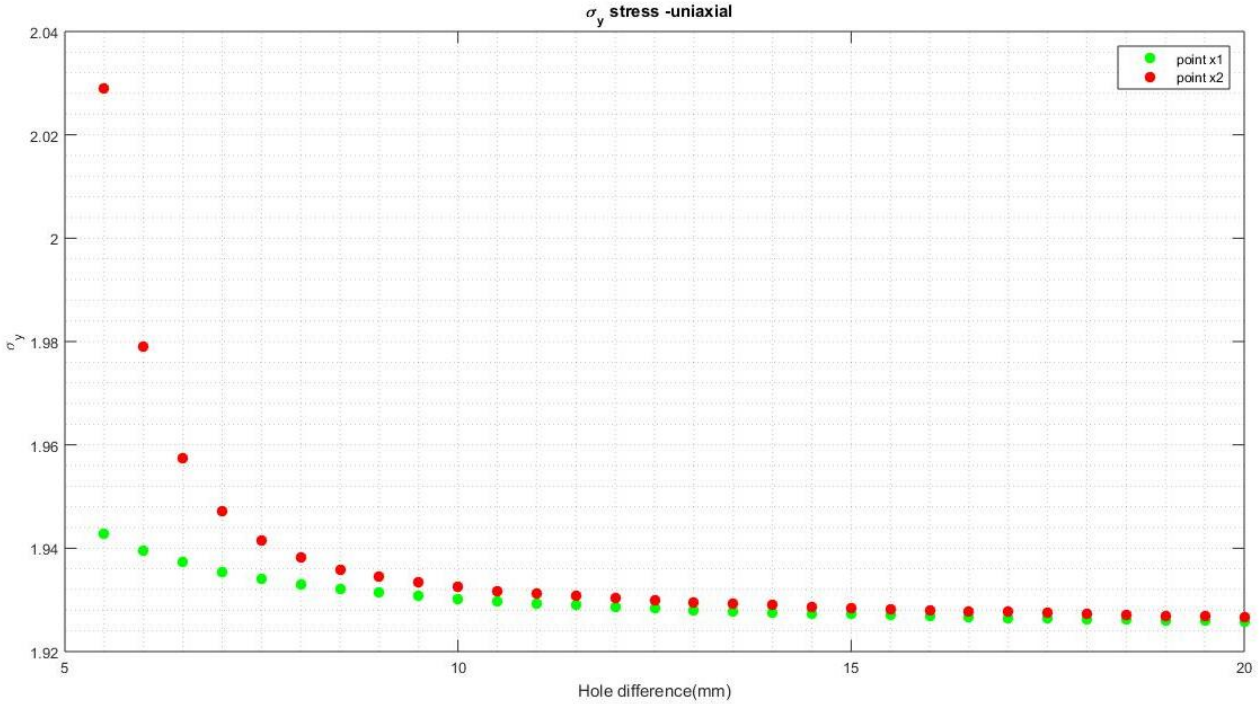


(a)Uniaxial, Transverse load

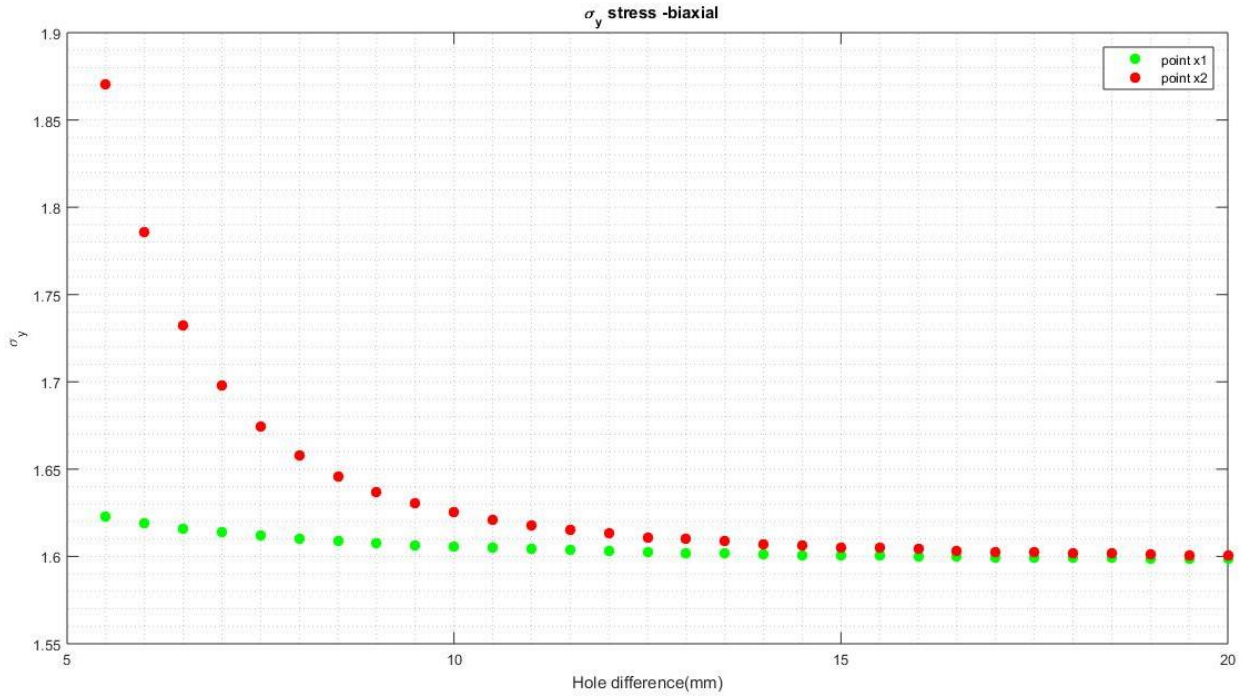


(b)Biaxial load

A 14 mm plate and two Circular Holes with 1 mm depth



(a)Uniaxial, Transverse load



(b)Biaxial load

Identified Problem

plate_1.5_depth_1.5

plate_1.5_depth_1

they need code repairs

* The coarse generation is coming before fine (ring) mesh generation;

* The node sequence change is not generic in one selection command (inside a loop):

```
...
! Section A3(y2/2)
!changing nodes sequence
asel,s,loc,y,y2/2
nsla,s,1
asel,s,loc,x,x2/4
nsla,u,1
asel,s,loc,x,x2/2
nsla,u,1
...
```

xcenter1

plate_14_depth_1 → Finished simulation

The problem was identified in the **plate_14_depth_1** code. It was repaired.

Files -> folders

- plate_1.5_depth_1.5
- plate_1.5_depth_1
- plate_14_depth_1

- **plate_1.5_depth_1.5**

  varying_hole_distance_with_refined_mesh_region_and_different_ring_thickness

  C:\Manasses\varying_hole_distance_with_refined_mesh_region_and_different_ring_thickness\uniaxial

  ?

- **plate_1.5_depth_1**

  varying_hole_distance_plate_1.5_depth_1_refined_mesh_region_ring

  C:\Manasses\varying_hole_distance_plate_1.5_depth_1_refined_mesh_region_ring\uniaxial

  C:\Manasses\varying_hole_distance_plate_1.5_depth_1_refined_mesh_region_ring\biaxial

- **plate_14_depth_1**

  varying_hole_distance_plate_14_depth_1_refined_mesh_region_ring

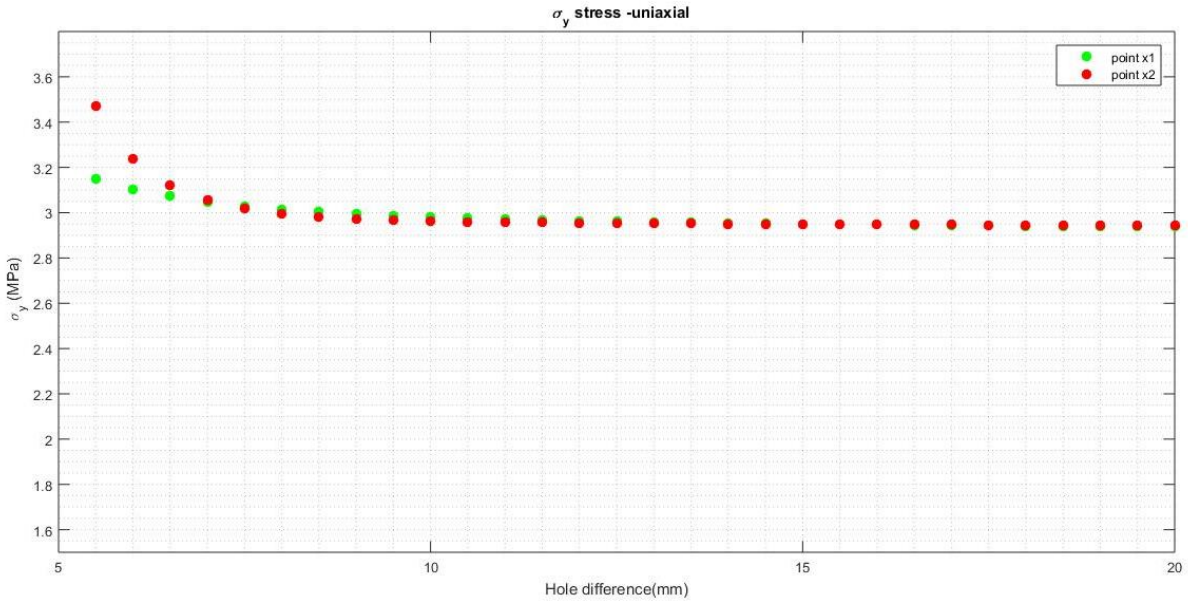
  C:\Manasses\varying_hole_distance_plate_14_depth_1_refined_mesh_region_ring\uniaxial

  C:\Manasses\varying_hole_distance_plate_14_depth_1_refined_mesh_region_ring\biaxial

three_geometries_comparison_same_scale

- **plate_1.5_depth_1.5**
- **plate_1.5_depth_1**
- **plate_14_depth_1**

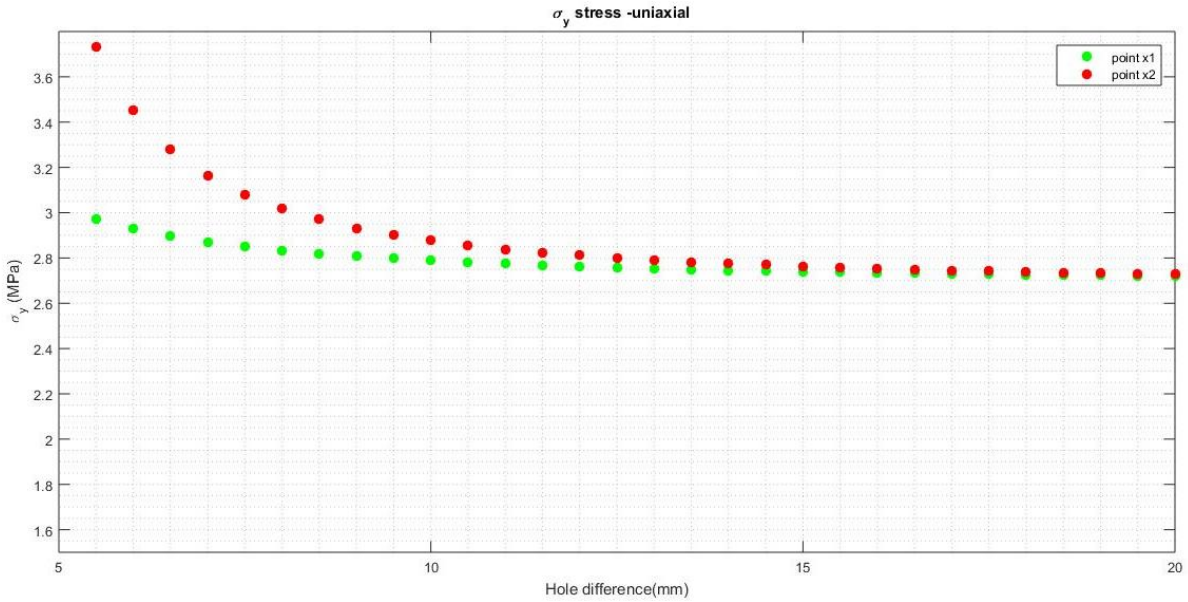
plate_1.5_depth_1.5



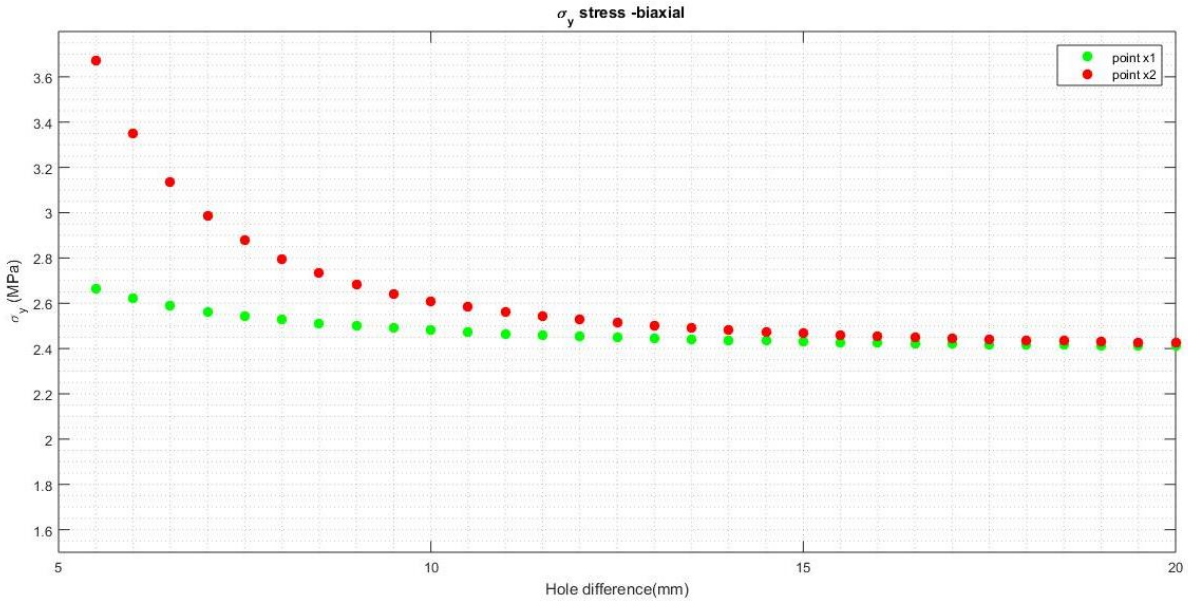
(a)Uniaxial, Transverse load

(b)Biaxial load

plate_1.5_depth_1

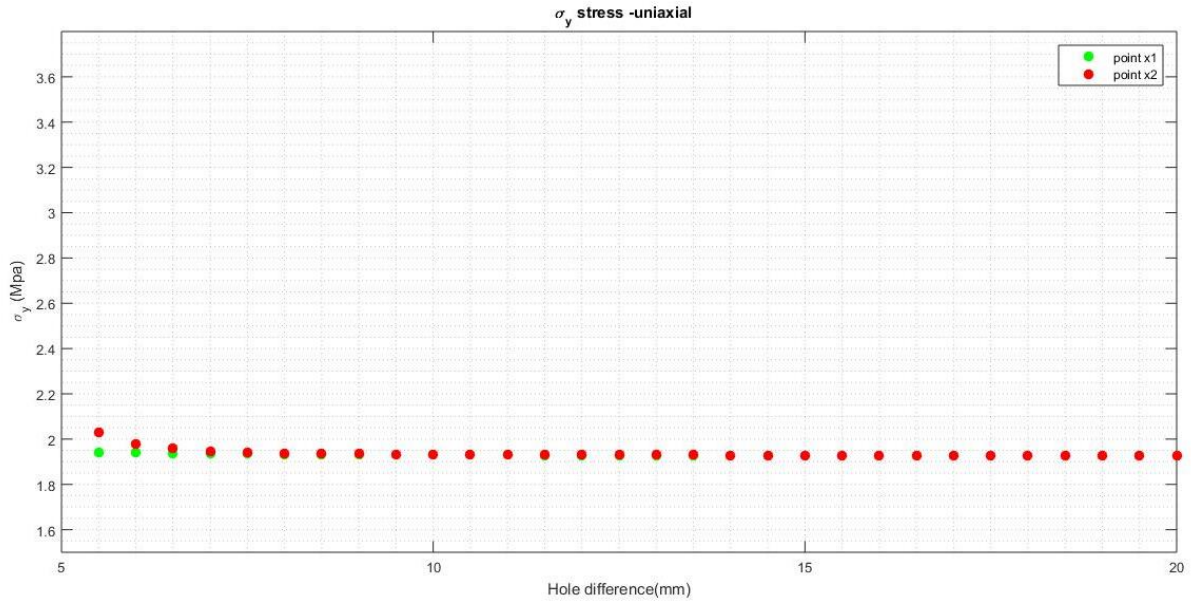


(a)Uniaxial, Transverse load

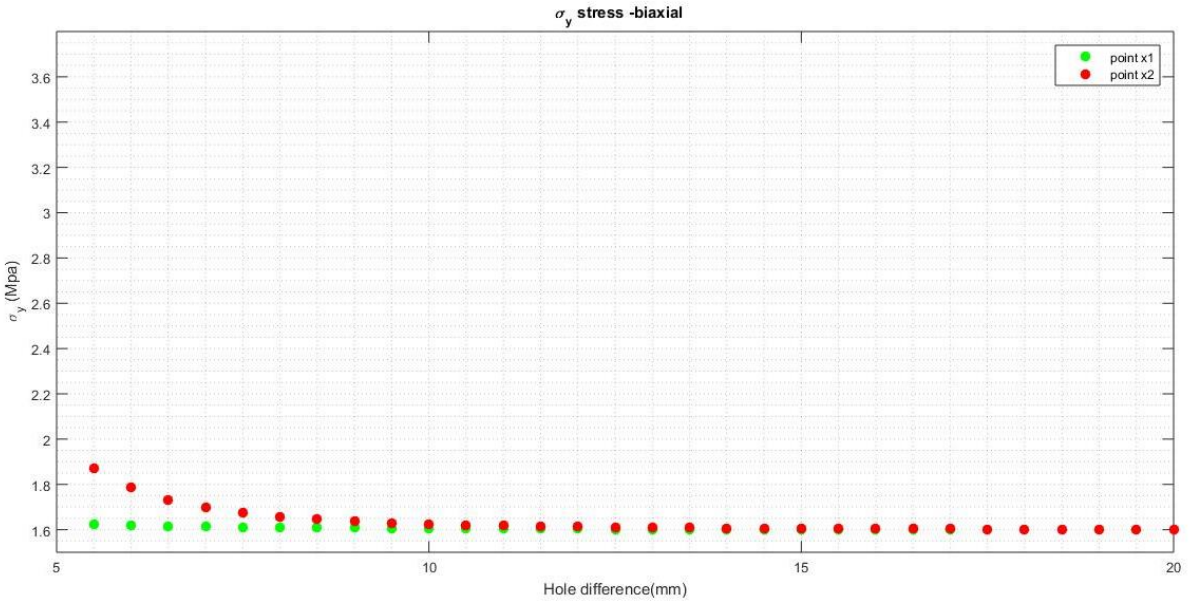


(b)Biaxial load

plate_14_depth_1



(a)Uniaxial, Transverse load



(b)Biaxial load

Repairing the Code Problem

- **plate_1.5_depth_1.5 -> changing name folder**

  varying_hole_distance_with_refined_mesh_region_and_different_ring_thickness

  varying_hole_distance_plate_1.5_depth_1.5_refined_mesh_region_ring

C:\Manasses\varying_hole_distance_plate_1.5_de

C:\Manasses\varying_hole_distance_with_refined

?

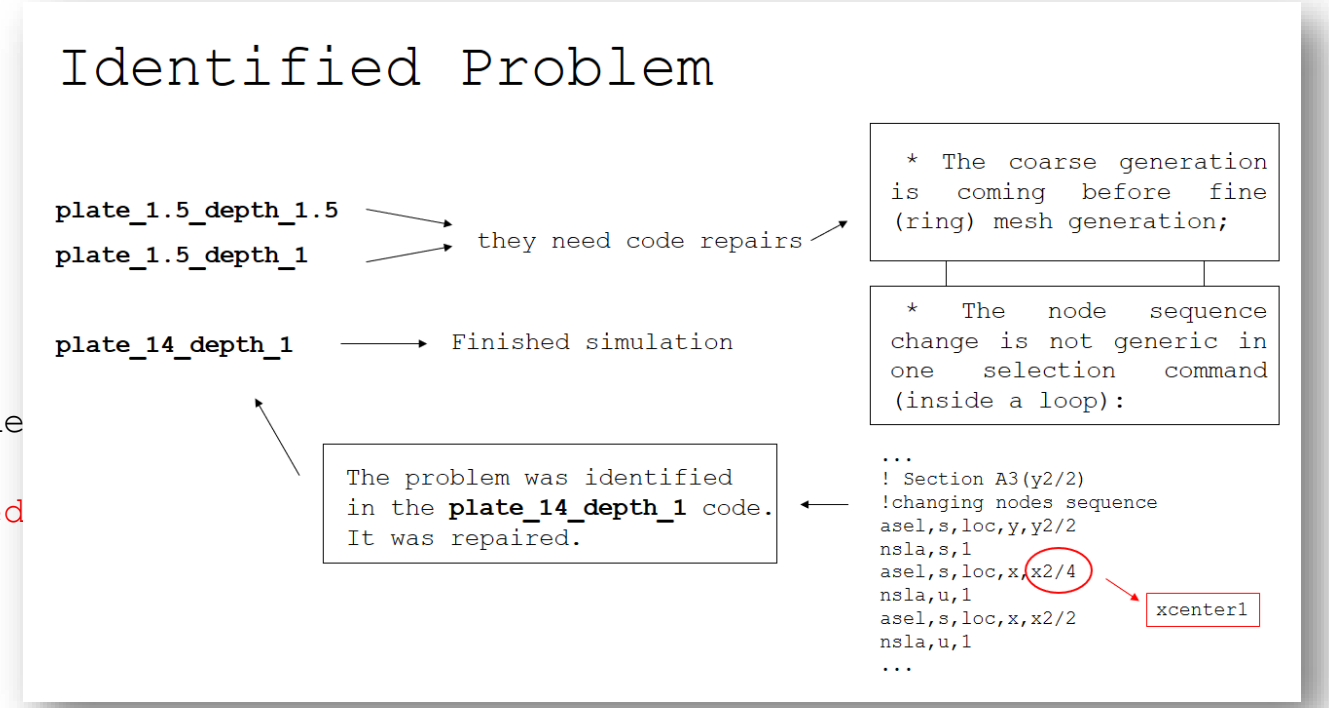
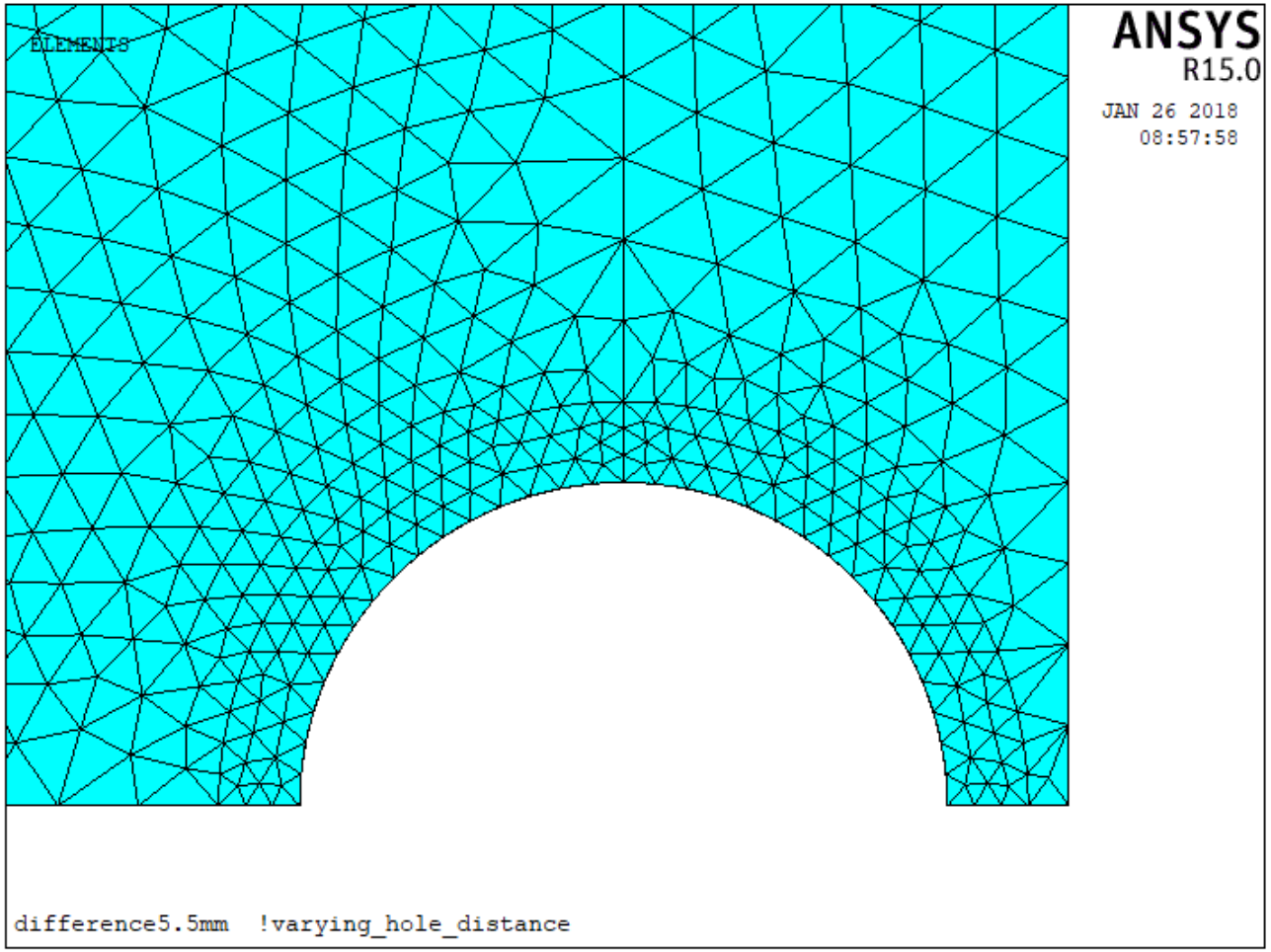
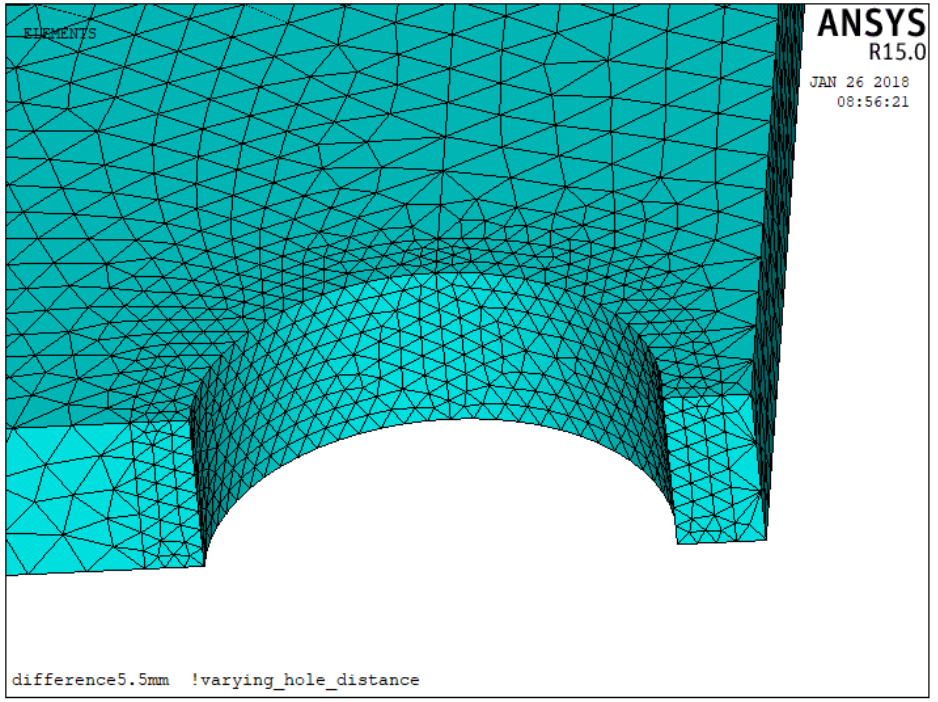


plate_1.5_depth_1.5





Comparison with the previous geometry code

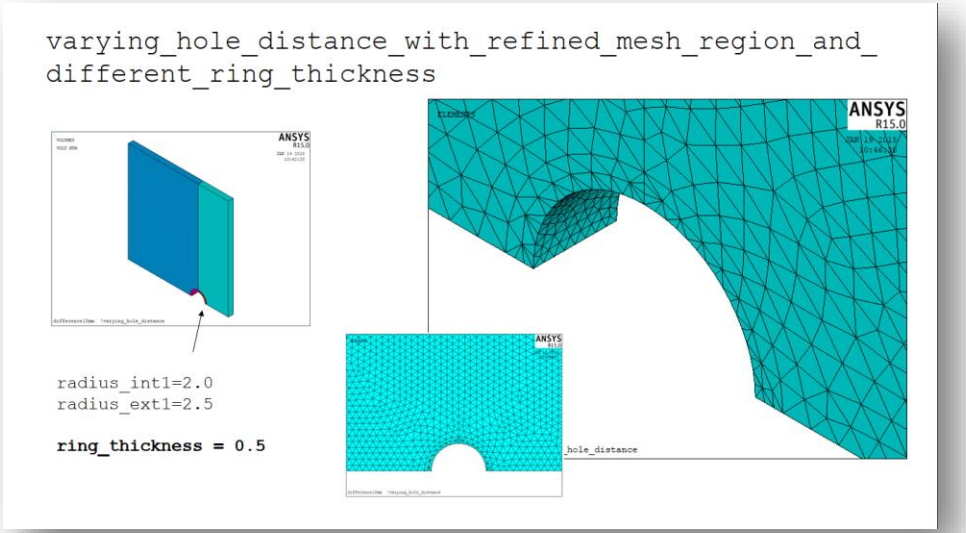
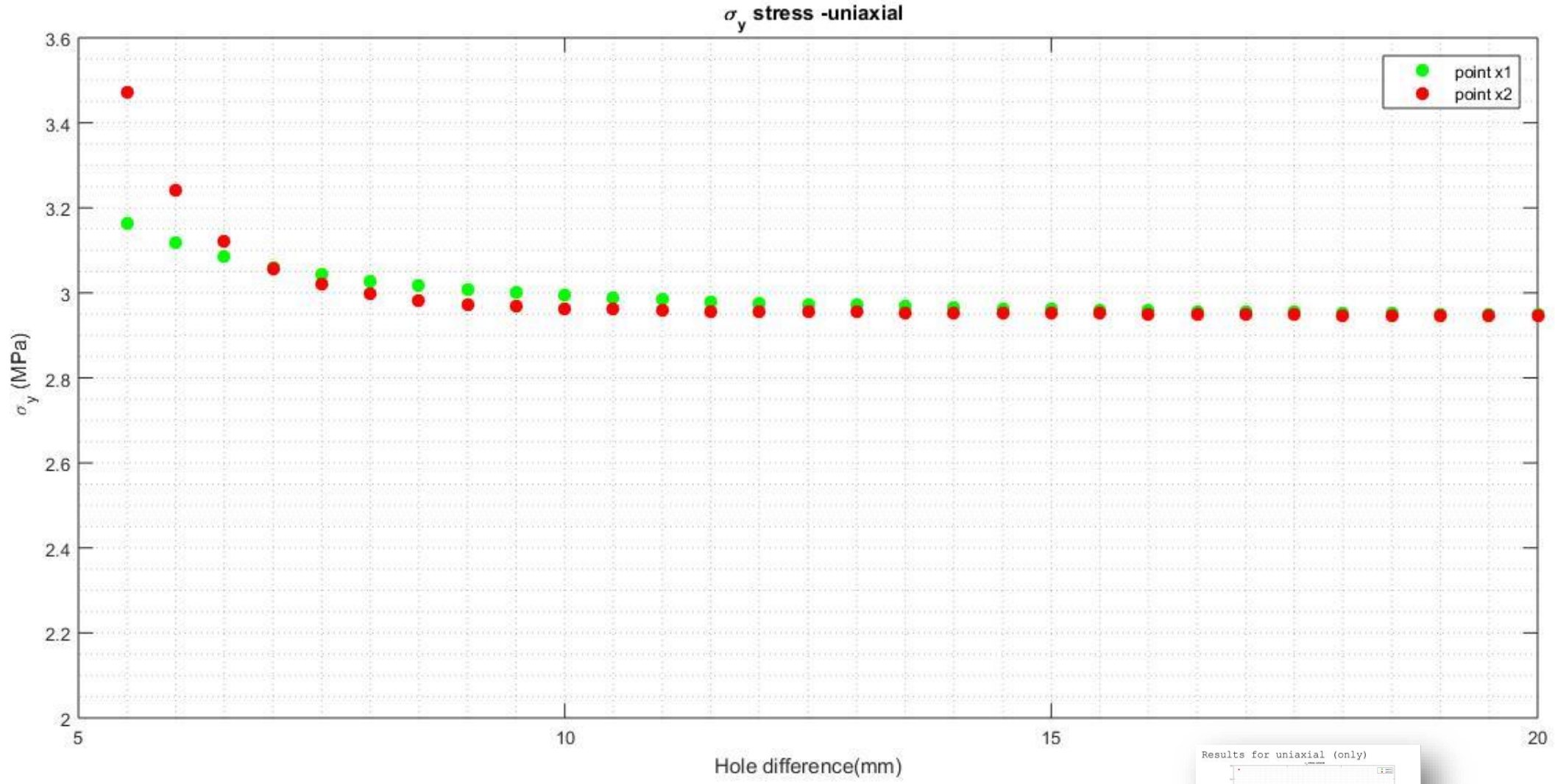


plate_1.5_depth_1.5



Comparison with the previous geometry code →

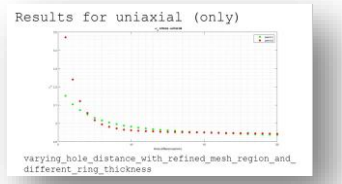
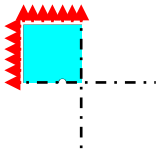


plate_1.5_depth_1.5



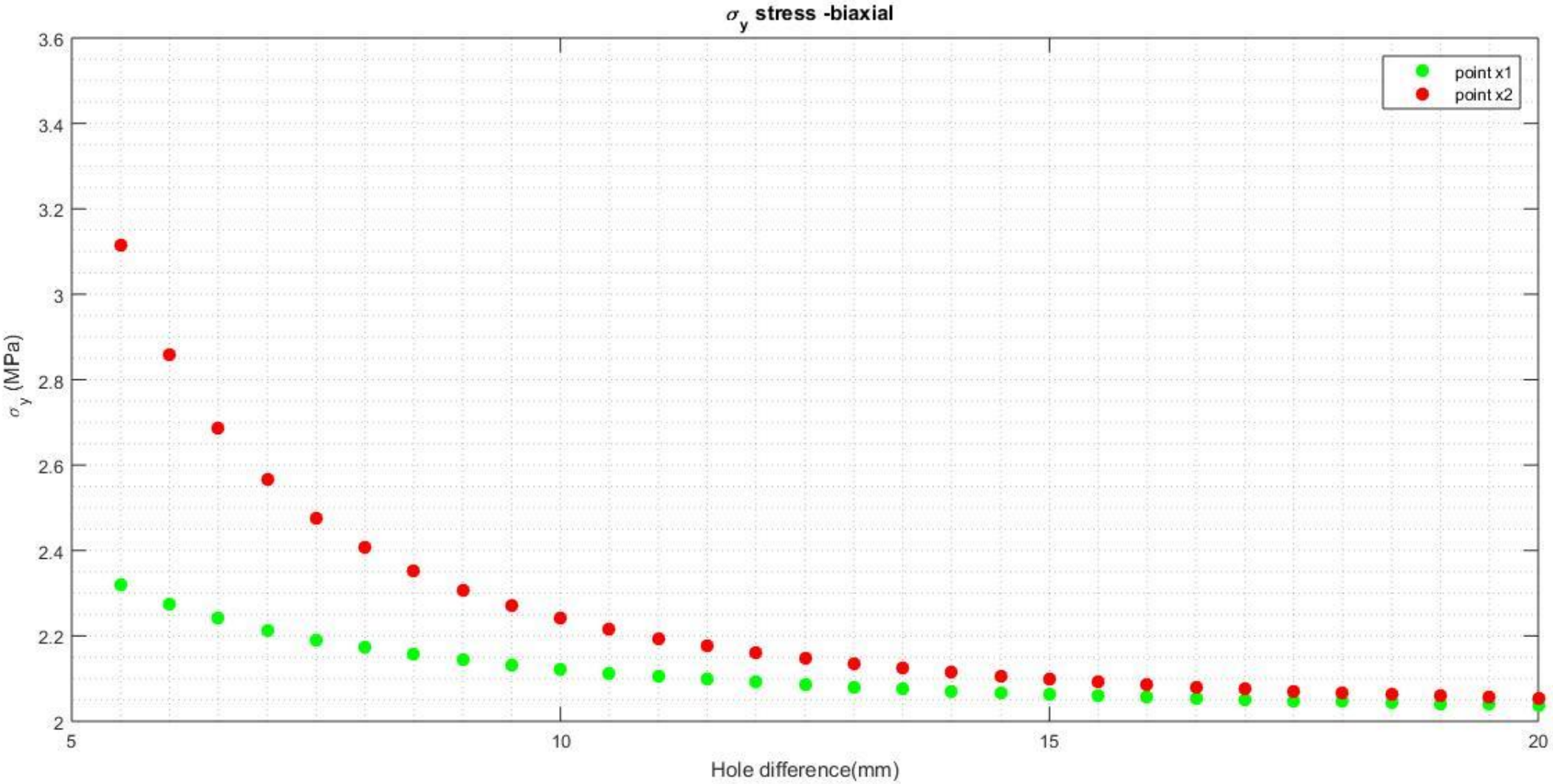
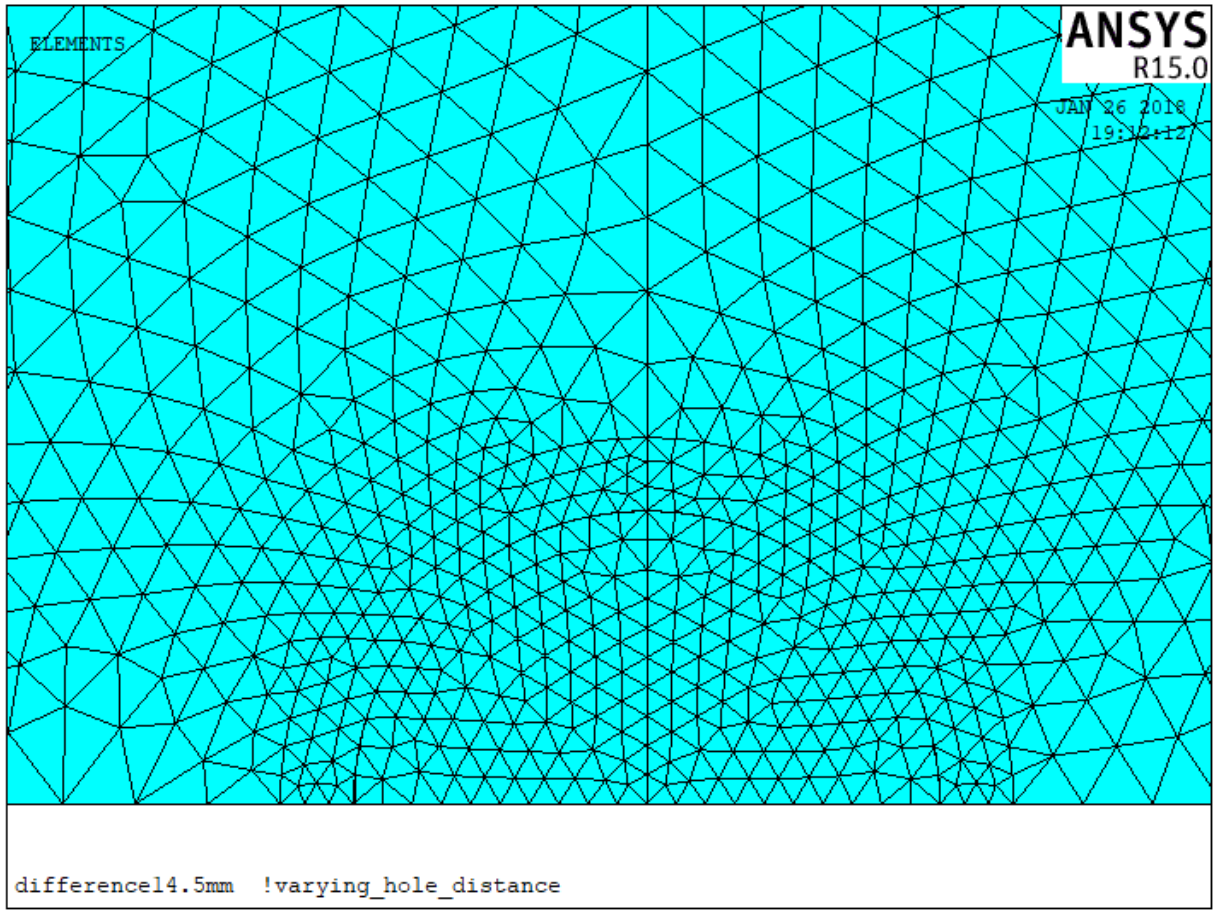
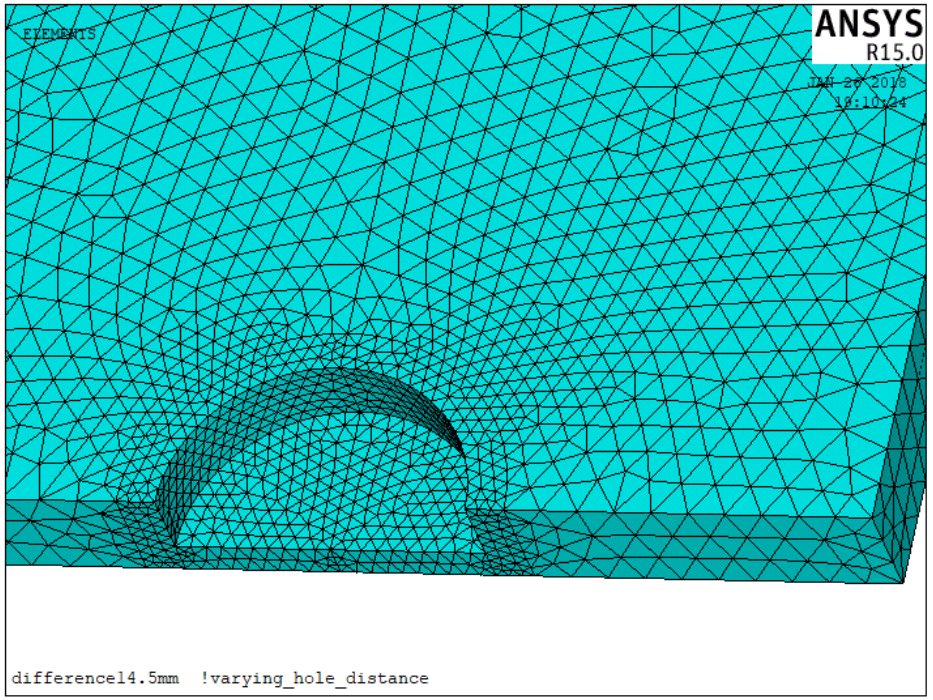
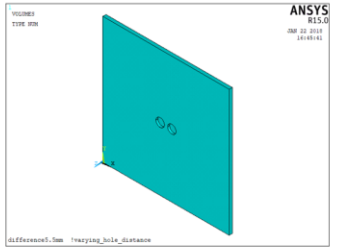


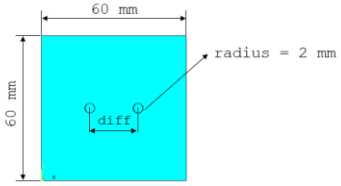
plate_1.5_depth_1





A 1.5 mm plate and two Circular Holes with 1 mm depth





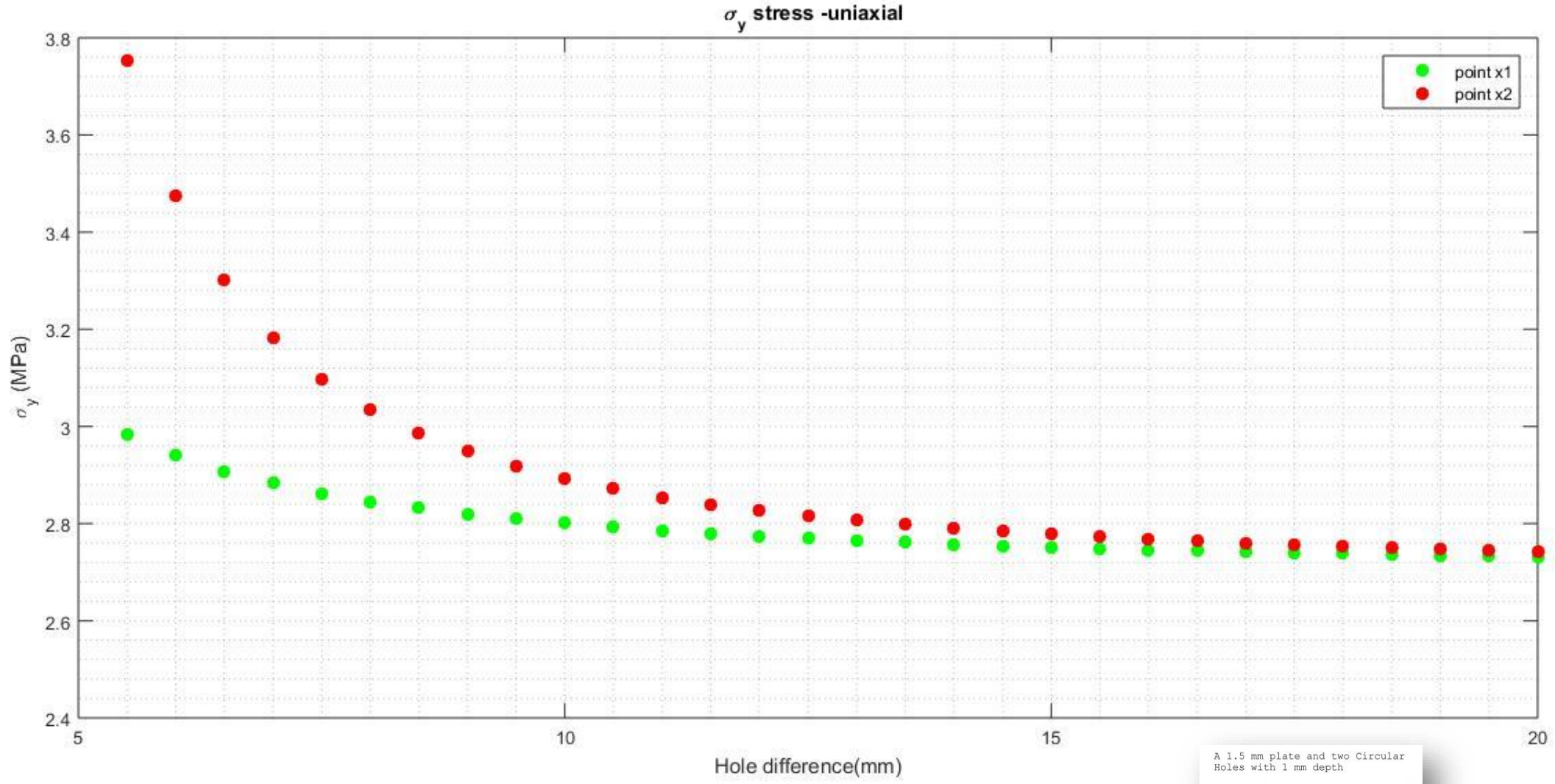
plate_thickness = 1.5 mm

depth = 1.0 mm

"cylindrical hole"

- Varying the hole distance

plate_1.5_depth_1



Comparison with the previous geometry code →

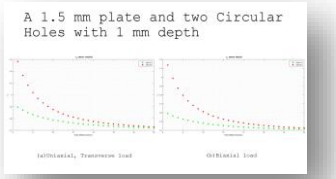
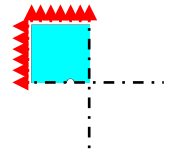
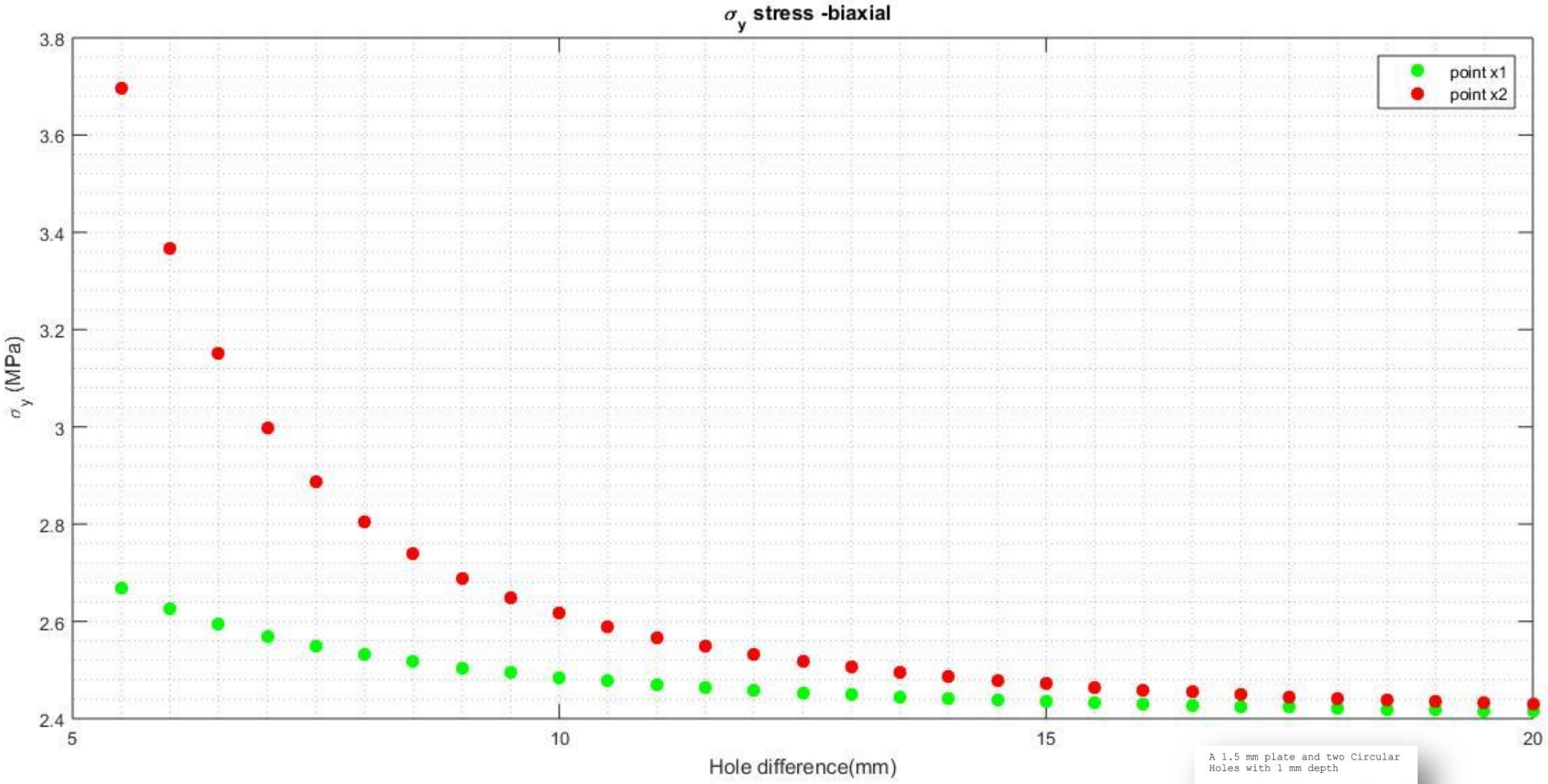
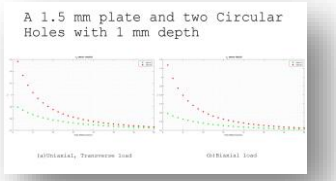


plate_1.5_depth_1

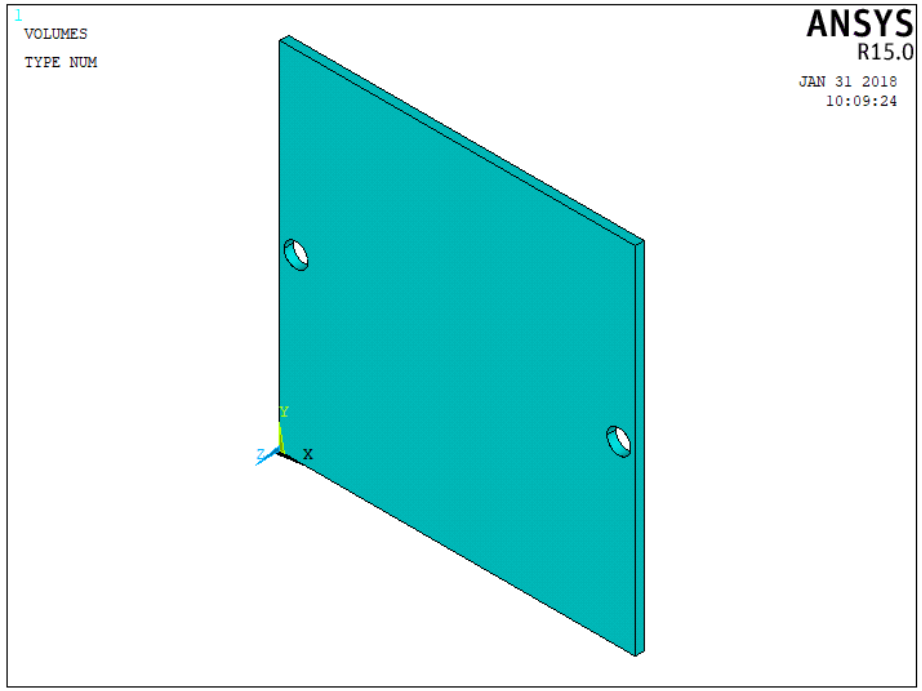


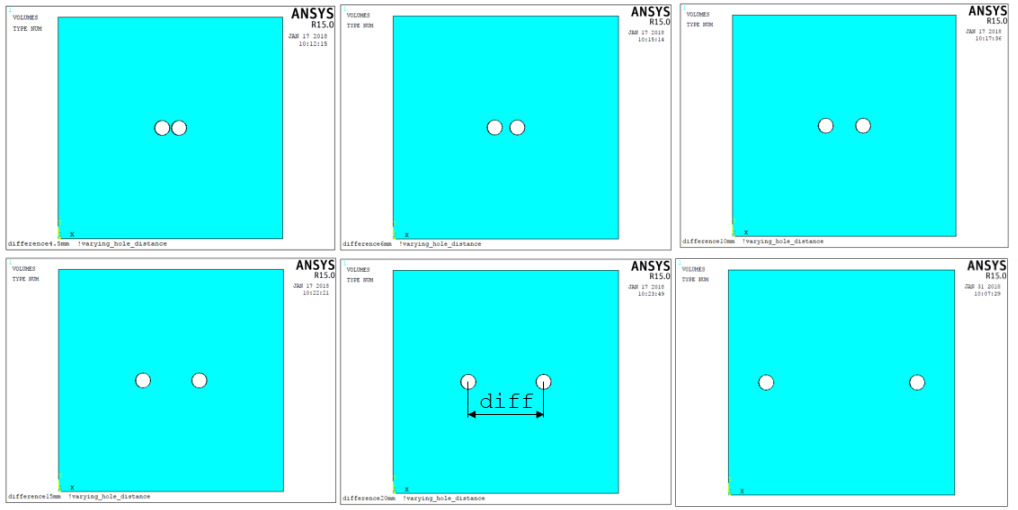


Comparison with the previous geometry code →



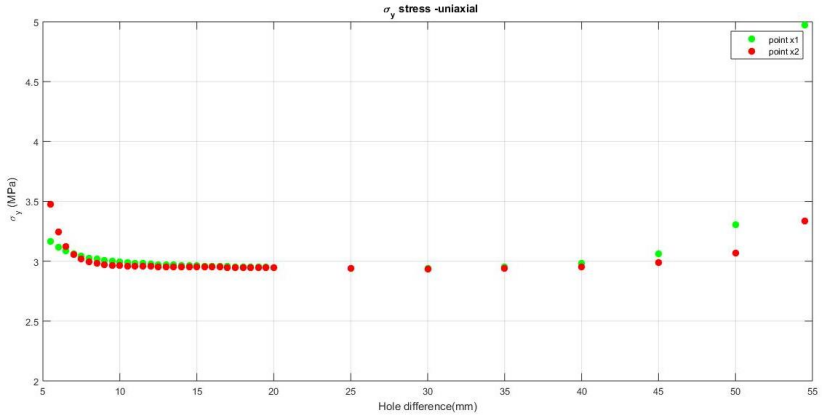
Extending Range

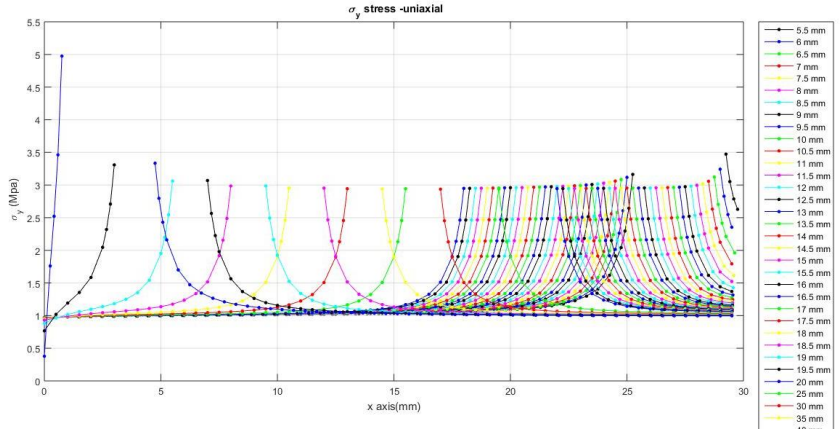


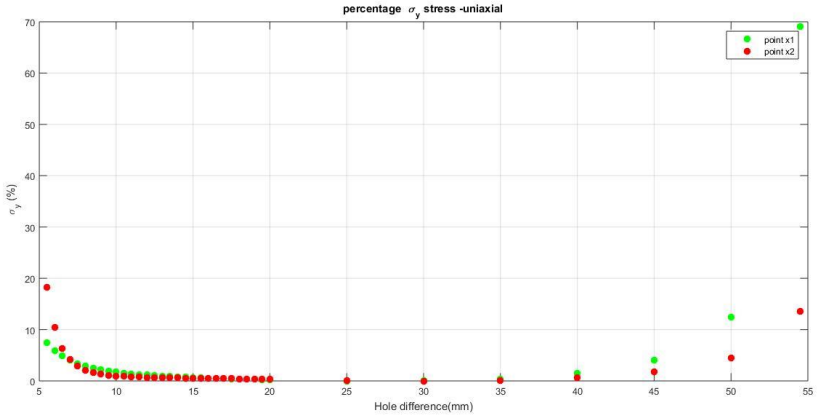



```
inicial = 25 !mm
final = 54.5 !mm
incr = 5 !mm

*do,diff,inicial,final,incr
        ...
        ...
*enddo
```

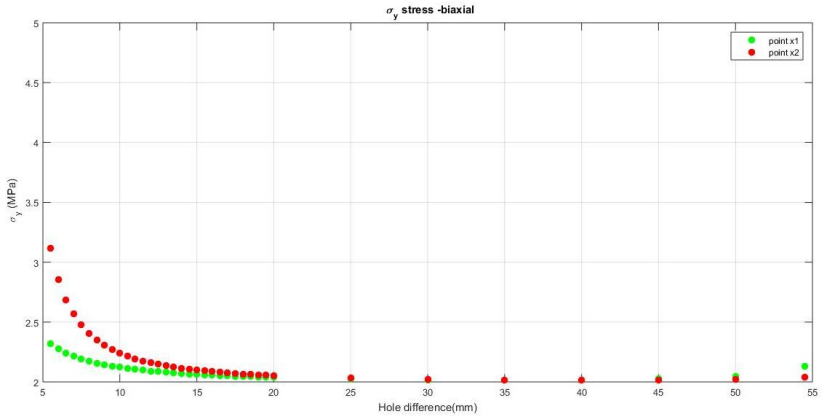
plate_1.5_depth_1.5_through_hole

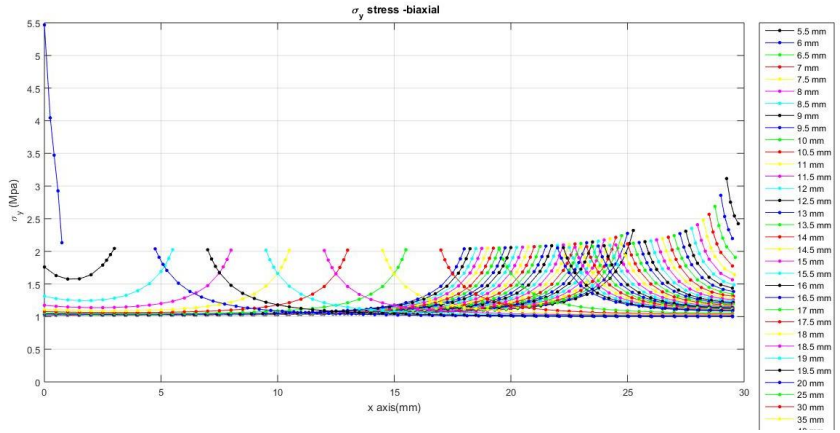


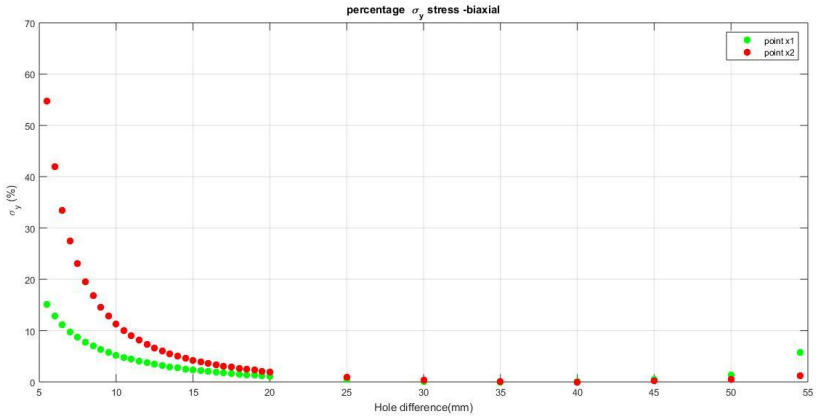




(a) Uniaxial, Transverse load

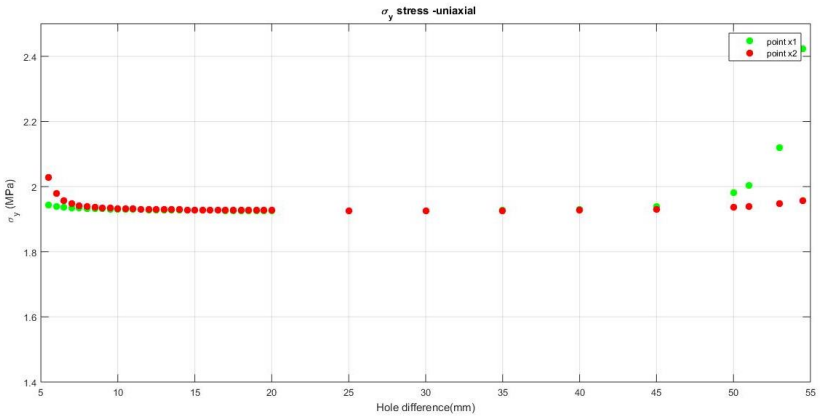


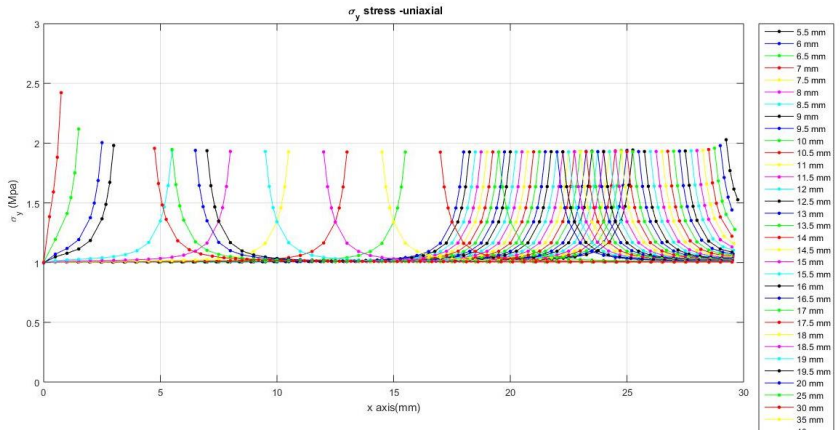


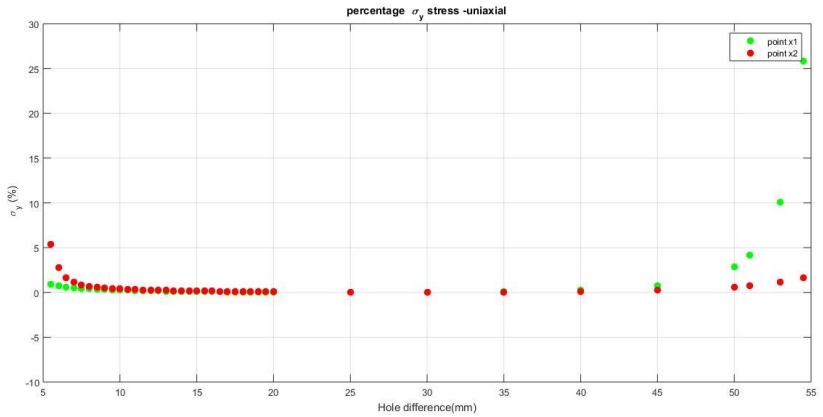


(b)Biaxial load

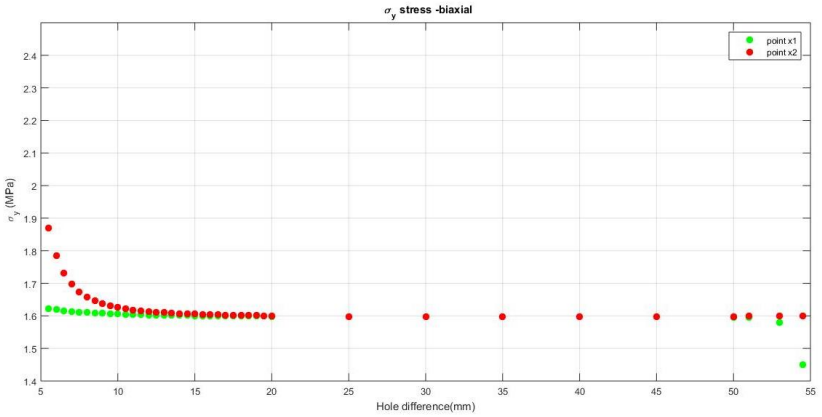
plate_14_depth_1

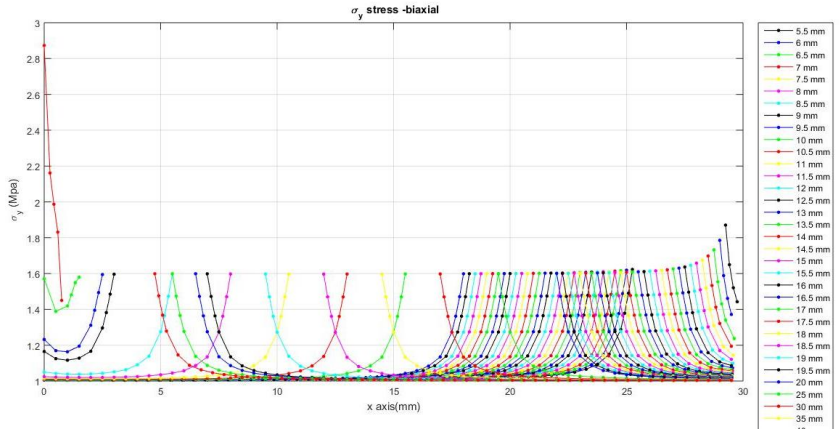


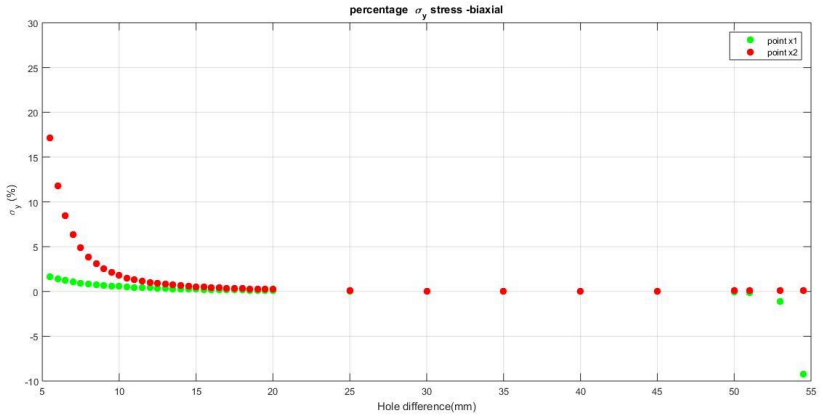




(a) Uniaxial, Transverse load

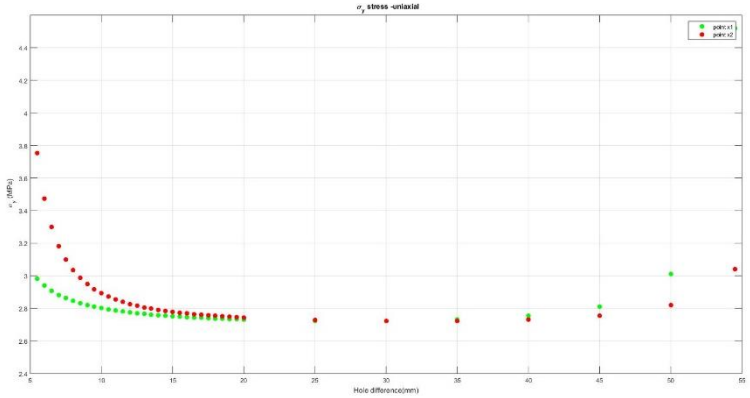


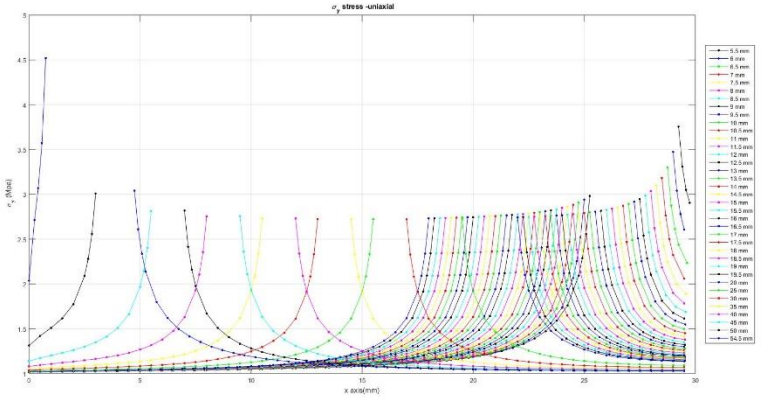


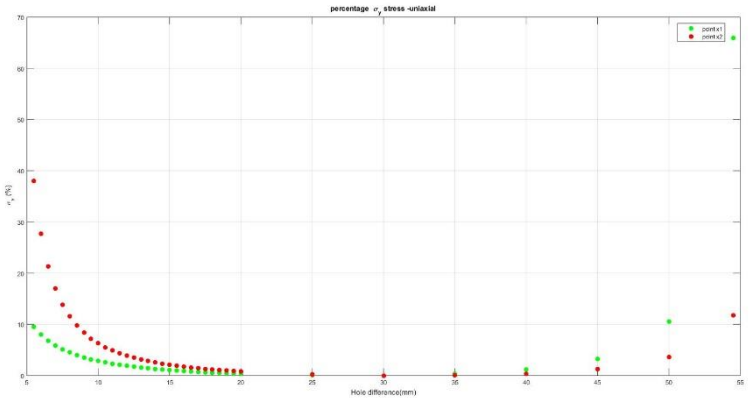


(b)Biaxial load

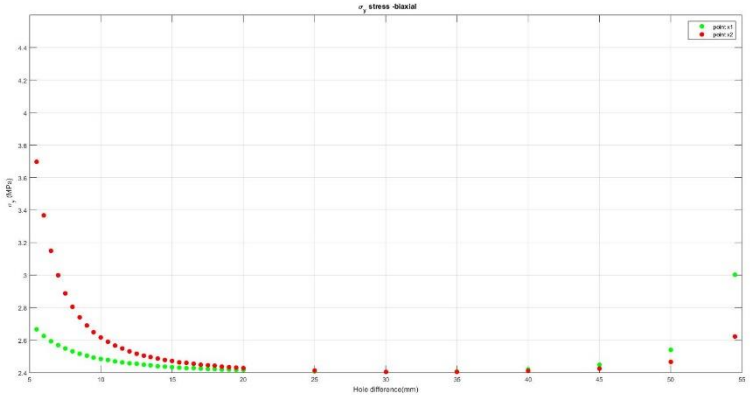
plate_1.5_depth_1

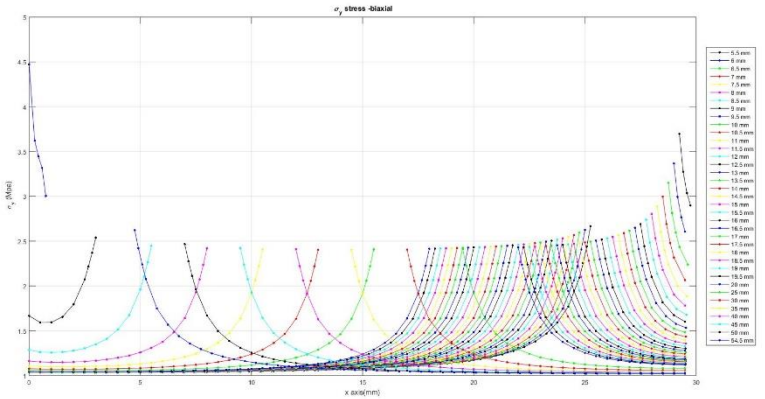


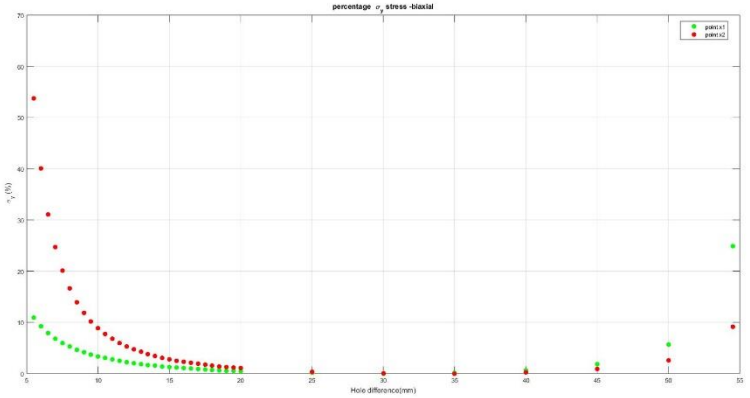




(a) Uniaxial, Transverse load



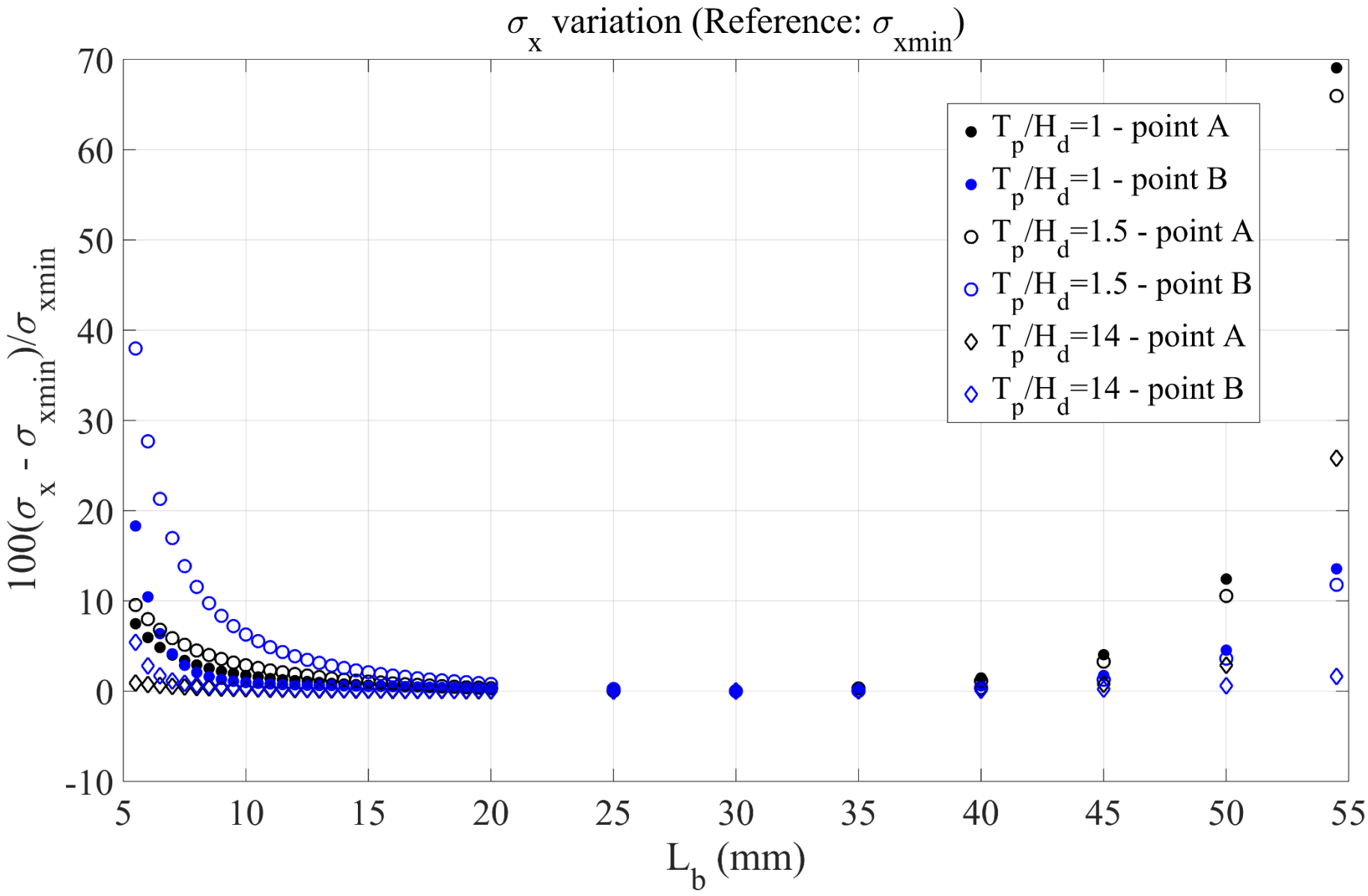




(b)Biaxial load

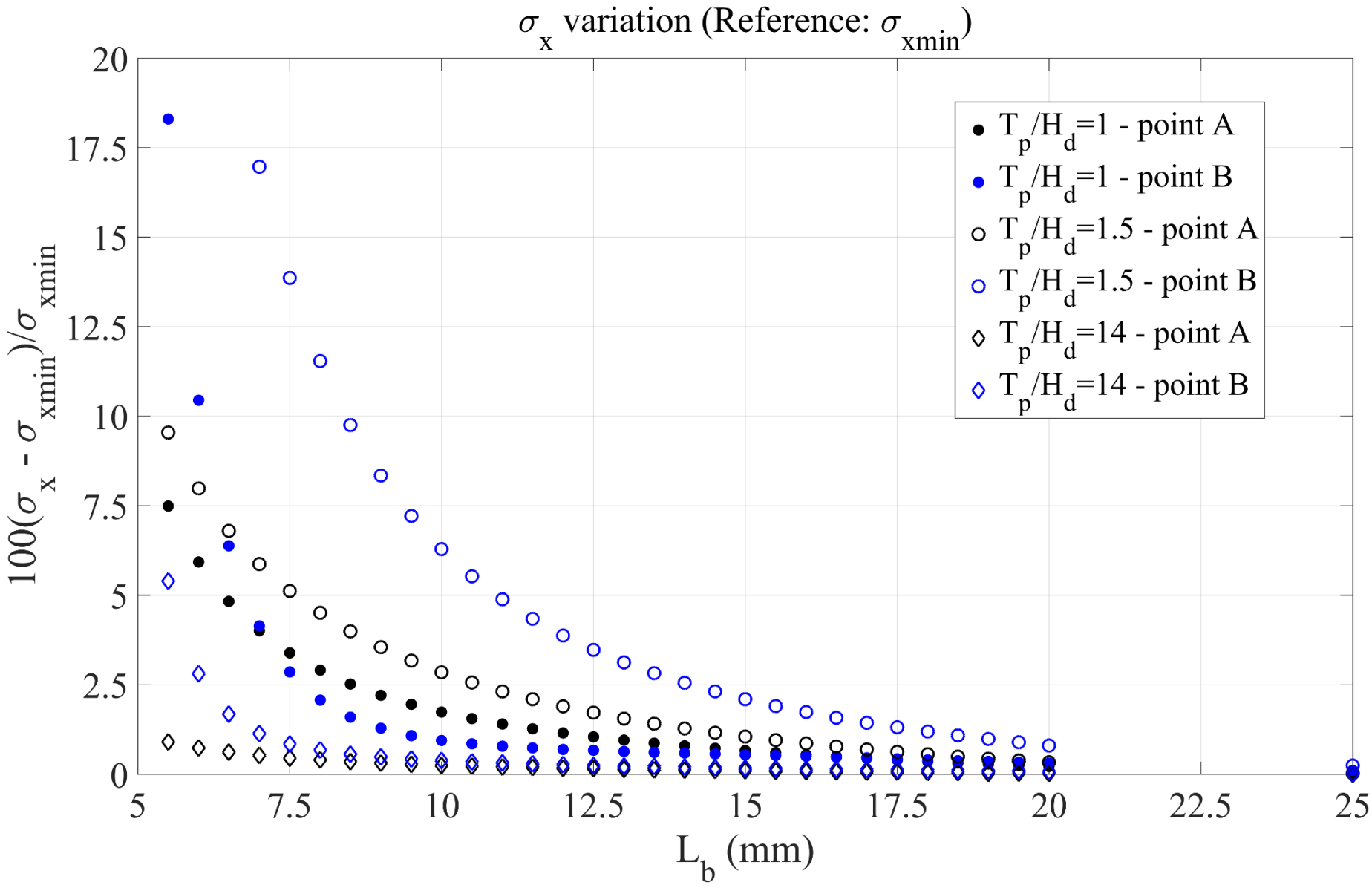
Prepare slides -> problem description

all_uniaxial_biaxial_3_geometries



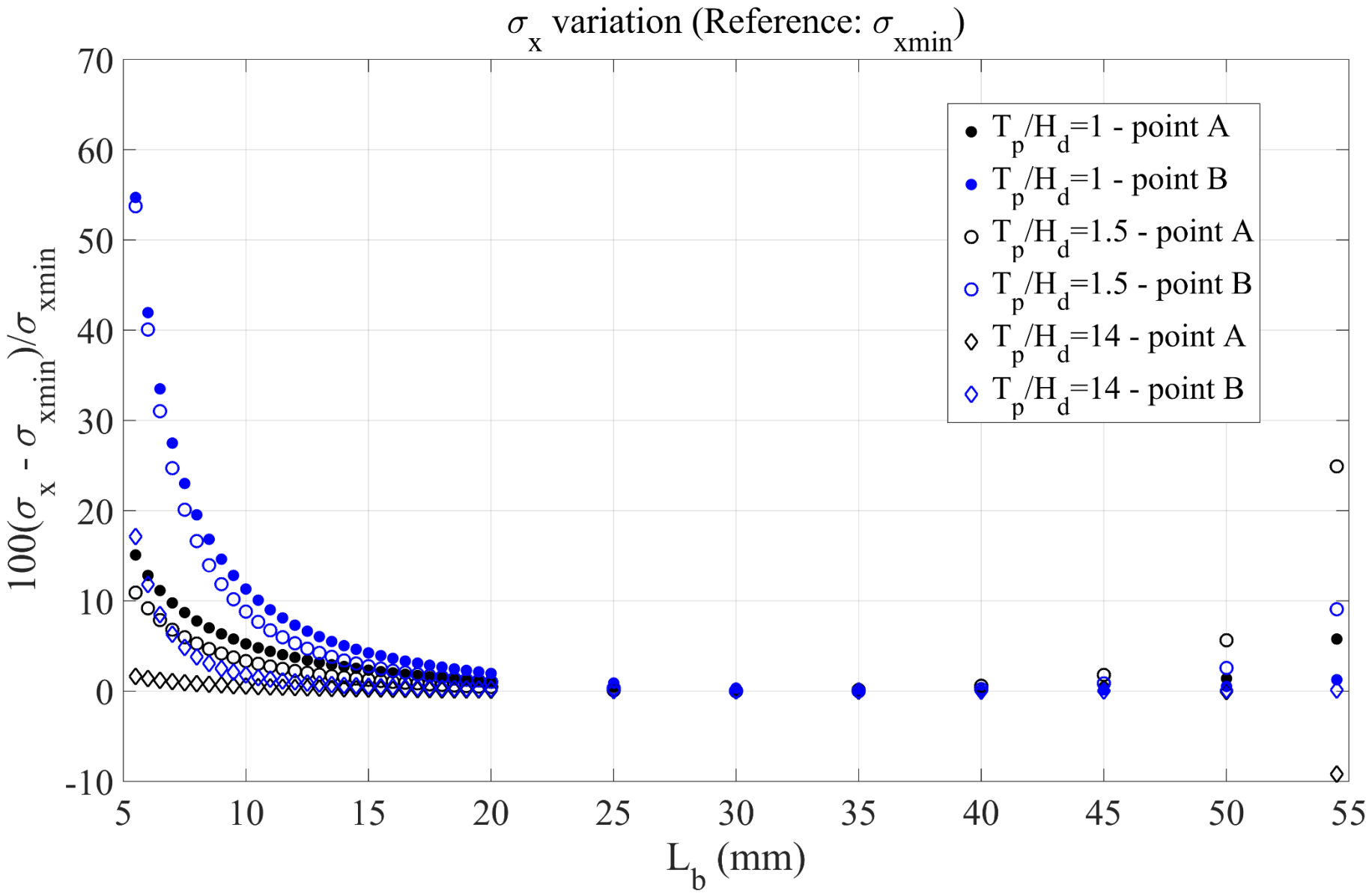
uniaxial

all_uniaxial_biaxial_3_geometries



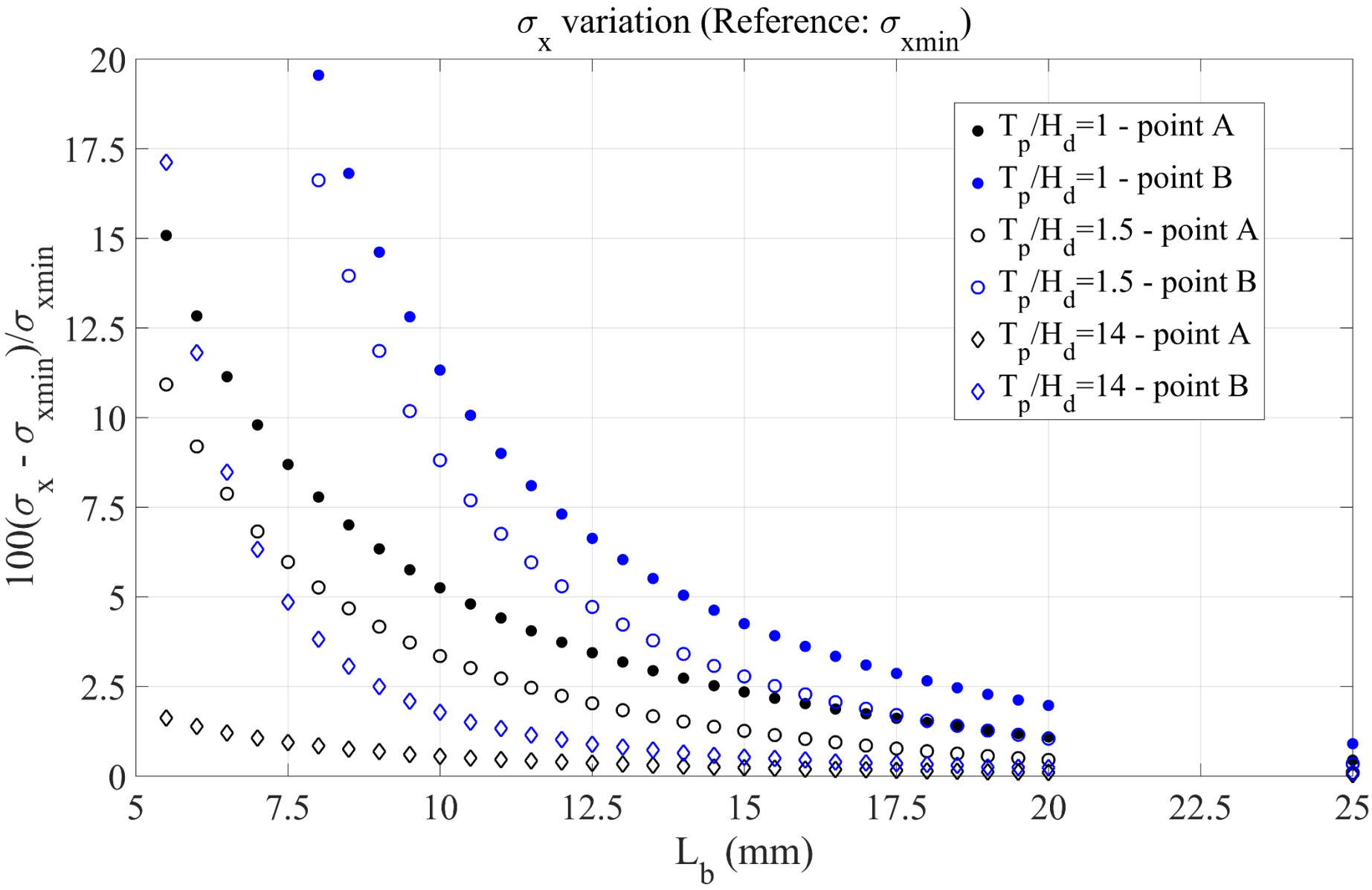
uniaxial

all_uniaxial_biaxial_3_geometries



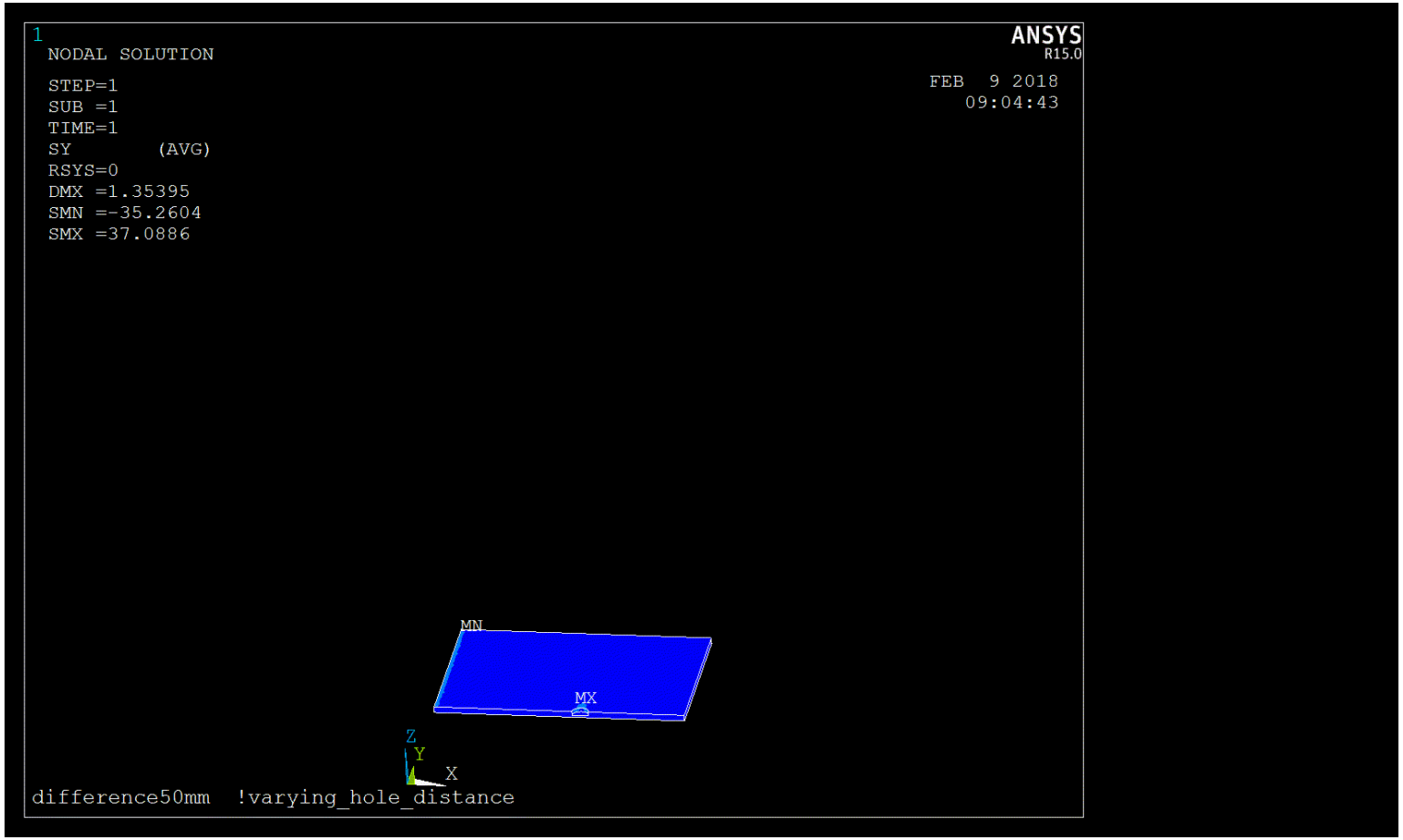
biaxial

all_uniaxial_biaxial_3_geometries



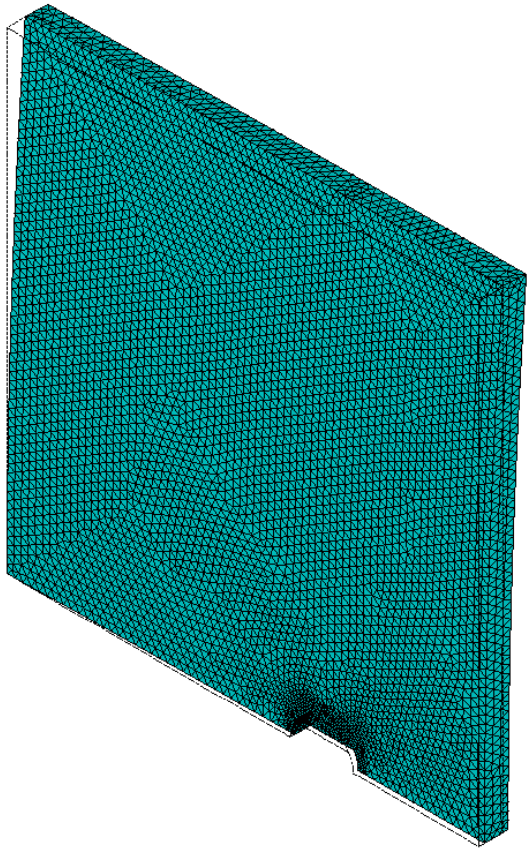
biaxial

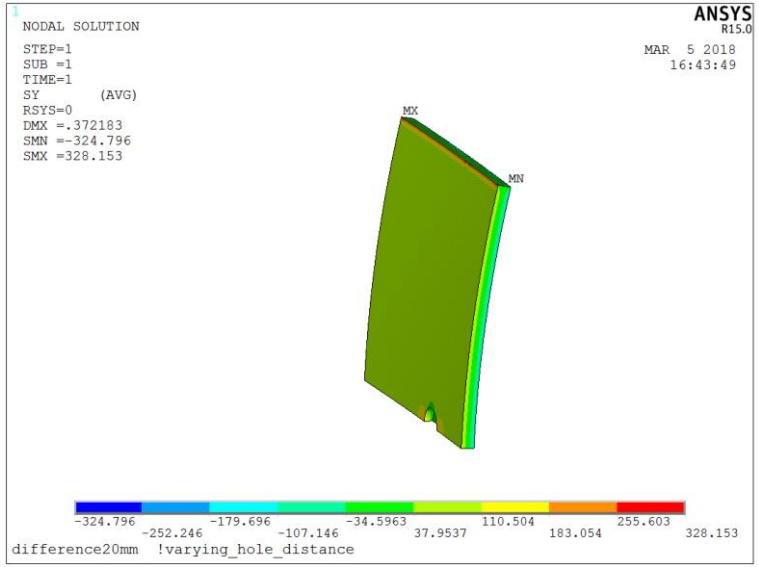
https://convertio.co/pt/avi-converter/

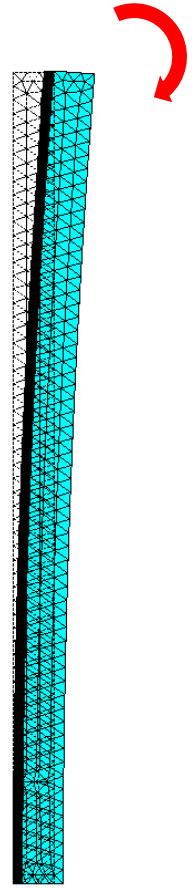


varying_hole_distance_bending

```
! BENDING
! apply displacements conditions at the nodes of the line:
! x=0, z=0

allsel
lsel,s,loc,y,y2
lsel,r,loc,z,z1
nsll,s
d,all,uy,0.0145

allsel
lsel,s,loc,x,x1
lsel,r,loc,z,z1
nsll,s
d,all,ux,-0.0145

allsel
lsel,s,loc,y,y2
lsel,r,loc,z,-z2
nsll,s
d,all,uy,-0.0145

allsel
lsel,s,loc,x,x1
lsel,r,loc,z,-z2
nsll,s
d,all,ux,0.0145
```



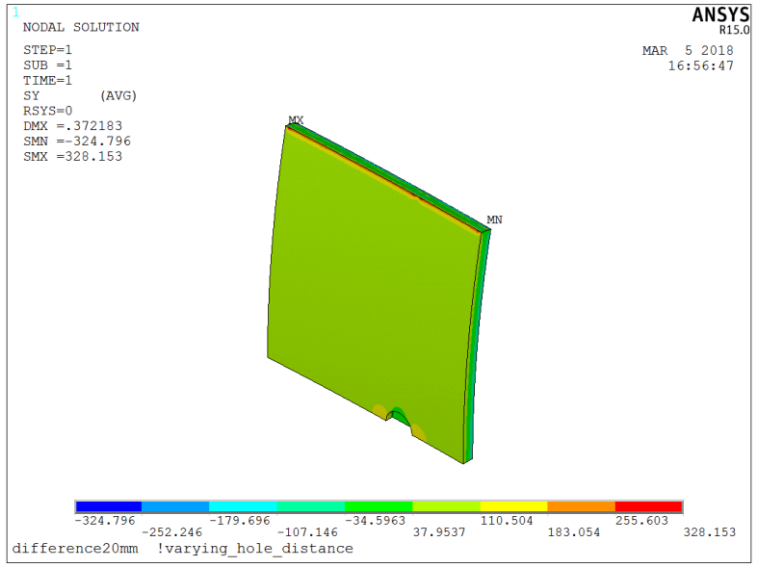




!The same CODE for Uniaxial and Biaxial cases, just comment or uncomment some commands
!lines: 17/18 , 55/56 , 315/321 , 327/333

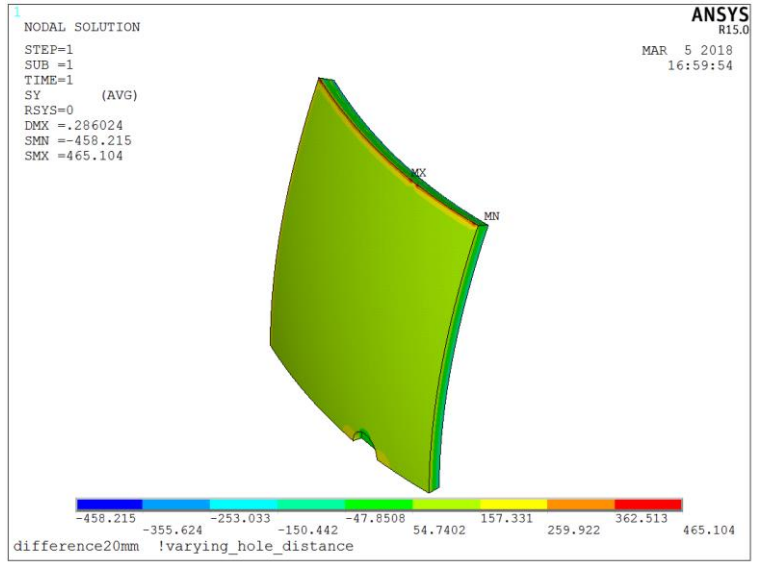
varying_hole_distance_bending

```
! UNIAXIAL BENDING
! apply displacements conditions at the nodes of the line:
! x=0, z=0

allsel
lsel,s,loc,y,y2
lsel,r,loc,z,z1
nsll,s
d,all,uy,0.0145

!
!
!
!
!

allsel
lsel,s,loc,y,y2
lsel,r,loc,z,-z2
nsll,s
d,all,uy,-0.0145

!
!
!
!
!
```



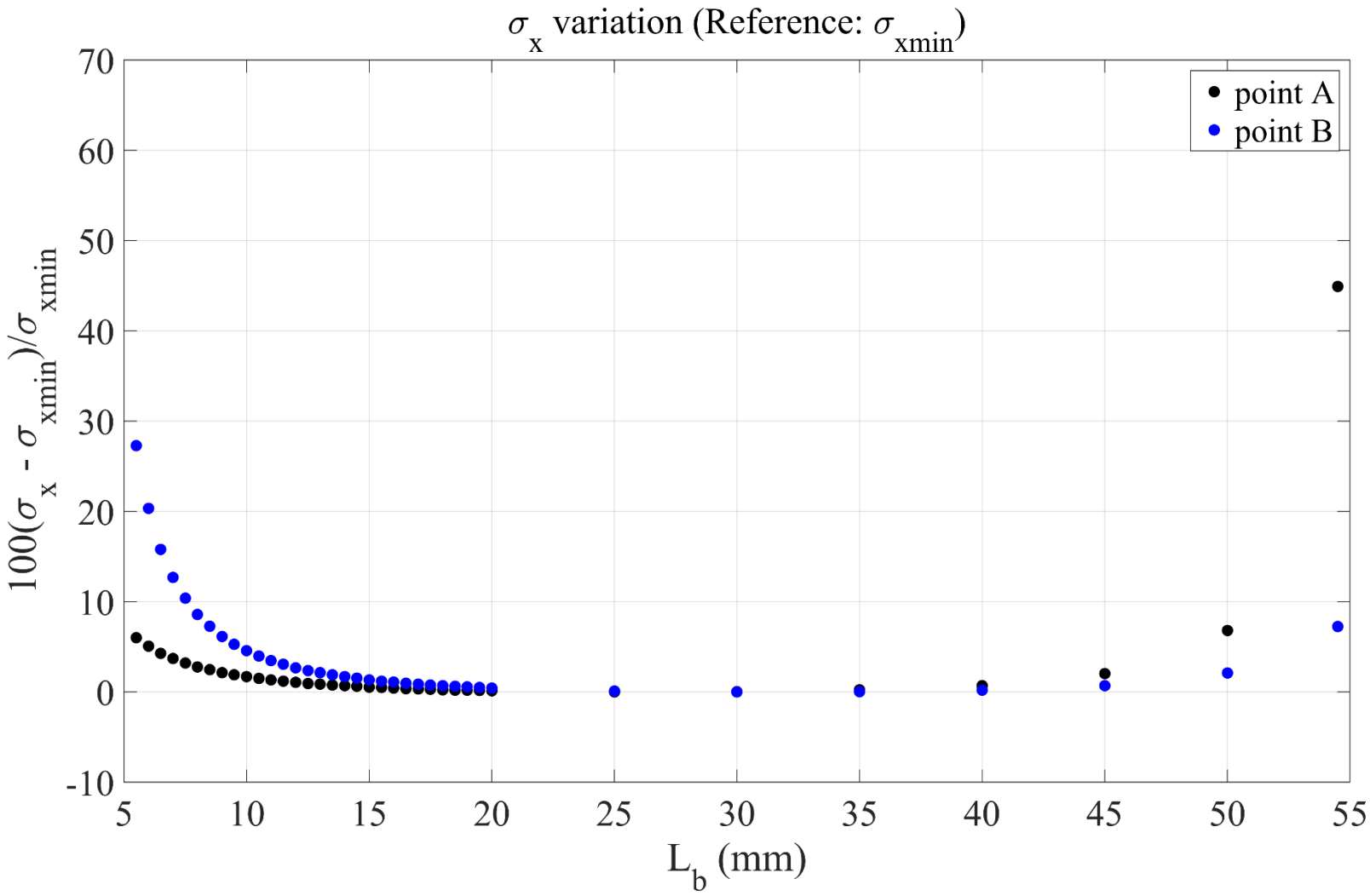
(a) Uniaxial (Transverse) Bending

```
! BIAXIAL BENDING
! apply displacements conditions at the nodes of the line:
! x=0, z=0

allsel
lsel,s,loc,y,y2
lsel,r,loc,z,z1
nsll,s
d,all,uy,0.0145

allsel
lsel,s,loc,x,x1
lsel,r,loc,z,z1
nsll,s
d,all,ux,-0.0145

allsel
lsel,s,loc,y,y2
lsel,r,loc,z,-z2
nsll,s
d,all,uy,-0.0145

allsel
lsel,s,loc,x,x1
lsel,r,loc,z,-z2
nsll,s
d,all,ux,0.0145
```



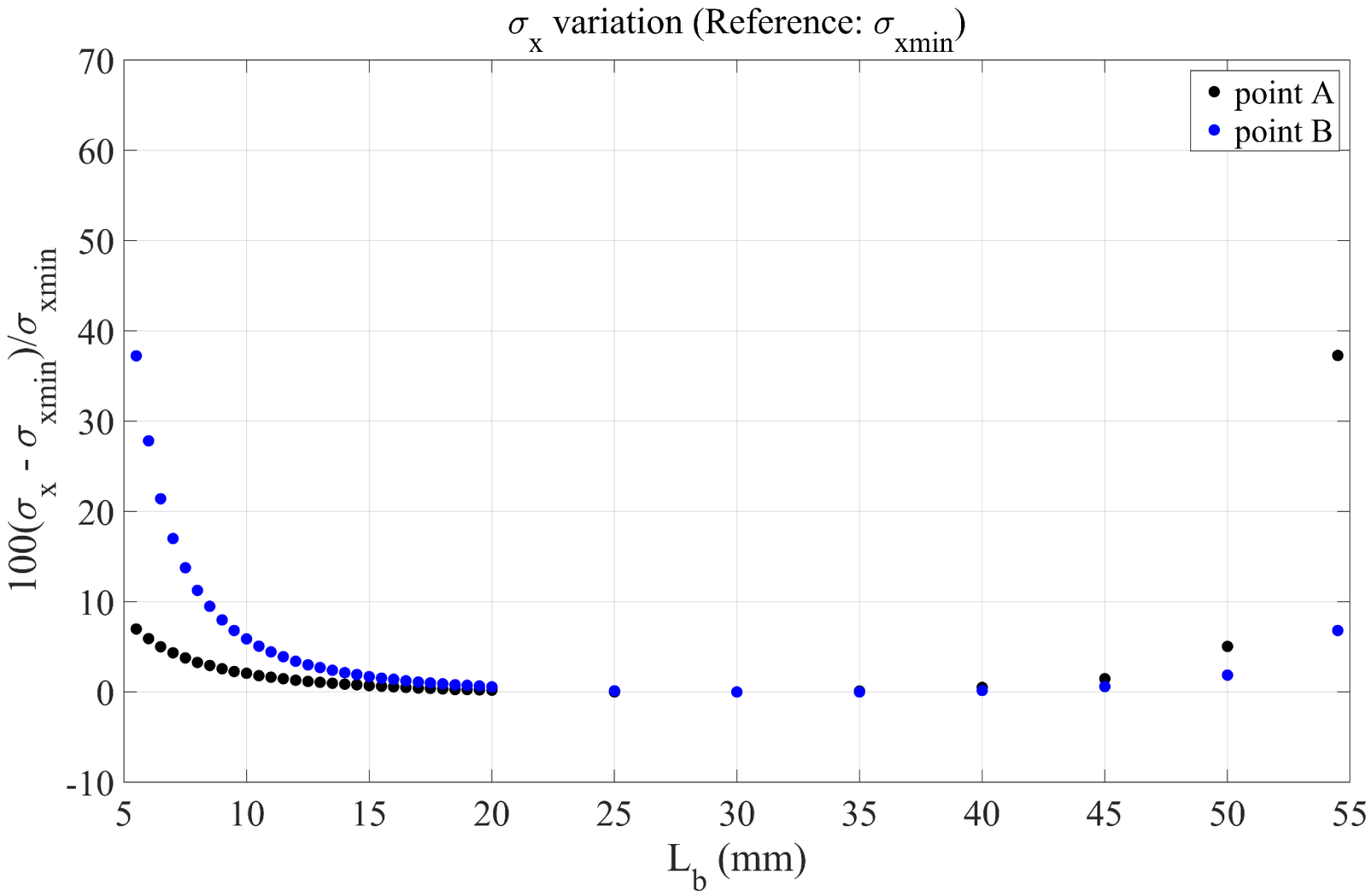
(b) Biaxial Bending

varying_hole_distance_bending



(a) Uniaxial (Transverse) Bending

varying_hole_distance_bending

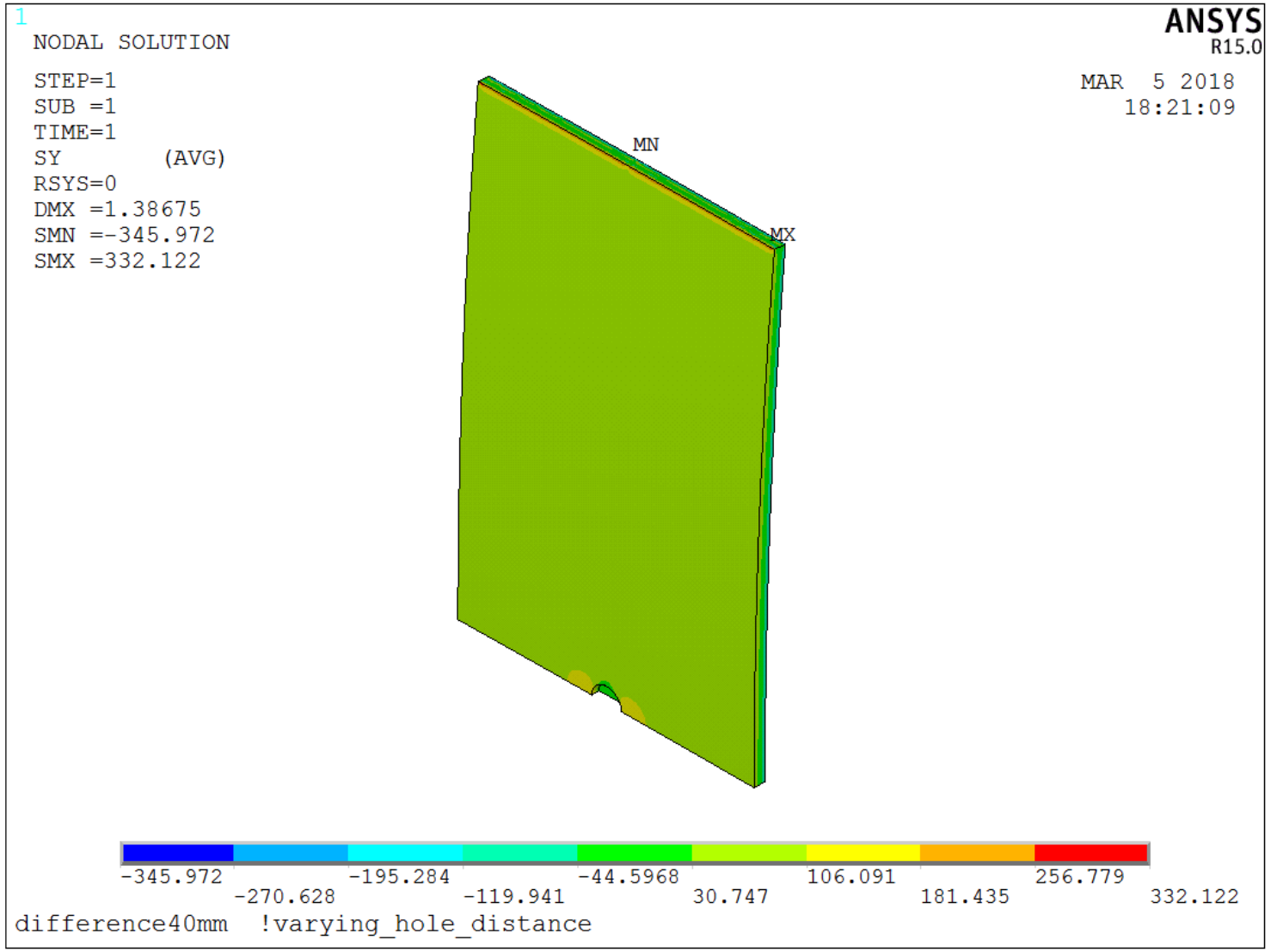


(b) Biaxial Bending

varying_hole_distance_bending_80x124mm

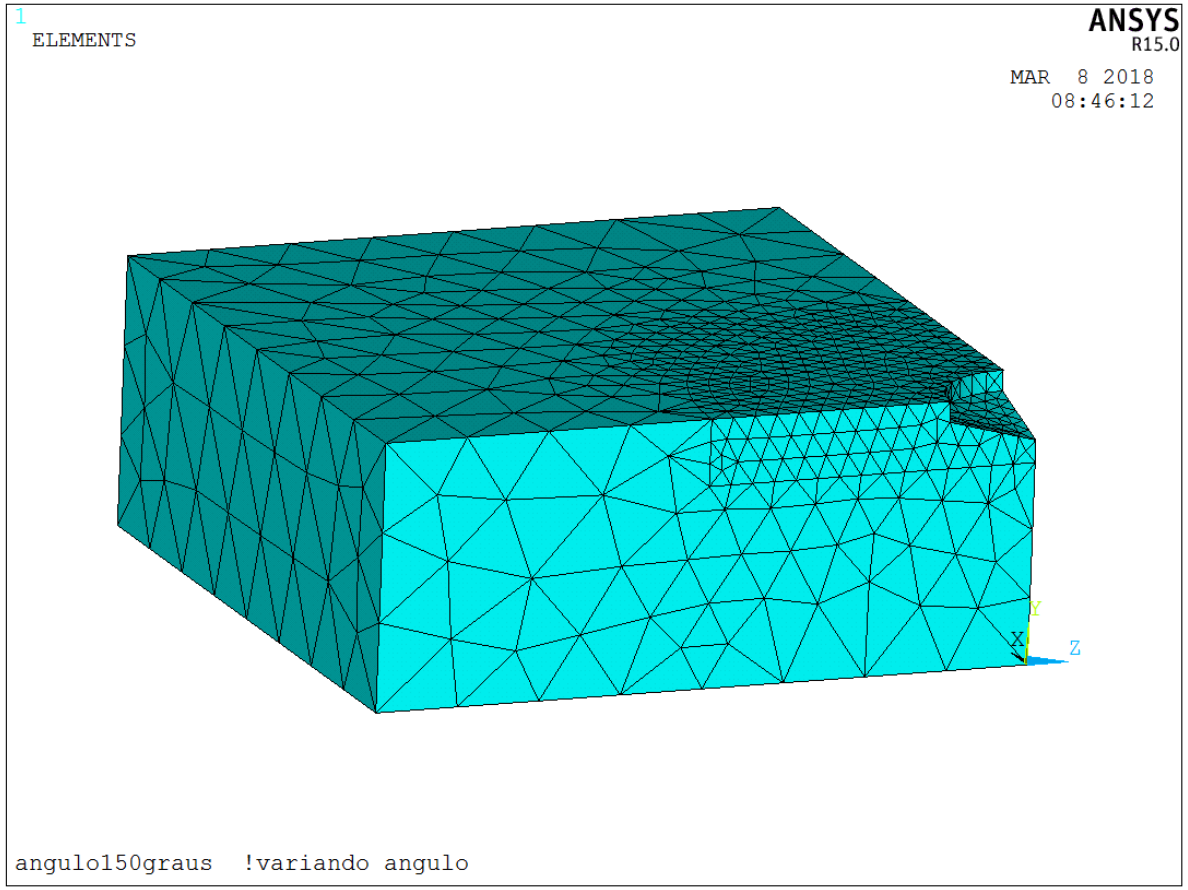
(a) Uniaxial
(Transverse) Bending

```
x1 = 0
x2 = 80
y1 = 0
y2 = 124
z1 = 0
z2 = 1.5

inicial = 10
final = 72
incr = 2
```



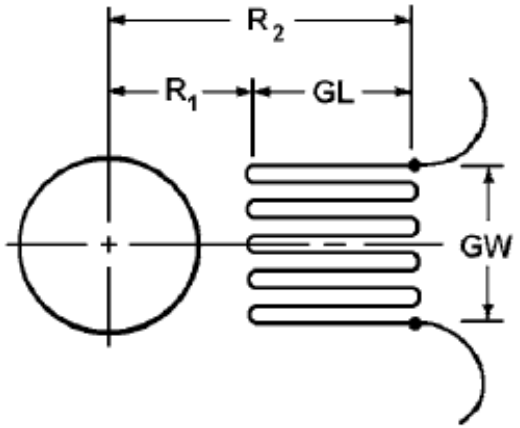
tarefa_furo_diferente_angulos

```
inicial = 130
final = 180
incr = 10

*do,angle,inicial,final,
incr
  .
  .
  .
*enddo
```

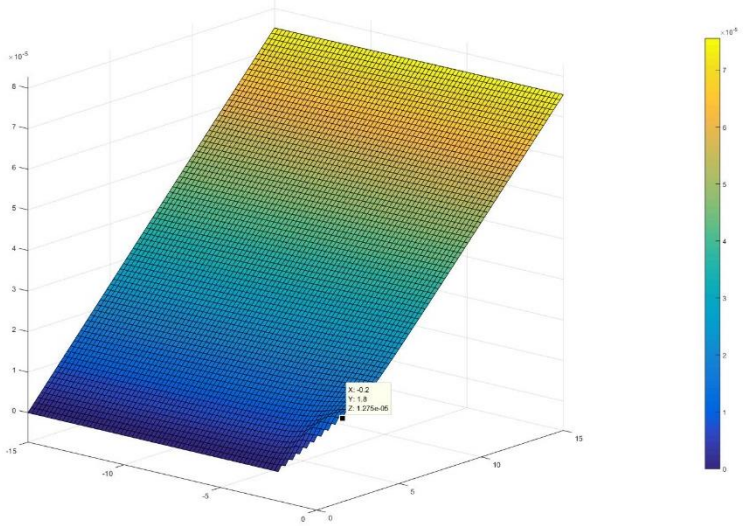


Result Deformation -> “tarefa_furo_diferente_angulos”

```
F_angle = scatteredInterpolant(xloc,zloc,ux,'linear','none');
```



$$\varepsilon = \sum_{i=1}^{n} \frac{U_{i2} - U_{i1}}{n(r_2 - r_1)}$$



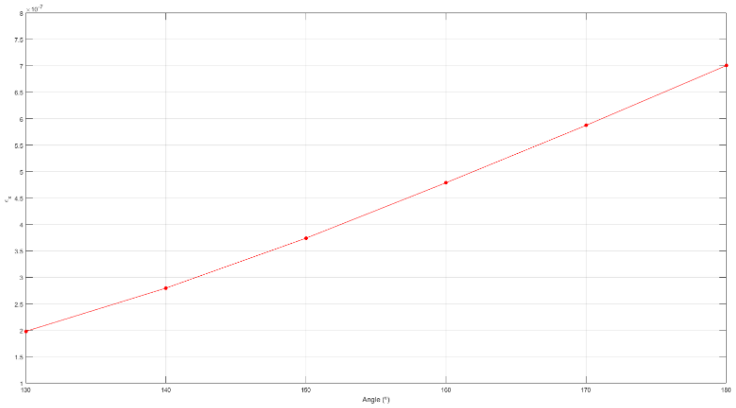
```
matrix_u0 =[n(:,1),xloc(:,1),zloc(:,1),ux(:,1)];
%matrix with ux data, strain gauge with tetha = 0° direction
```

```
%parameters:
%take a look at the PDF NORMA
r1=3.54; %values according to the NORMA [?], distane from the hole to the initial position of the strain gauge (x axis)
r2=6.72; %values according to the NORMA [?], distane from the hole to the final position of the strain gauge (x axis)
D=(r1+r2);
GL=3.18; %strain gauge length, %values according to the NORMA [?]
GW=3.18; %strain gauge width,  %values according to the NORMA [?]
ngrids=21; %number of grids -> strain gauge
```

TABLE 1 Rosette Dimensions[A]

Rosette Type	D	GL[B]	GW[B]	R_1[B]	R_2[B]
		Type A			
Conceptual	D	0.309D	0.309D	0.3455D	0.6545D
1/32 in. nominal	0.101 (2.57)	0.031 (0.79)	0.031 (0.79)	0.035 (0.89)	0.066 (1.68)
1/16 in. nominal	0.202 (5.13)	0.062 (1.59)	0.062 (1.59)	0.070 (1.77)	0.132 (3.36)
1/8 in. nominal	0.404 (10.26)	0.125 (3.18)	0.125 (3.18)	0.140 (3.54)	0.264 (6.72)
		Type B			
Conceptual	D	0.309D	0.223D	0.3455D	0.6545D
1/16 in. nominal	0.202 (5.13)	0.062 (1.59)	0.045 (1.14)	0.070 (1.77)	0.132 (3.36)
		Type C			
Conceptual	D	0.176D	30° sector	0.412D	0.588D
1/16 in. nominal	0.170 (4.32)	0.030 (0.76)	30° (30°)	0.070 (1.78)	0.100 (2.54)

[A] Dimensions are in inches (mm).
[B] Rosette dimensions are defined in Fig. 2.



strain_gauge_deformation.m

center_hole uniaxial plate_1.5_depth_1.5 “through hole”

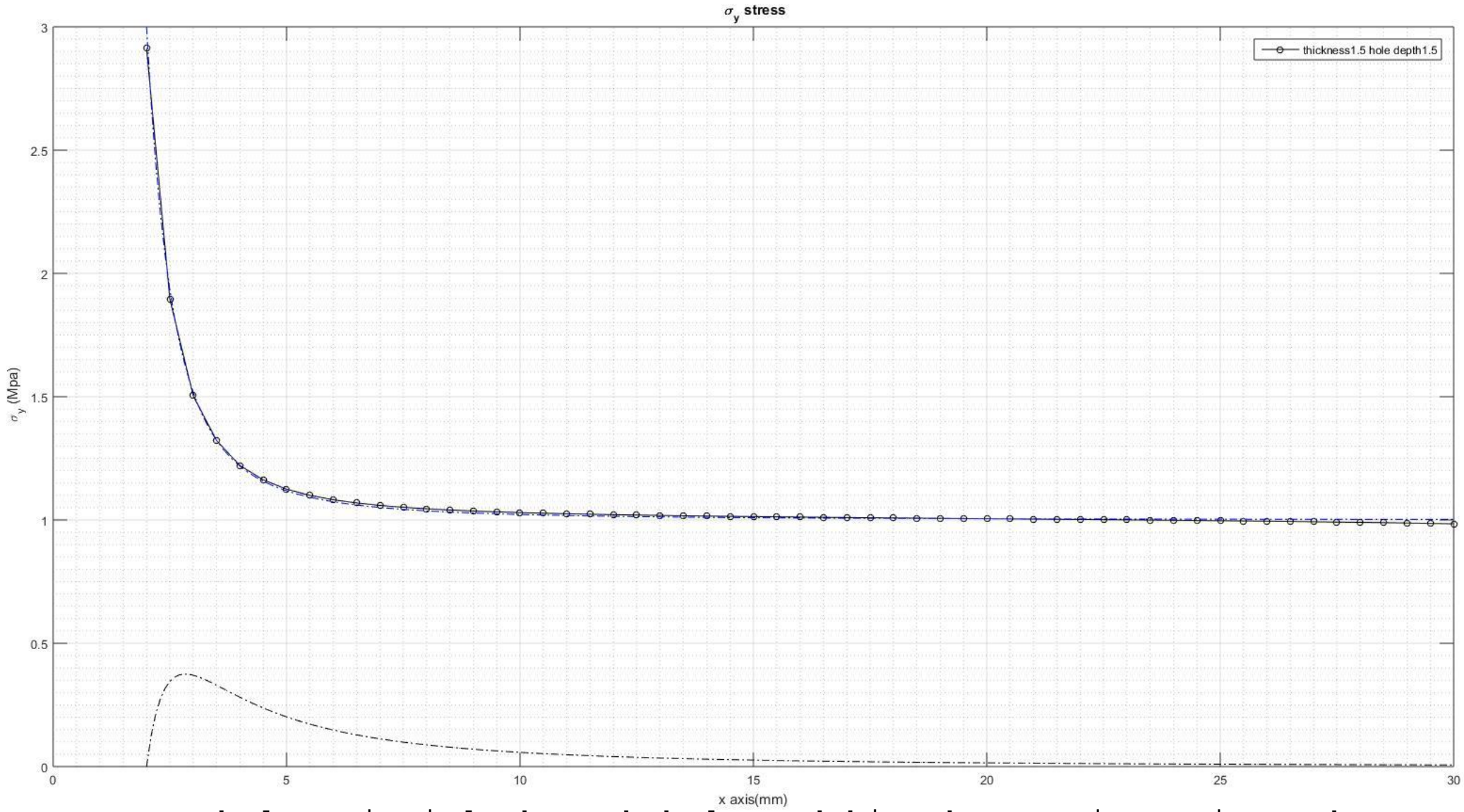
⟶ tensile_stress_concentration_polar_equations.m

+

⟶ uniaxial_biaxial_stress_profile_center_hole.m

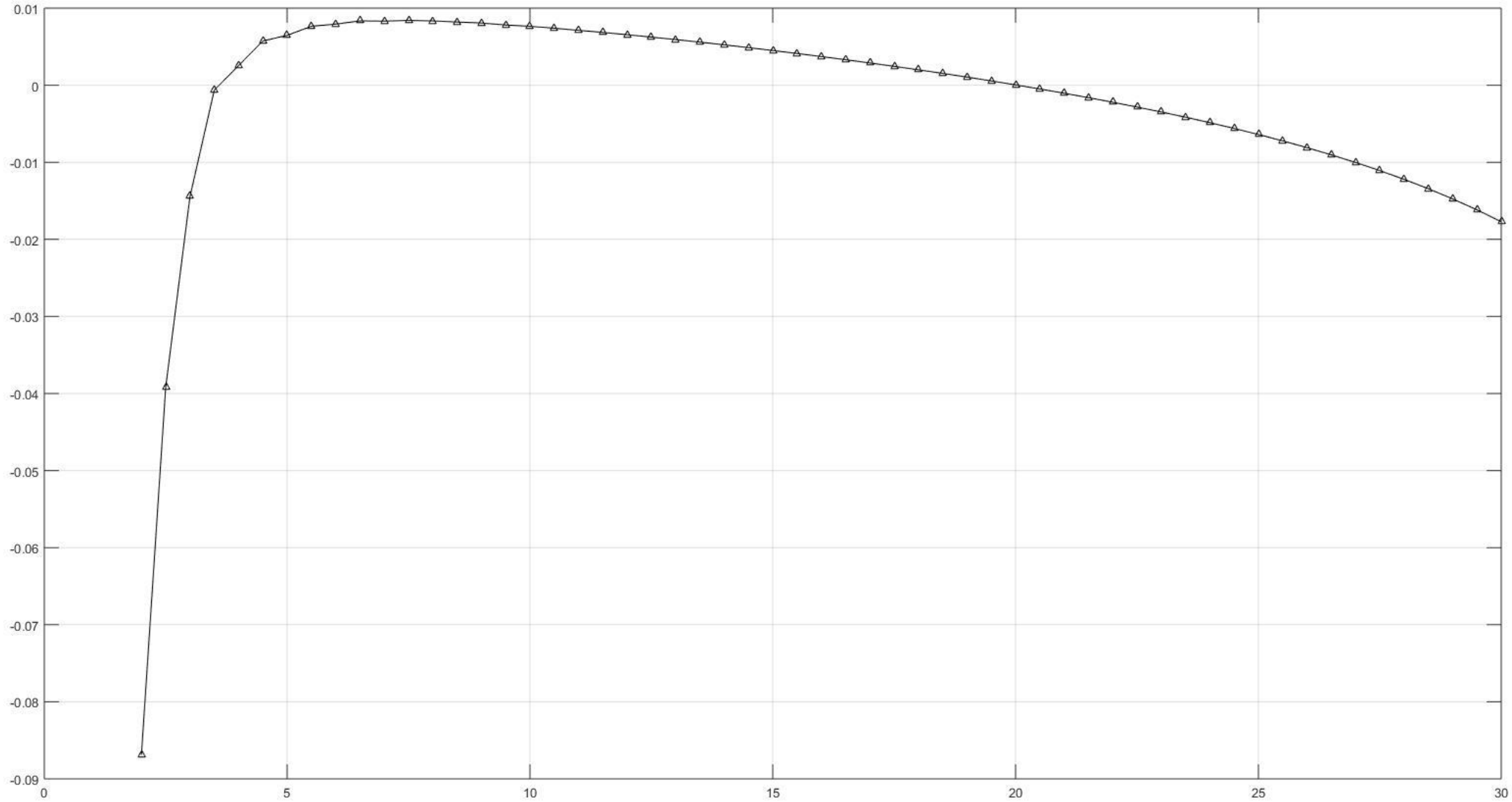
```
t=1 % uniaxial only
m=1 % through hole
```

center_hole uniaxial plate_1.5_depth_1.5 "through hole"



center_hole_uniaxial_through_hole_and_kirsch_equations_sigma_theta

center_hole uniaxial plate_1.5_depth_1.5 "through hole"



center_hole_uniaxial_through_hole_and_kirsch_equations_sigma_theta_diff_K_sim

center_hole with “through hole”

plate_1.5_depth_1.5

radius = 2 mm

1° case

plate_1.5_depth_1.5

radius = 1 mm

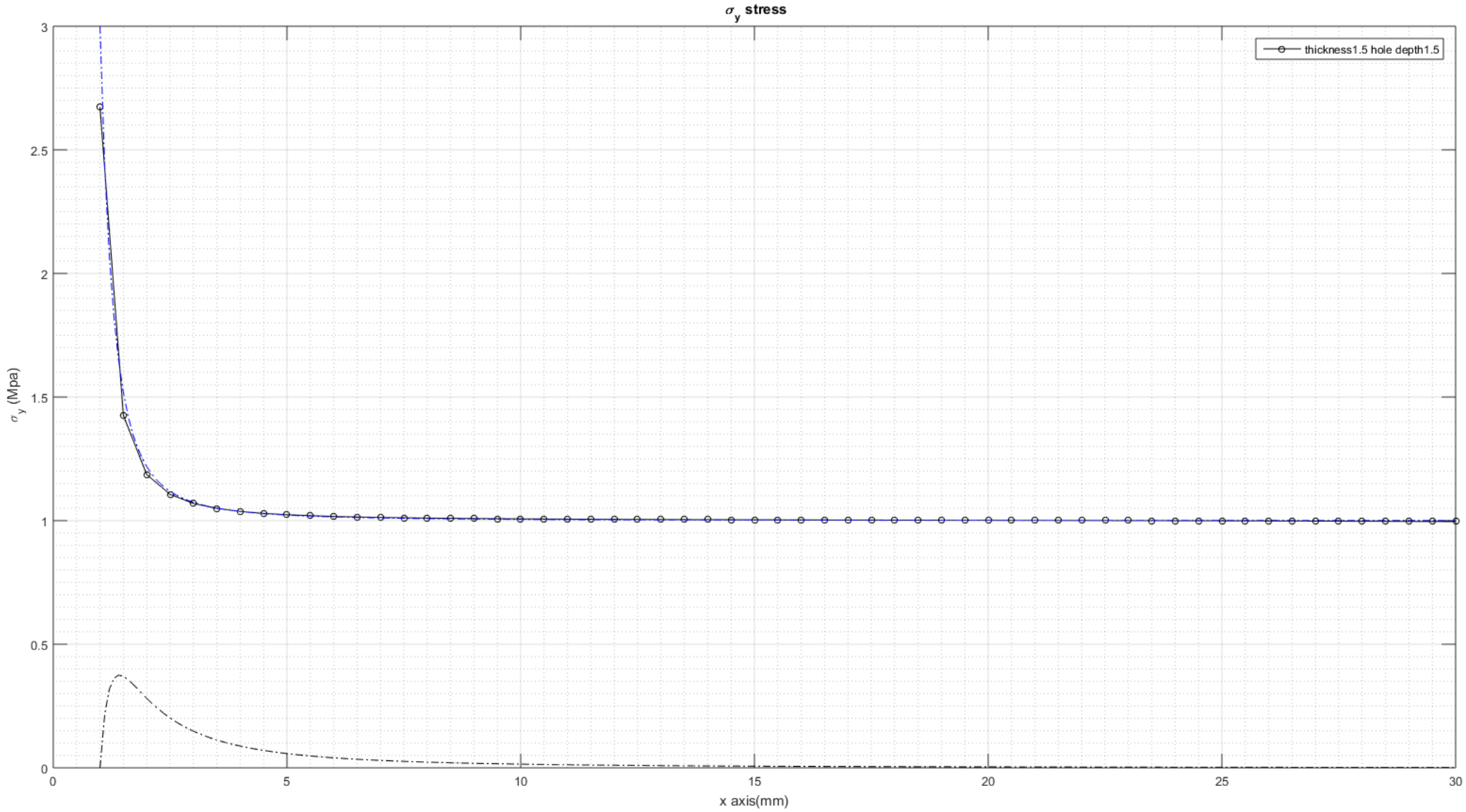
2° case

plate_0.5_depth_0.5

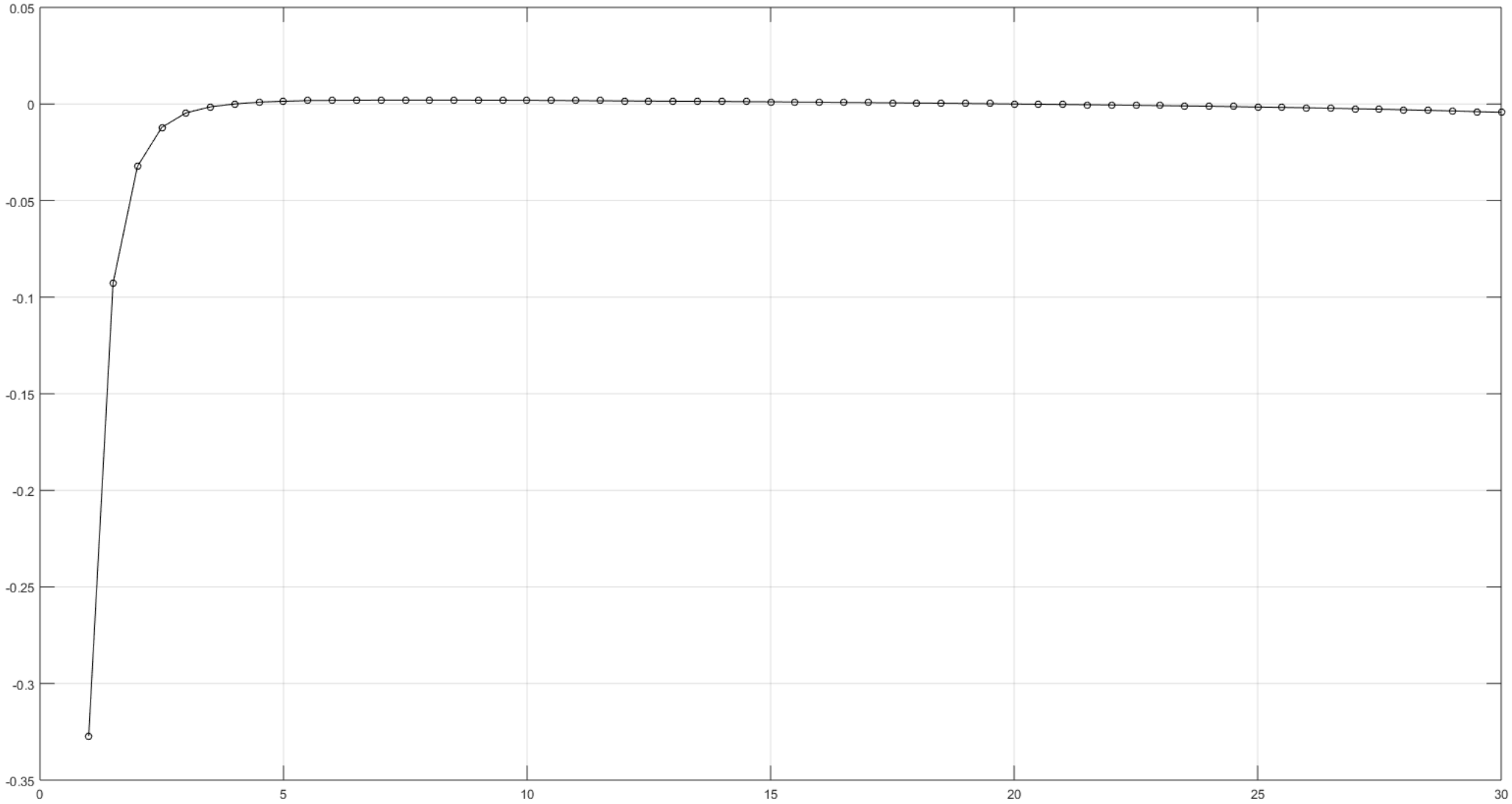
radius = 2 mm

3° case

2°case: plate_1.5_depth_1.5 radius=1mm

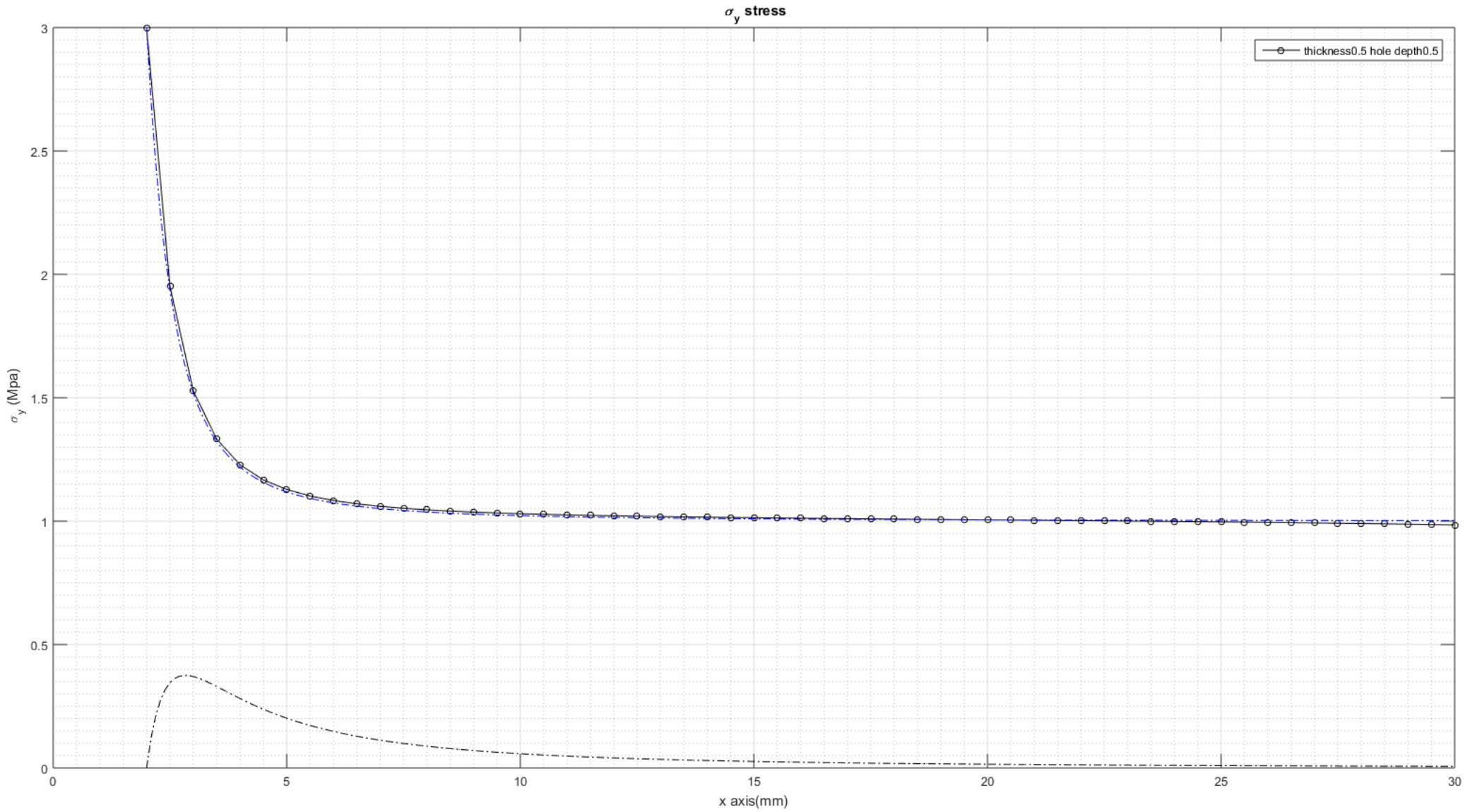


2°case: plate_1.5_depth_1.5 radius=1mm

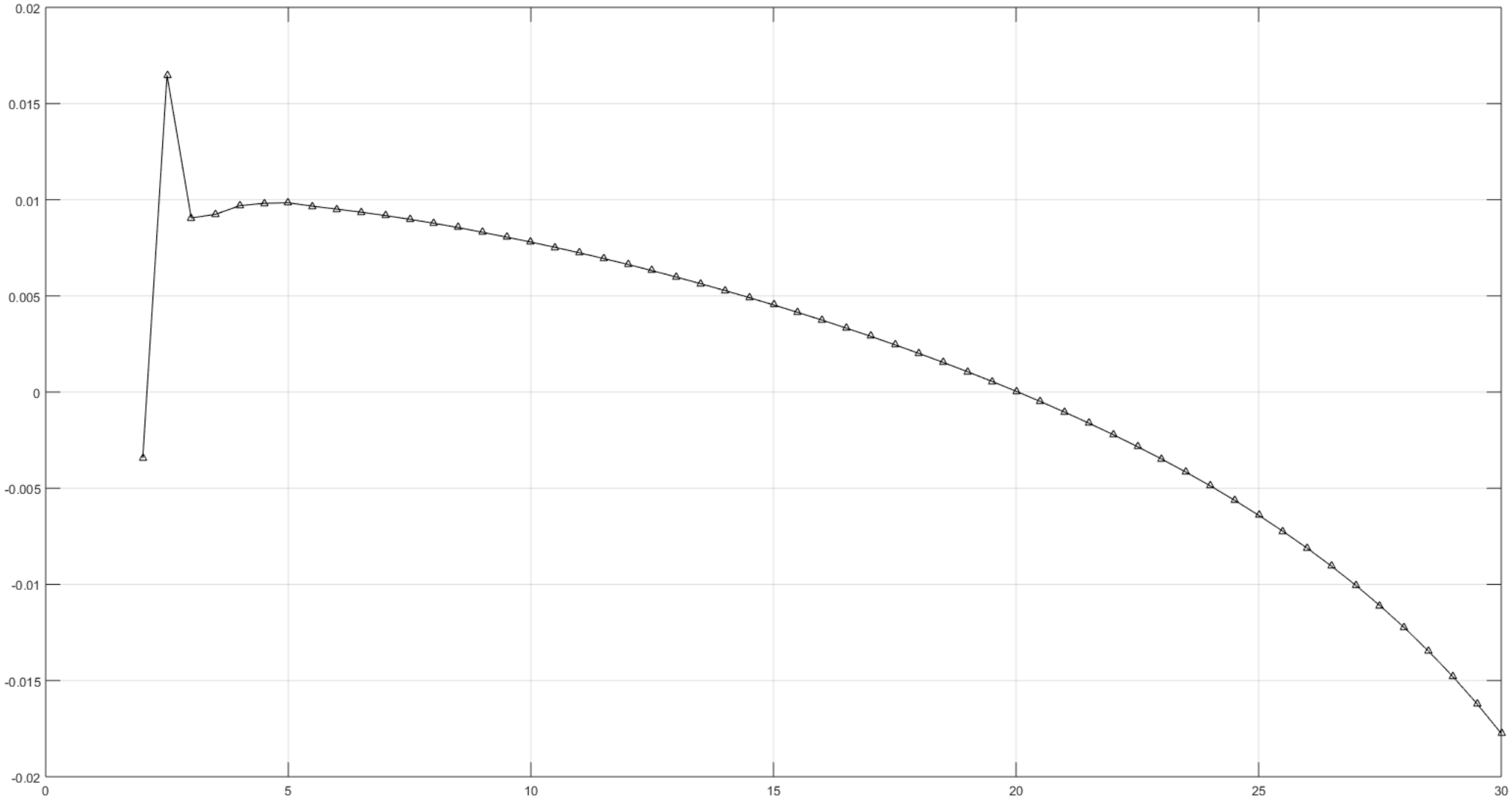


center_hole_uniaxial_through_hole_and_kirsch_equations_sigma_theta_diff_K_sim

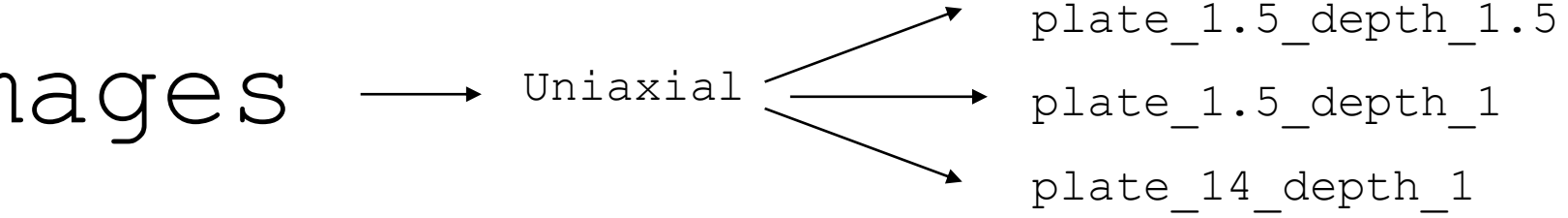
3°case: plate_0.5_depth_0.5 radius=2mm



3°case: plate_0.5_depth_0.5 radius=2mm

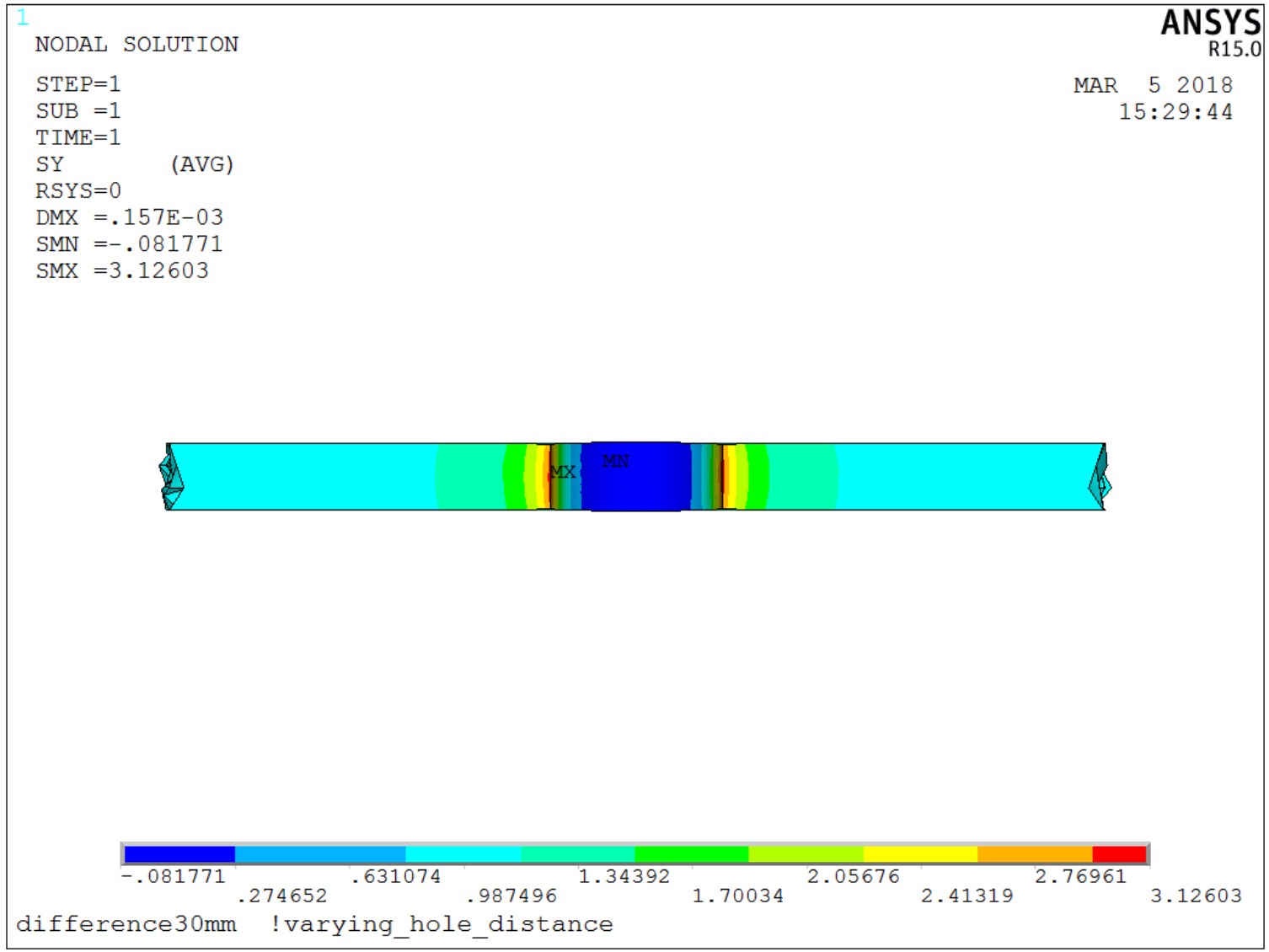


elements_images

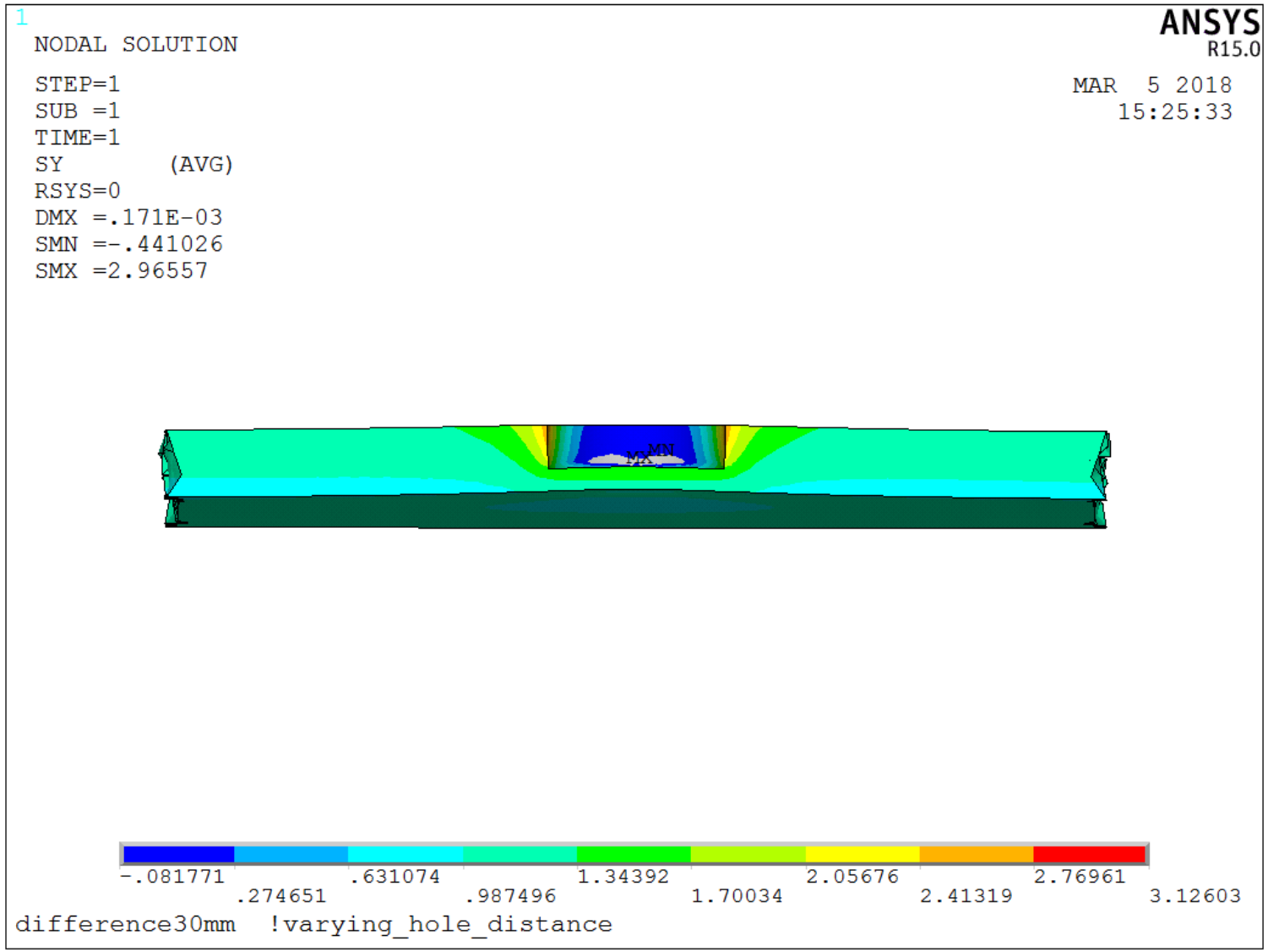



```
! the following code takes images from elements inside the geometry (3
geometries)

! Geometries and simulations:
! -> varying_hole_distance_plate_1.5_depth_1.5_refined_mesh_region_ring
! -> varying_hole_distance_plate_1.5_depth_1_refined_mesh_region_ring
! -> varying_hole_distance_plate_14_depth_1_refined_mesh_region_ring

allsel
diff = 30

x1 = 0
x2 = 60
y1 = 0
y2 = 60
z1 = 0
z2 = 1.5

xcenter1 = (x2 - diff)/2

allsel
vplot
/VIEW,1,0,-1
/rep
nsel,s,loc,x,xcenter1-10,xcenter1+10
nplot
esln
/post1
plnsol,s,y
!plesol,sy

/contour,1,,-0.081771,,3.12603
/rep
```

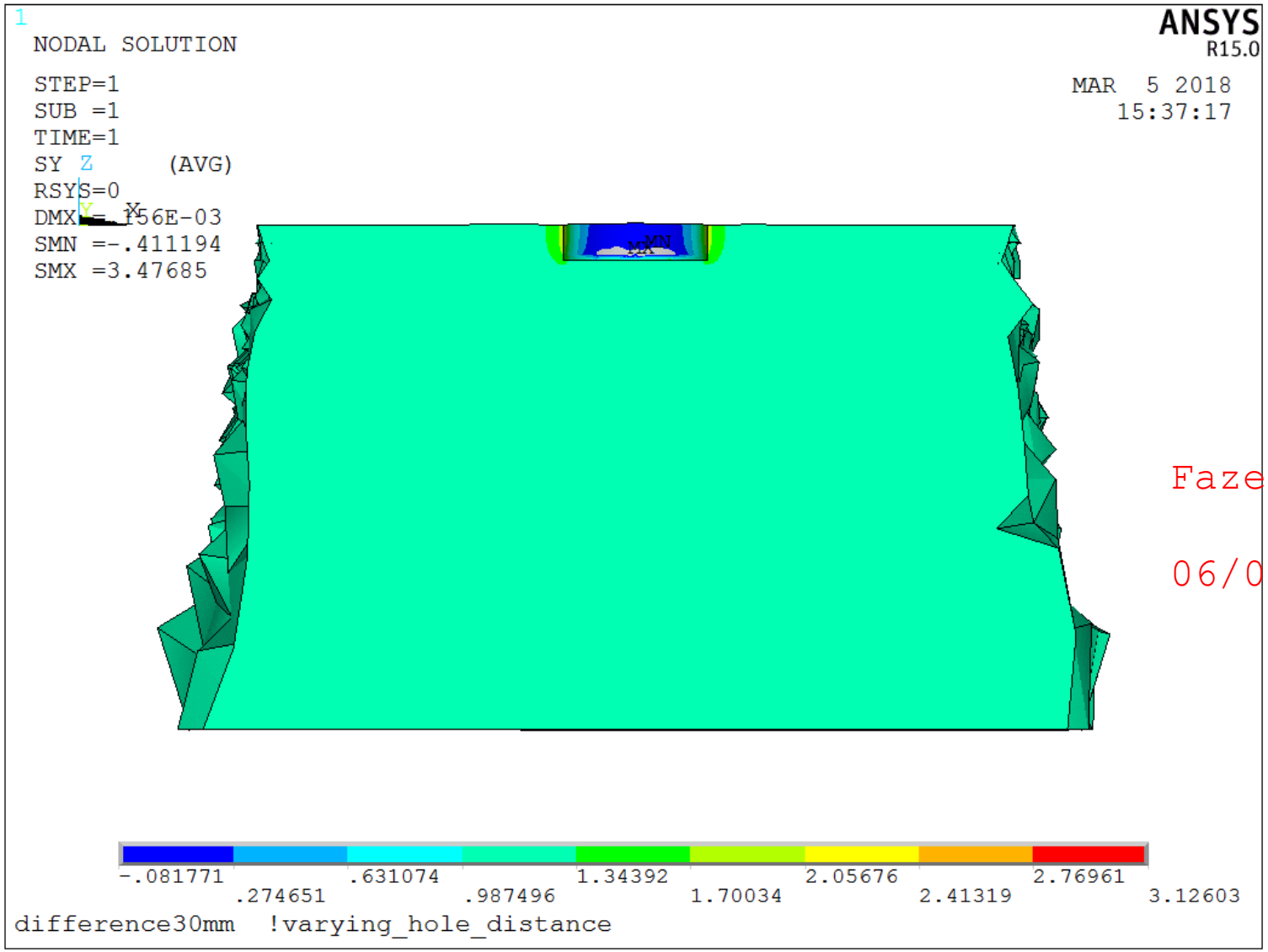
elements_images → Uniaxial → plate_1.5_depth_1.5



elements_images → Uniaxial → plate_1.5_depth_1



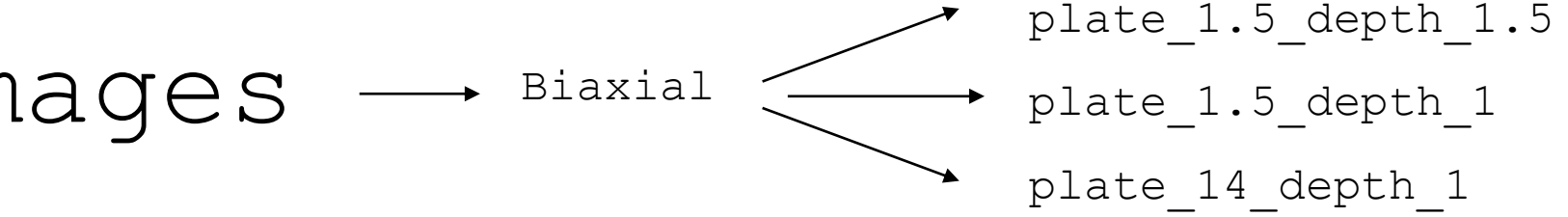
elements_images → Uniaxial → plate_14_depth_1



Fazer para Biaxial

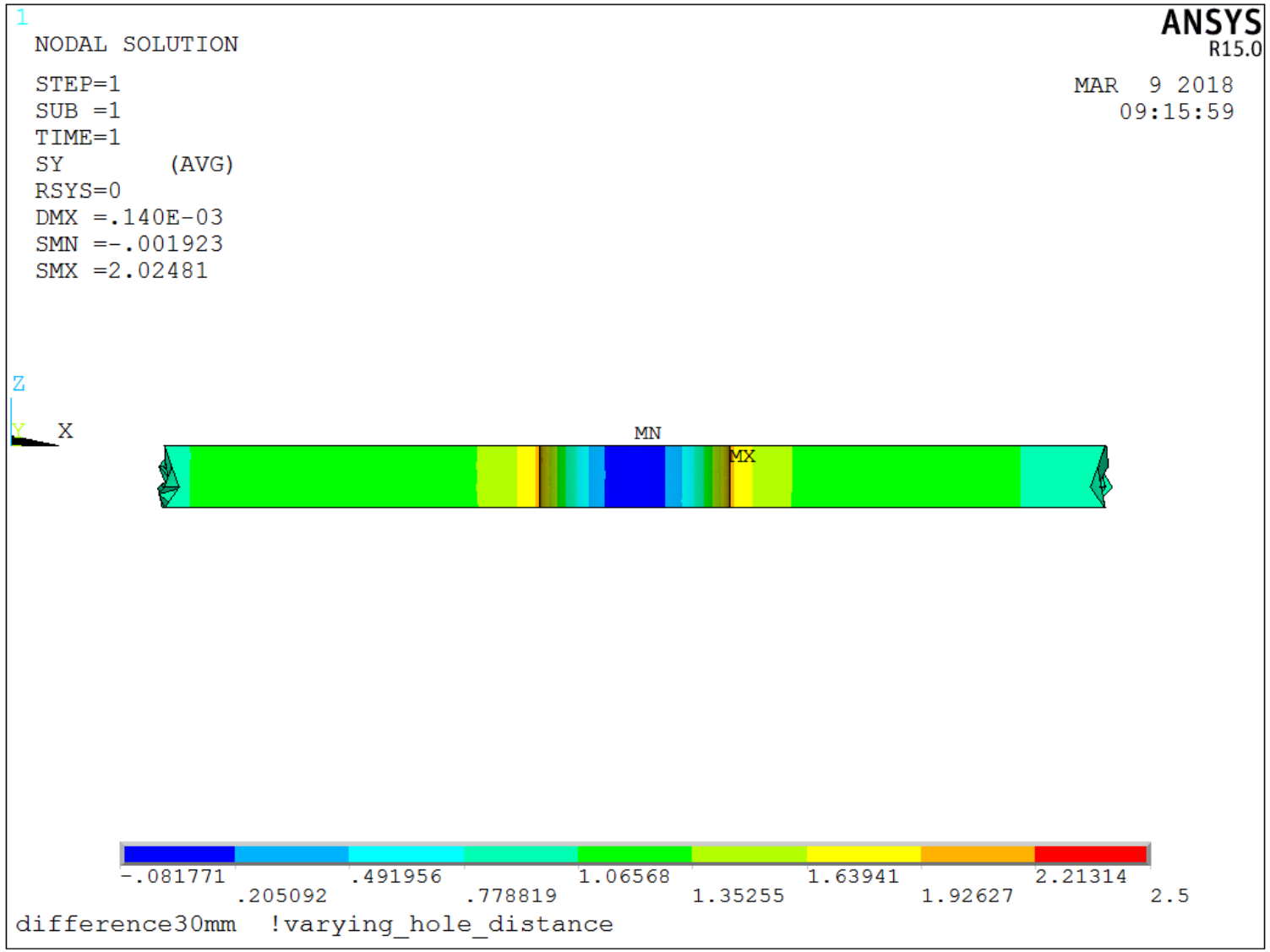
06/03/2018

elements_images

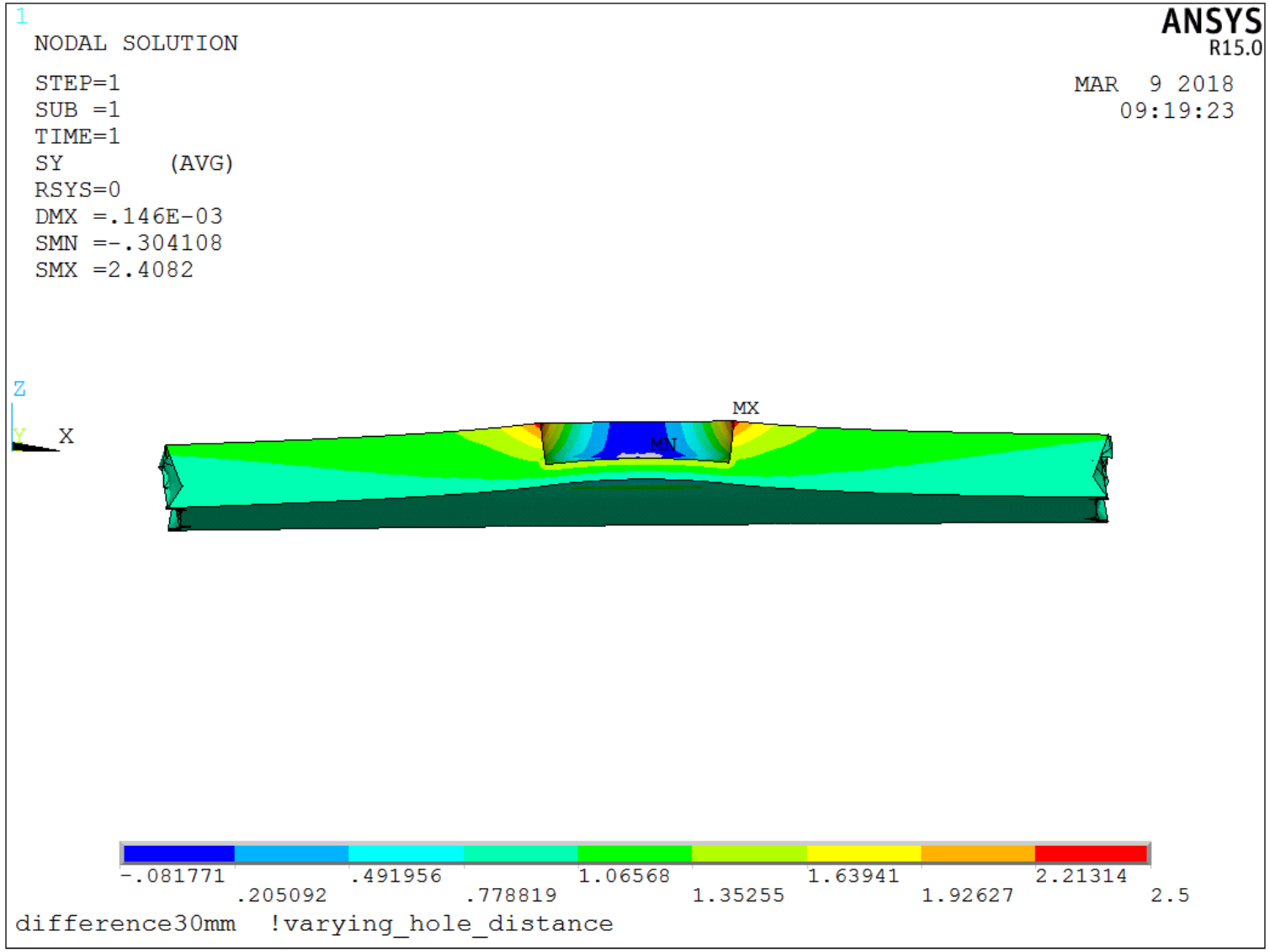



```
! the following code takes images from elements inside the geometry (3
geometries)

! Geometries and simulations:
! -> varying_hole_distance_plate_1.5_depth_1.5_refined_mesh_region_ring
! -> varying_hole_distance_plate_1.5_depth_1_refined_mesh_region_ring
! -> varying_hole_distance_plate_14_depth_1_refined_mesh_region_ring

allsel
diff = 30

x1 = 0
x2 = 60
y1 = 0
y2 = 60
z1 = 0
z2 = 1.5

xcenter1 = (x2 - diff)/2

allsel
vplot
/VIEW,1,0,-1
/rep
nsel,s,loc,x,xcenter1-10,xcenter1+10
nplot
esln
/post1
plnsol,s,y
!plesol,sy

/contour,1,,-0.081771,,3.12603
/rep
```

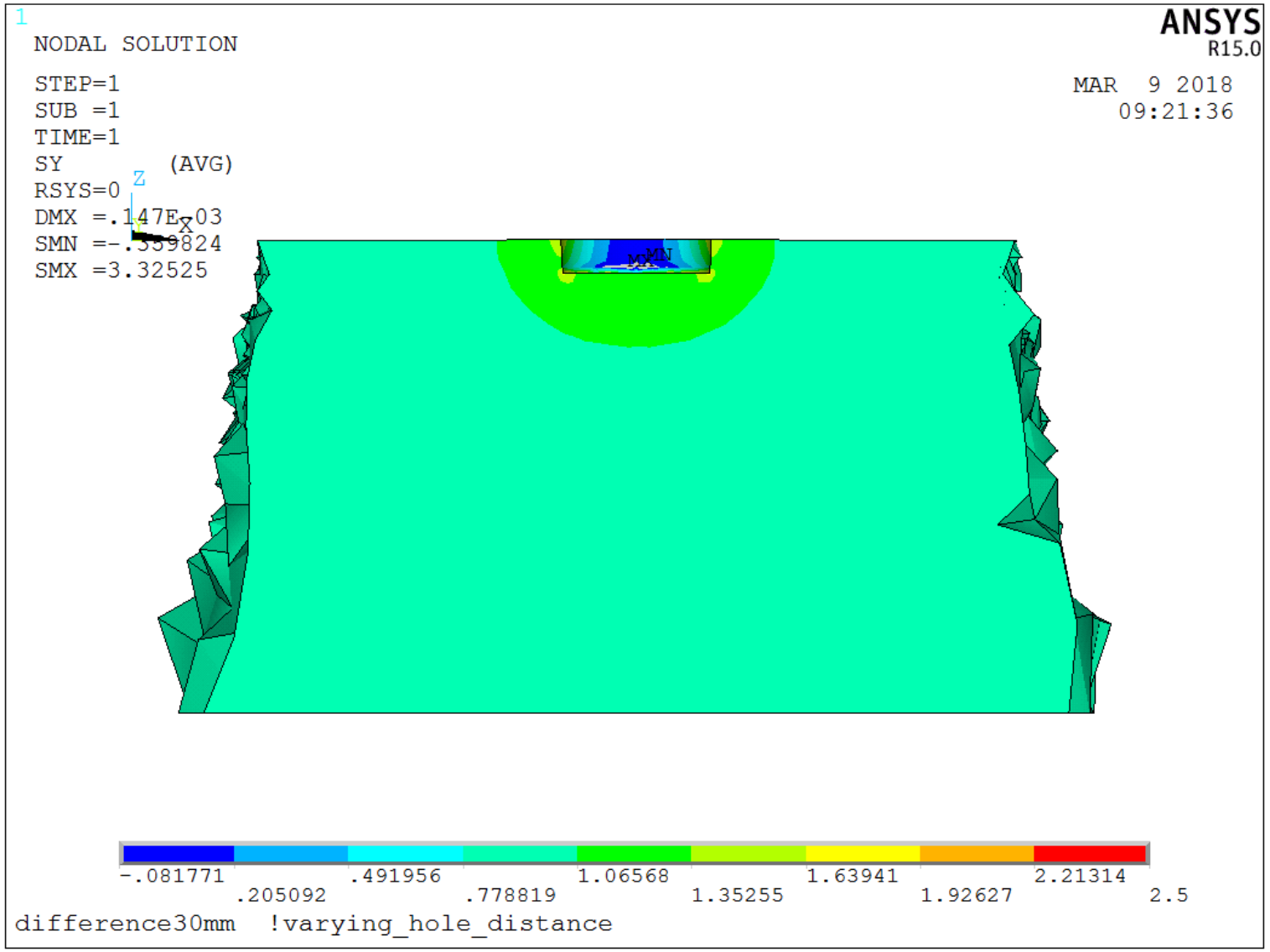
elements_images → Biaxial → plate_1.5_depth_1.5



elements_images → Biaxial → plate_1.5_depth_1



elements_images → Biaxial → plate_14_depth_1



Sigma_min

	Uniaxial		
	T_p/H_d=1	T_p/H_d=1.5	T_p/H_d=14
Point A (x1)	2.942446768300000	2.722951114200000	1.925316333800000
Point B (x2)	2.935607373700000	2.721057593800000	1.925137460200000
	Biaxial		
	T_p/H_d=1	T_p/H_d=1.5	T_p/H_d=14
Point A (x1)	2.015860319100000	2.404486894600000	1.596784085000000
Point B (x2)	2.013187766100000	2.404265463400000	1.596903532700000

Na Geometria T_p/H_d=14,
Intervalo do Sigma_min {20,40}

Sigma min calculated via u_b_s_p_center_hole_withou_kirsch.m at

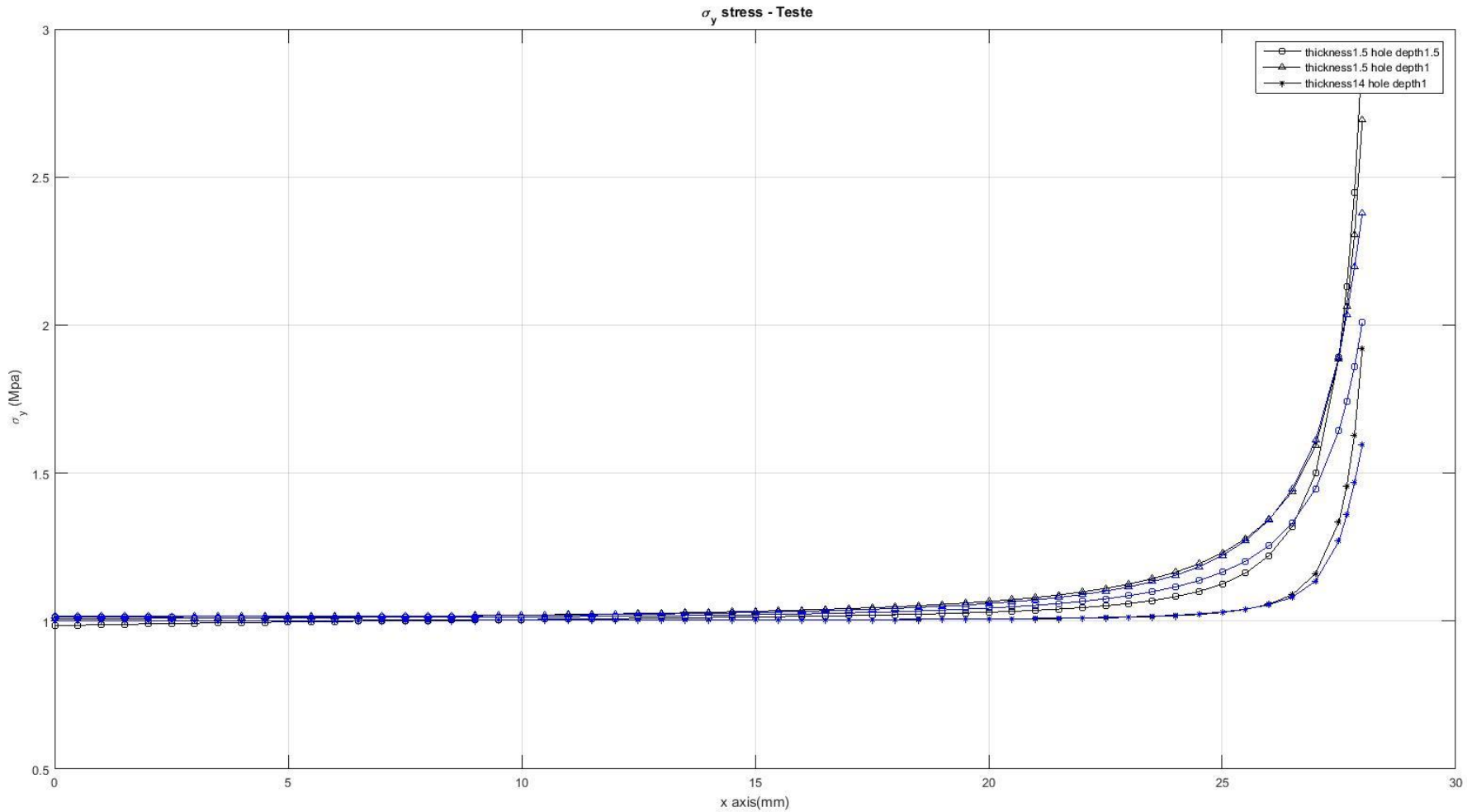
C:\Manasses\center_hole\u_b_s_p_center_hole_withou_kirsch.m

sig_min(cont_min)=matriz(end,9);

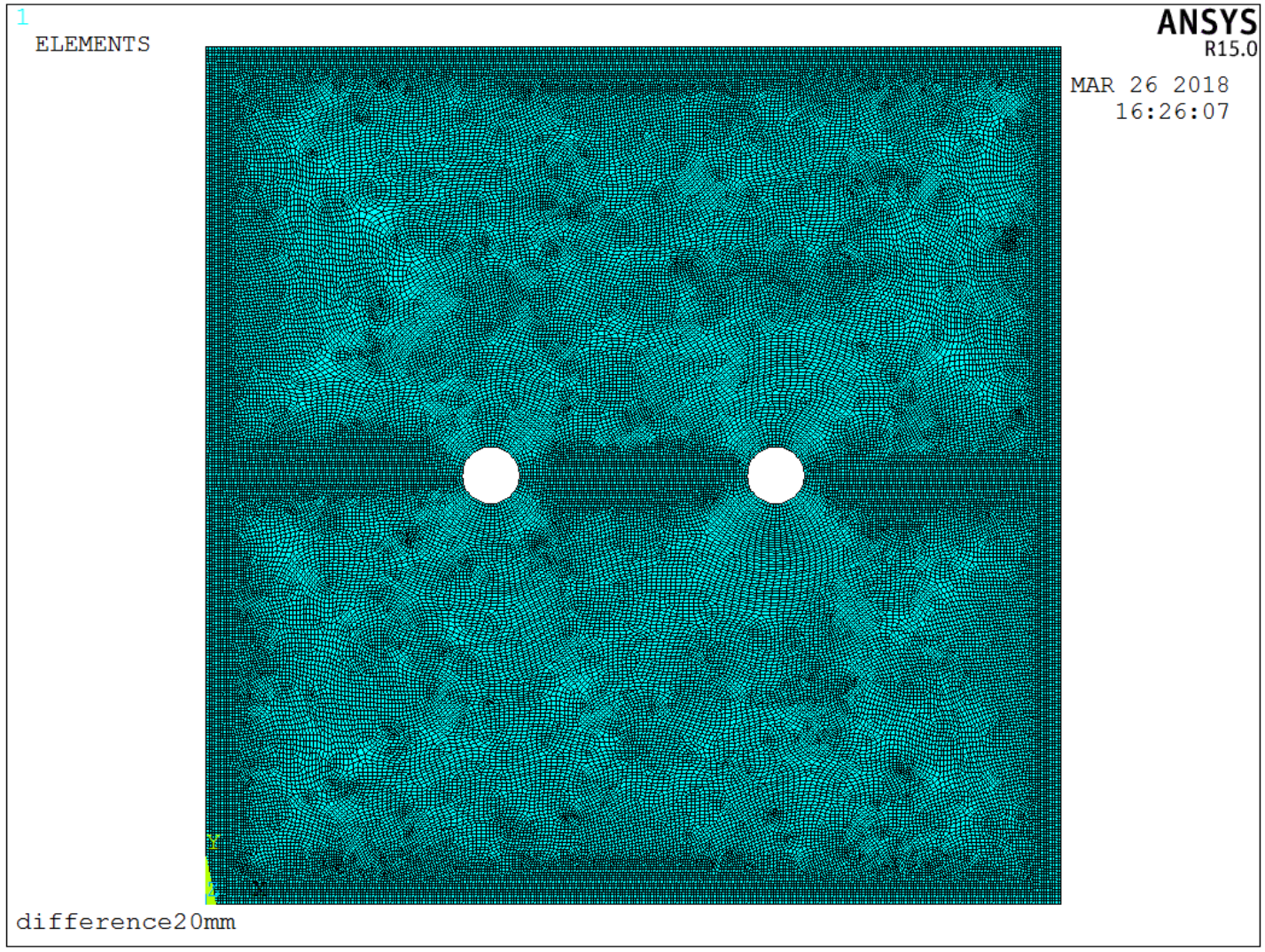
	Uniaxial		
	T_p/H_d=1	T_p/H_d=1.5	T_p/H_d=14
Point A (x1)	2.933690130700000	2.692401707200000	1.920085877200000
Point B (x2)	=	=	=
	Biaxial		
	T_p/H_d=1	T_p/H_d=1.5	T_p/H_d=14
Point A (x1)	2.008045554200000	2.378486096900000	1.594718247700000
Point B (x2)	=	=	=

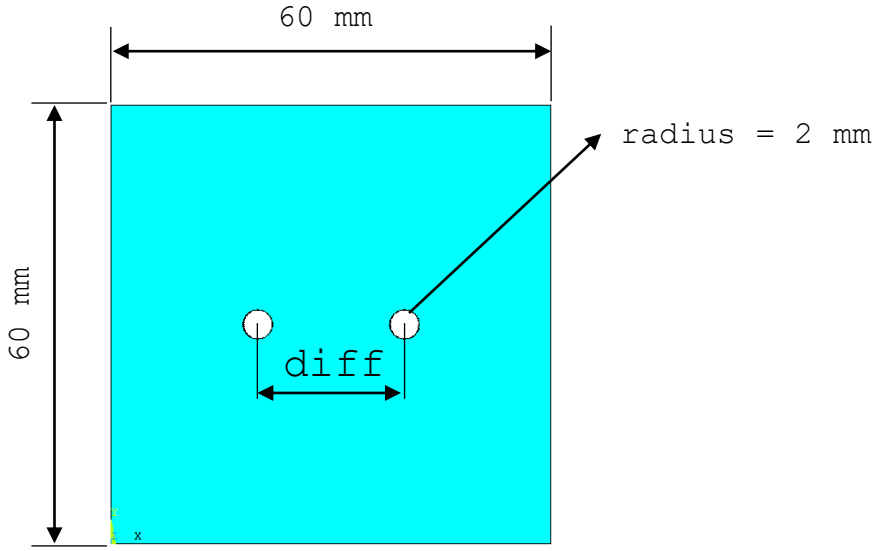
Sigma min calculated via u_b_s_p_center_hole_withou_kirsch.m at

C:\Manasses\center_hole\u_b_s_p_center_hole_withou_kirsch.m



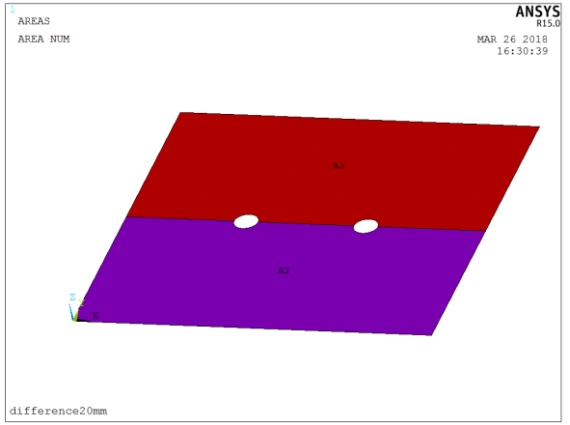
varying_hole_distance_2D diff=20 mm



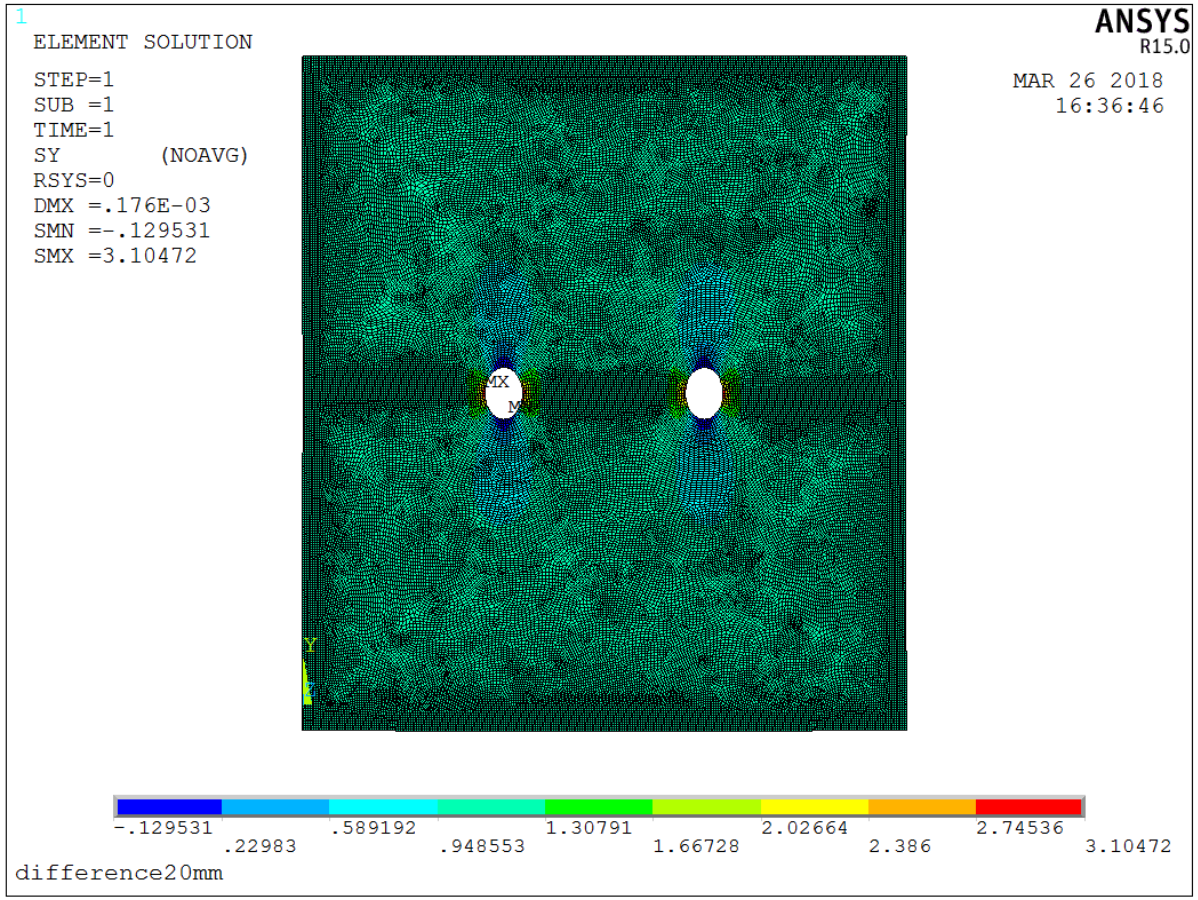


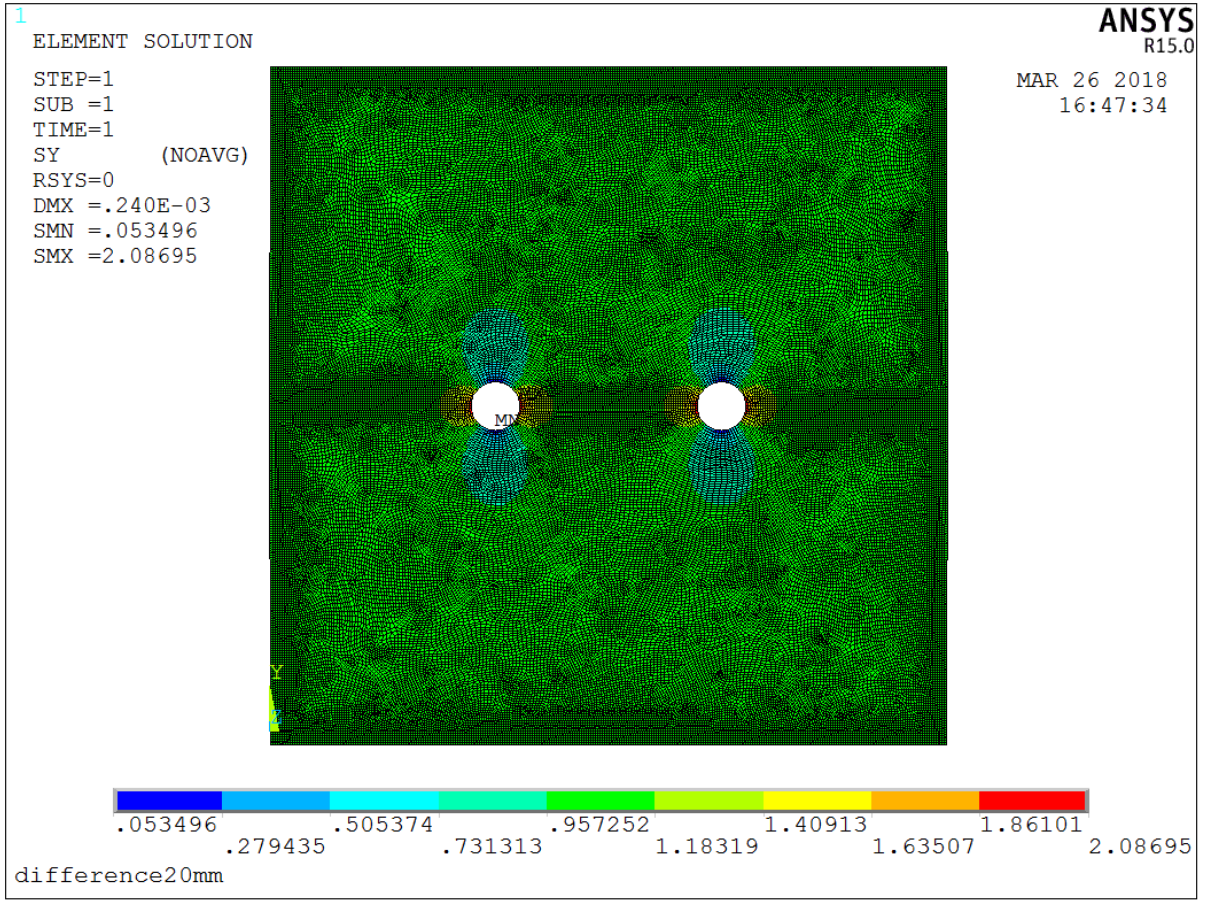
plate_thickness = depth = 0.0 mm

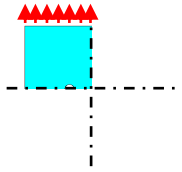
"through hole"



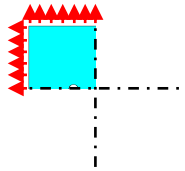
varying_hole_distance_2D diff=20 mm





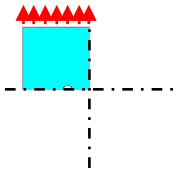


(a) Uniaxial Transverse load



(b) Biaxial load

varying_hole_distance_2D diff=20 mm



Uniaxial Transverse Load

$$Sigma_{\max(60X60)}^{diff=(5*D)=20} = 3.088956714$$

$$Sigma_{max(150X150)}^{diff=\left(\frac{70}{4}*D\right)=70} = 3.024106741$$

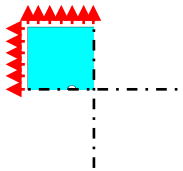
$$Sigma_{\max(150X150)}^{diff=(5*D)=20} = 3.037305094$$

$$Erro = \frac{\left|Sigma_{max(60X60)}^{diff=(5*D)=20} - Sigma_{max(150X150)}^{diff=\left(\frac{70}{4}*D\right)=70}\right|}{Sigma_{max(150X150)}^{diff=\left(\frac{70}{4}*D\right)=70}}$$

$$Erro = \frac{|3.088956714 - 3.024106741|}{3.024106741} = 0.02144433995 = \mathbf{2.14}\ \%$$

$$Erro = \frac{\left|Sigma_{max(150X150)}^{diff=(5*D)=20} - Sigma_{max(150X150)}^{diff=\left(\frac{70}{4}*D\right)=70}\right|}{Sigma_{max(150X150)}^{diff=\left(\frac{70}{4}*D\right)=70}}$$

$$Erro = \frac{|3.037305094 - 3.024106741|}{3.024106741} = 0.004364380668532757984417984537 01 = \mathbf{0.4364}\ \%$$



Biaxial Load

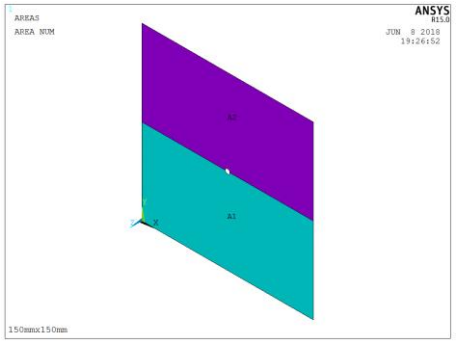
$$Sigma_{max(150X150)}^{diff=(5*D)=20} = 2.085622532$$

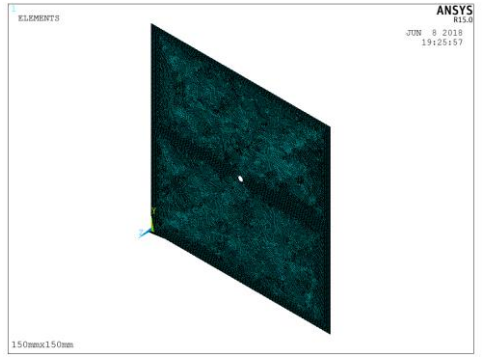
$$Sigma_{max(150X150)}^{diff=\left(\frac{70}{4}*D\right)=70} = 2.030161023$$

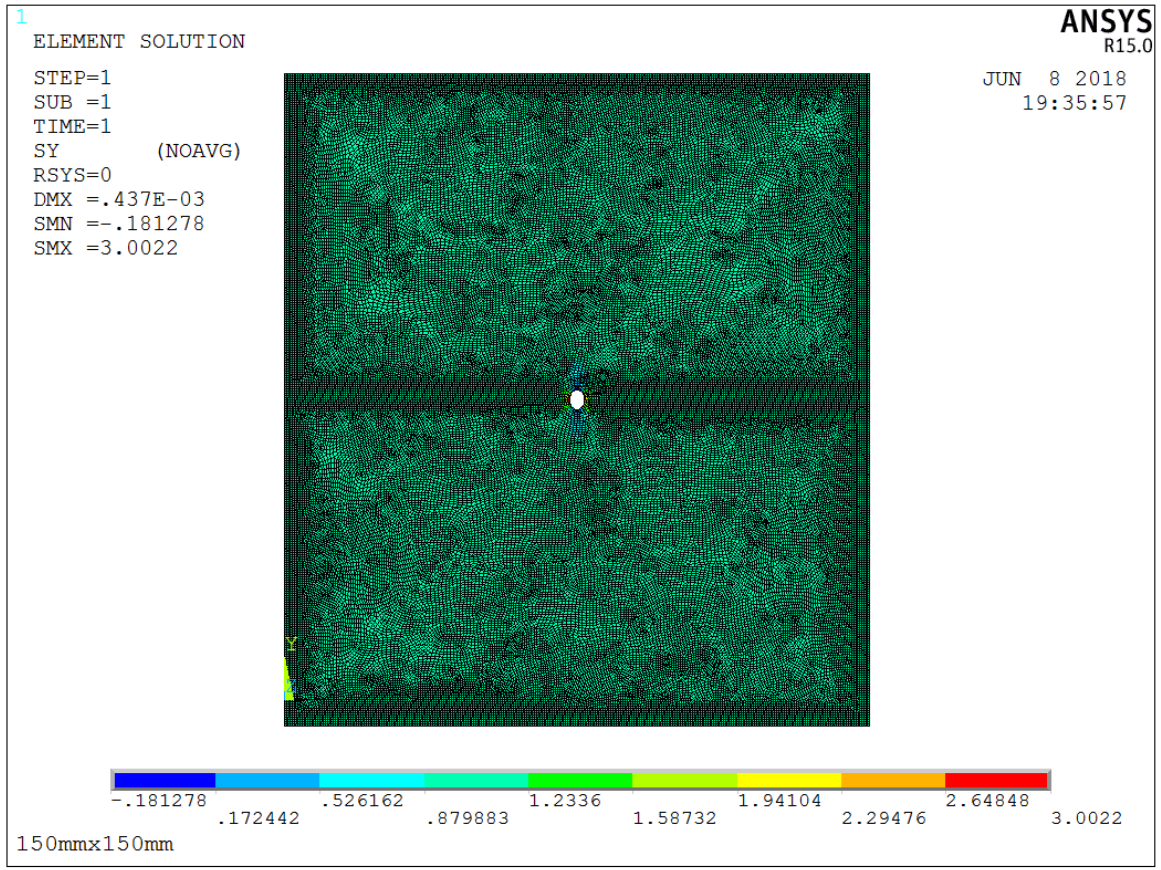
$$Erro = \frac{\left|Sigma_{max(150X150)}^{diff=(5*D)=20} - Sigma_{max(150X150)}^{diff=\left(\frac{70}{4}*D\right)=70}\right|}{Sigma_{max(150X150)}^{diff=\left(\frac{70}{4}*D\right)=70}}$$

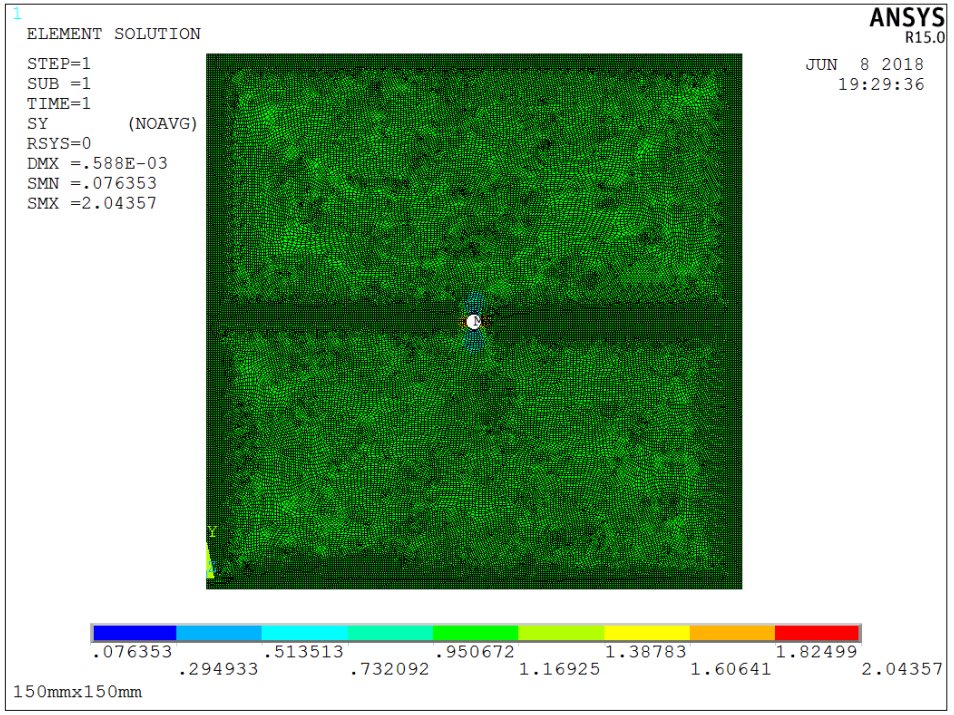
$$Erro = \frac{|2.085622532 - 2.030161023|}{2.030161023} = 0,027318773423225158628217836689 3 = \mathbf{2.7318}\ \%$$

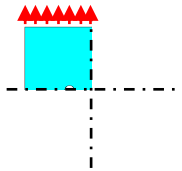
center_hole_2d



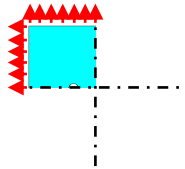








(a) Uniaxial Transverse load



(b) Biaxial load