>> IN THE NAME OF GOD <<

Moment-Curvature Analysis of Double I steel sections with Plates on Flanges, with Five Different Axial Load effect In MATLAB

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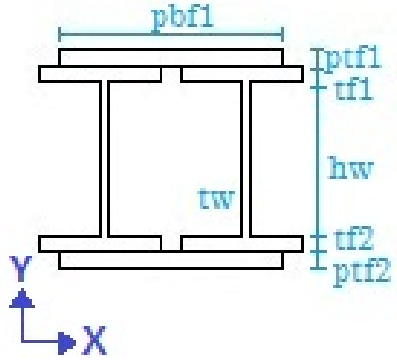


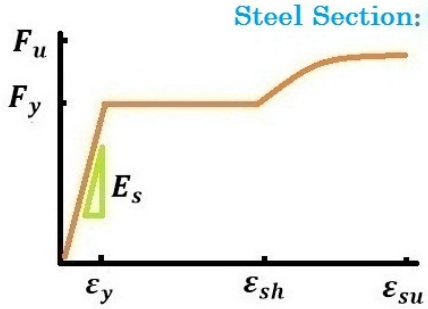
Double steel I sections with plates on flanges
(Moment - Curvature analysis along X axis)

Section Properties:

```
Ptarget =[0;+100000;+250000;+500000;+600000];
% [N] Target axial load [+ : Compression]
%% Section Properties
tf1=9.2;% [mm] I section thickness on Top flange
bf1=110;% [mm] I section width on Top flange
tw=5.9;% [mm] I section thickness of Web
hw=201.6;% [mm] Height of web
tf2=9.2;% [mm] I section thickness on Bottom flange
bf2=110;% [mm] I section width on Bottom flange
ptf1=10;% [mm] Plate section thickness on Top flange
pbf1=150;% [mm] Plate section width on Top flange
ptf2=10;% [mm] Plate section thickness on Bottom flange
pbf2=150;% [mm] Plate section width on Bottom flange
```

Stress-Strain of materials

Steel Section: Stress-Strain Relationship (Curve strain hardening)



$$\begin{cases} \varepsilon_s \le \varepsilon_y & f_s = E_s\varepsilon_s \\ \varepsilon_y < \varepsilon_s \le \varepsilon_{sh} & f_s = F_y \\ \varepsilon_{sh} < \varepsilon_s \le \varepsilon_{su} & f_s = F_u + (F_u - F_y)\left(\frac{\varepsilon_{su}-\varepsilon_s}{\varepsilon_{su}-\varepsilon_{sh}}\right)^2 \end{cases}$$

Steel Properties:

```
fy =240;% [N/mm^2] Yield strength of steel section
Es =2e5;% [N/mm^2] Modulus of elasticity of steel section
fu=1.5*fy;% Ultimate steel stress
ey=fy/Es;% Yield steel strain
esh=0.025;% Strain at steel strain-hardening
```

```
esu=0.35;% Ultimate steel strain
Esh=(fu-fy)/(esu-esh);
```

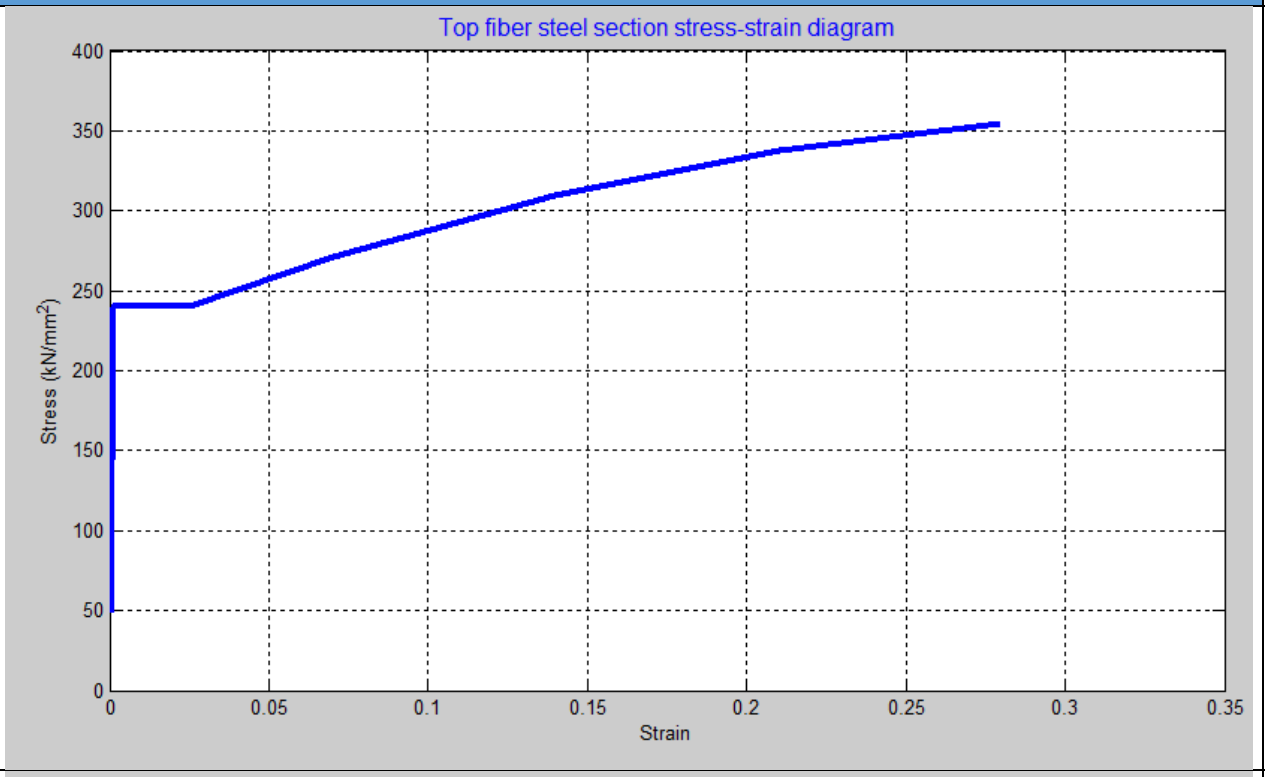
Analysis Report:

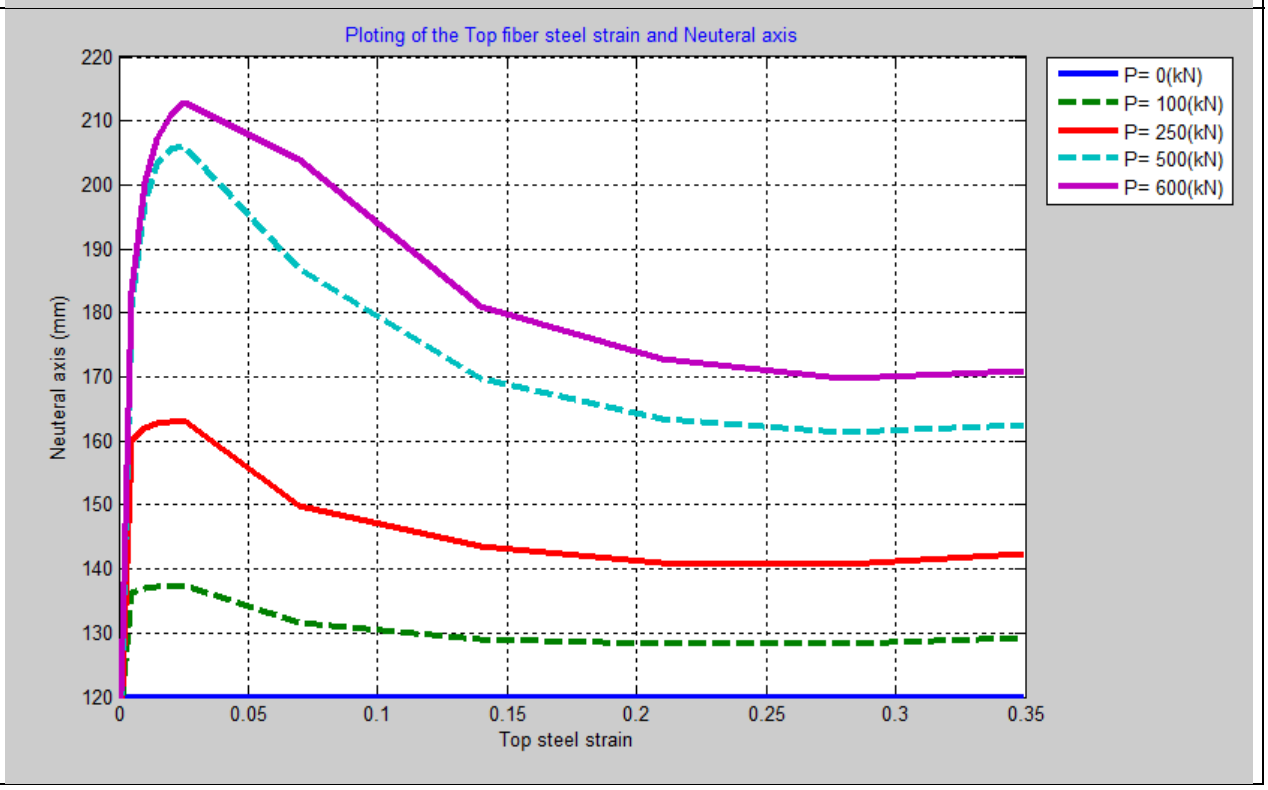
```
Yield strength axial force capacity of the section: 1586.611 (kN) - Ultimate strength axial force capacity of the section: 2379.917 (kN)

                                                    ############################
                                                    # AXIAL LOAD = 0.00  (kN)    #
                                                    ############################
(+)Increment 1 : It is converged in 7 iterations - strain: 0.00024 - x: 120.00 - Phi: 0.00200 - Moment: 37.10
(+)Increment 2 : It is converged in 1 iterations - strain: 0.00048 - x: 120.00 - Phi: 0.00400 - Moment: 74.20
(+)Increment 3 : It is converged in 1 iterations - strain: 0.00072 - x: 120.00 - Phi: 0.00600 - Moment: 111.31
(+)Increment 4 : It is converged in 1 iterations - strain: 0.00096 - x: 120.00 - Phi: 0.00800 - Moment: 148.41
(+)Increment 5 : It is converged in 1 iterations - strain: 0.00120 - x: 120.00 - Phi: 0.01000 - Moment: 185.51
(+)Increment 6 : It is converged in 1 iterations - strain: 0.00500 - x: 120.00 - Phi: 0.04167 - Moment: 213.19
(+)Increment 7 : It is converged in 1 iterations - strain: 0.01000 - x: 120.00 - Phi: 0.08333 - Moment: 213.78
(+)Increment 8 : It is converged in 1 iterations - strain: 0.01500 - x: 120.00 - Phi: 0.12500 - Moment: 213.89
(+)Increment 9 : It is converged in 1 iterations - strain: 0.02000 - x: 120.00 - Phi: 0.16667 - Moment: 213.92
(+)Increment 10 : It is converged in 1 iterations - strain: 0.02500 - x: 120.00 - Phi: 0.20833 - Moment: 213.94
(+)Increment 11 : It is converged in 1 iterations - strain: 0.07000 - x: 120.00 - Phi: 0.58333 - Moment: 236.20
(+)Increment 12 : It is converged in 1 iterations - strain: 0.14000 - x: 120.00 - Phi: 1.16667 - Moment: 267.62
(+)Increment 13 : It is converged in 1 iterations - strain: 0.21000 - x: 120.00 - Phi: 1.75000 - Moment: 291.44
(+)Increment 14 : It is converged in 1 iterations - strain: 0.28000 - x: 120.00 - Phi: 2.33333 - Moment: 307.59
(+)Increment 15 : It is converged in 1 iterations - strain: 0.35000 - x: 120.00 - Phi: 2.91667 - Moment: 316.07

    ## Strain Reached to Ultimate Strain: 0.3500 ##

+======================+
= Steel Section curve fitted  =
   Curvature    Moment
    (1/m)     (kN.m)
----------------------------------------
      0       0
   0.0124  229.6579
   2.9167  316.0717
+=======================+
+-------------------------------------------------------------------------+
 Elastic EI : 18551.08 (kN.m^2)
 Plastic EI : 29.75 (kN.m^2)
Steel Section Ductility Rito : 235.60
 Steel Section Over Strength Factor  :  1.38
+-------------------------------------------------------------------------+
                                                    ############################
                                                    # AXIAL LOAD = 100.00  (kN)  #
                                                    ############################
(+)It is converged in 2 iterations - Initial axial strain: 0.000053 - Initial axial stress: 10.608 (N/mm^2)

(+)Increment 1 : It is converged in 7 iterations - strain: 0.00024 - x: 120.00 - Phi: 0.00200 - Moment: 37.10
(+)Increment 2 : It is converged in 1 iterations - strain: 0.00048 - x: 120.00 - Phi: 0.00400 - Moment: 74.20
(+)Increment 3 : It is converged in 1 iterations - strain: 0.00072 - x: 120.00 - Phi: 0.00600 - Moment: 111.31
(+)Increment 4 : It is converged in 1 iterations - strain: 0.00096 - x: 120.00 - Phi: 0.00800 - Moment: 148.41
(+)Increment 5 : It is converged in 4 iterations - strain: 0.00120 - x: 120.22 - Phi: 0.00998 - Moment: 184.71
(+)Increment 6 : It is converged in 5 iterations - strain: 0.00500 - x: 136.21 - Phi: 0.03671 - Moment: 215.32
(+)Increment 7 : It is converged in 4 iterations - strain: 0.01000 - x: 136.93 - Phi: 0.07303 - Moment: 216.22
(+)Increment 8 : It is converged in 4 iterations - strain: 0.01500 - x: 137.17 - Phi: 0.10935 - Moment: 216.41
(+)Increment 9 : It is converged in 4 iterations - strain: 0.02000 - x: 137.29 - Phi: 0.14568 - Moment: 216.48
(+)Increment 10 : It is converged in 4 iterations - strain: 0.02500 - x: 137.36 - Phi: 0.18200 - Moment: 216.52
(+)Increment 11 : It is converged in 14 iterations - strain: 0.07000 - x: 131.49 - Phi: 0.53236 - Moment: 235.02
(+)Increment 12 : It is converged in 23 iterations - strain: 0.14000 - x: 129.08 - Phi: 1.08461 - Moment: 265.15
(+)Increment 13 : It is converged in 32 iterations - strain: 0.21000 - x: 128.26 - Phi: 1.63731 - Moment: 288.72
(+)Increment 14 : It is converged in 41 iterations - strain: 0.28000 - x: 128.36 - Phi: 2.18129 - Moment: 305.27
(+)Increment 15 : It is converged in 75 iterations - strain: 0.35000 - x: 129.36 - Phi: 2.70568 - Moment: 314.88

    ## Strain Reached to Ultimate Strain: 0.3500 ##
+======================+
```

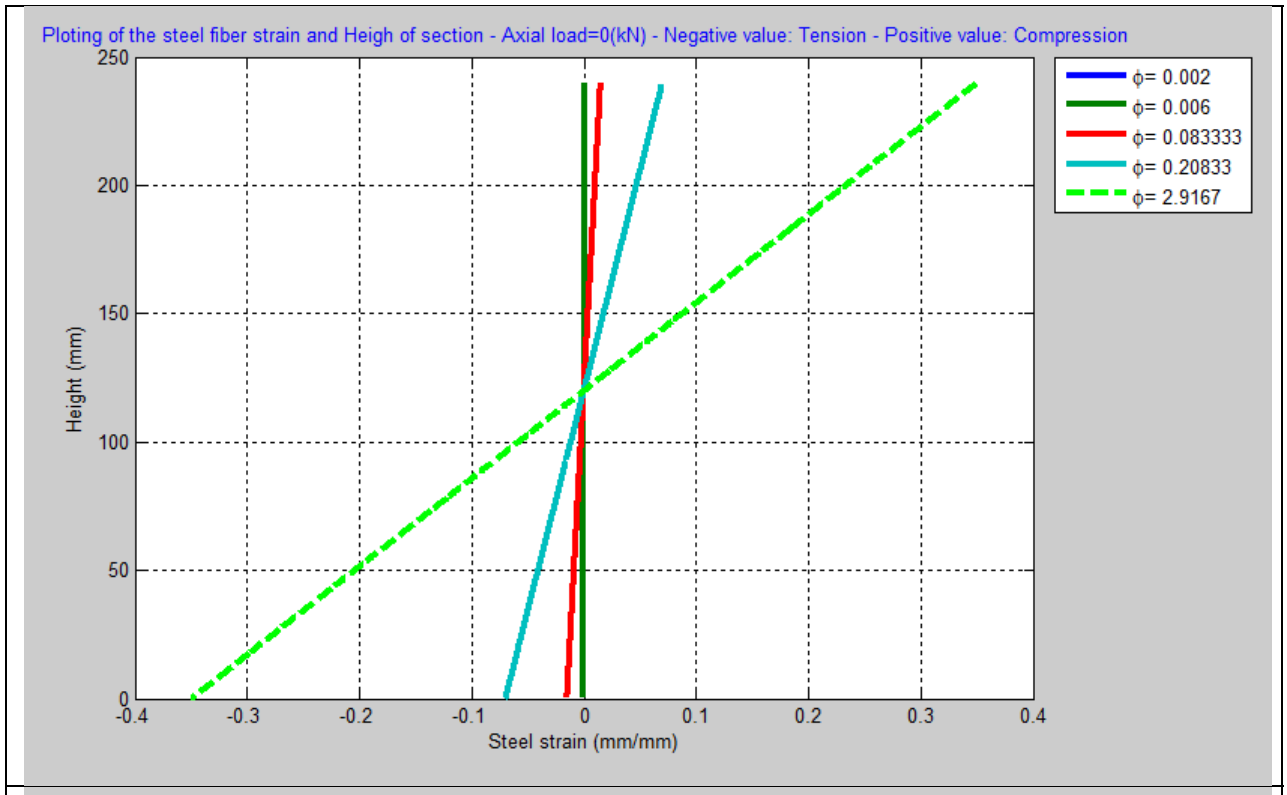
```
= Steel Section curve fitted  =
    Curvature    Moment
      (1/m)     (kN.m)
--------------------------------
       0       0
   0.0123  227.7248
   2.7057  314.8806
+====================+
+-----------------------------------------------------------------------+
 Elastic EI : 18551.08 (kN.m^2)
 Plastic EI : 32.36 (kN.m^2)
Steel Section Ductility Rito : 220.41
 Steel Section Over Strength Factor :  1.38
+-----------------------------------------------------------------------+
                                                          ############################
                                                          # AXIAL LOAD = 250.00  (kN)  #
                                                          ############################
(+)It is converged in 2 iterations - Initial axial strain: 0.000133 - Initial axial stress: 26.520 (N/mm^2)

(+)Increment 1 : It is converged in 7 iterations - strain: 0.00024 - x: 120.00 - Phi: 0.00200 - Moment: 37.10
(+)Increment 2 : It is converged in 1 iterations - strain: 0.00048 - x: 120.00 - Phi: 0.00400 - Moment: 74.20
(+)Increment 3 : It is converged in 1 iterations - strain: 0.00072 - x: 120.00 - Phi: 0.00600 - Moment: 111.31
(+)Increment 4 : It is converged in 1 iterations - strain: 0.00096 - x: 120.00 - Phi: 0.00800 - Moment: 148.41
(+)Increment 5 : It is converged in 4 iterations - strain: 0.00120 - x: 121.48 - Phi: 0.00988 - Moment: 180.82
(+)Increment 6 : It is converged in 5 iterations - strain: 0.00500 - x: 159.90 - Phi: 0.03127 - Moment: 227.01
(+)Increment 7 : It is converged in 4 iterations - strain: 0.01000 - x: 161.99 - Phi: 0.06173 - Moment: 229.09
(+)Increment 8 : It is converged in 4 iterations - strain: 0.01500 - x: 162.70 - Phi: 0.09219 - Moment: 229.65
(+)Increment 9 : It is converged in 4 iterations - strain: 0.02000 - x: 163.06 - Phi: 0.12266 - Moment: 229.89
(+)Increment 10 : It is converged in 4 iterations - strain: 0.02500 - x: 163.27 - Phi: 0.15312 - Moment: 230.03
(+)Increment 11 : It is converged in 11 iterations - strain: 0.07000 - x: 149.95 - Phi: 0.46681 - Moment: 241.46
(+)Increment 12 : It is converged in 19 iterations - strain: 0.14000 - x: 143.46 - Phi: 0.97587 - Moment: 267.91
(+)Increment 13 : It is converged in 26 iterations - strain: 0.21000 - x: 140.96 - Phi: 1.48976 - Moment: 290.09
(+)Increment 14 : It is converged in 36 iterations - strain: 0.28000 - x: 140.61 - Phi: 1.99134 - Moment: 306.53
(+)Increment 15 : It is converged in 47 iterations - strain: 0.35000 - x: 142.40 - Phi: 2.45784 - Moment: 316.20

    ## Strain Reached to Ultimate Strain: 0.3500 ##

+========================+
= Steel Section curve fitted  =
    Curvature    Moment
      (1/m)     (kN.m)
--------------------------------
       0       0
   0.0127  234.7344
   2.4578  316.2024
+========================+
+-----------------------------------------------------------------------+
 Elastic EI : 18551.08 (kN.m^2)
 Plastic EI : 33.32 (kN.m^2)
Steel Section Ductility Rito : 194.24
 Steel Section Over Strength Factor :  1.35
+-----------------------------------------------------------------------+
                                                          ############################
                                                          # AXIAL LOAD = 500.00  (kN)  #
                                                          ############################
(+)It is converged in 2 iterations - Initial axial strain: 0.000265 - Initial axial stress: 53.040 (N/mm^2)

(+)Increment 1 : It is converged in 7 iterations - strain: 0.00024 - x: 120.00 - Phi: 0.00200 - Moment: 37.10
(+)Increment 2 : It is converged in 2 iterations - strain: 0.00048 - x: 120.00 - Phi: 0.00400 - Moment: 74.20
(+)Increment 3 : It is converged in 1 iterations - strain: 0.00072 - x: 120.00 - Phi: 0.00600 - Moment: 111.31
(+)Increment 4 : It is converged in 4 iterations - strain: 0.00096 - x: 120.08 - Phi: 0.00799 - Moment: 148.25
(+)Increment 5 : It is converged in 5 iterations - strain: 0.00120 - x: 126.57 - Phi: 0.00948 - Moment: 169.39
(+)Increment 6 : It is converged in 6 iterations - strain: 0.00500 - x: 181.11 - Phi: 0.02761 - Moment: 248.68
(+)Increment 7 : It is converged in 7 iterations - strain: 0.01000 - x: 197.39 - Phi: 0.05066 - Moment: 268.21
(+)Increment 8 : It is converged in 6 iterations - strain: 0.01500 - x: 203.25 - Phi: 0.07380 - Moment: 274.79
(+)Increment 9 : It is converged in 4 iterations - strain: 0.02000 - x: 205.55 - Phi: 0.09730 - Moment: 277.31
```

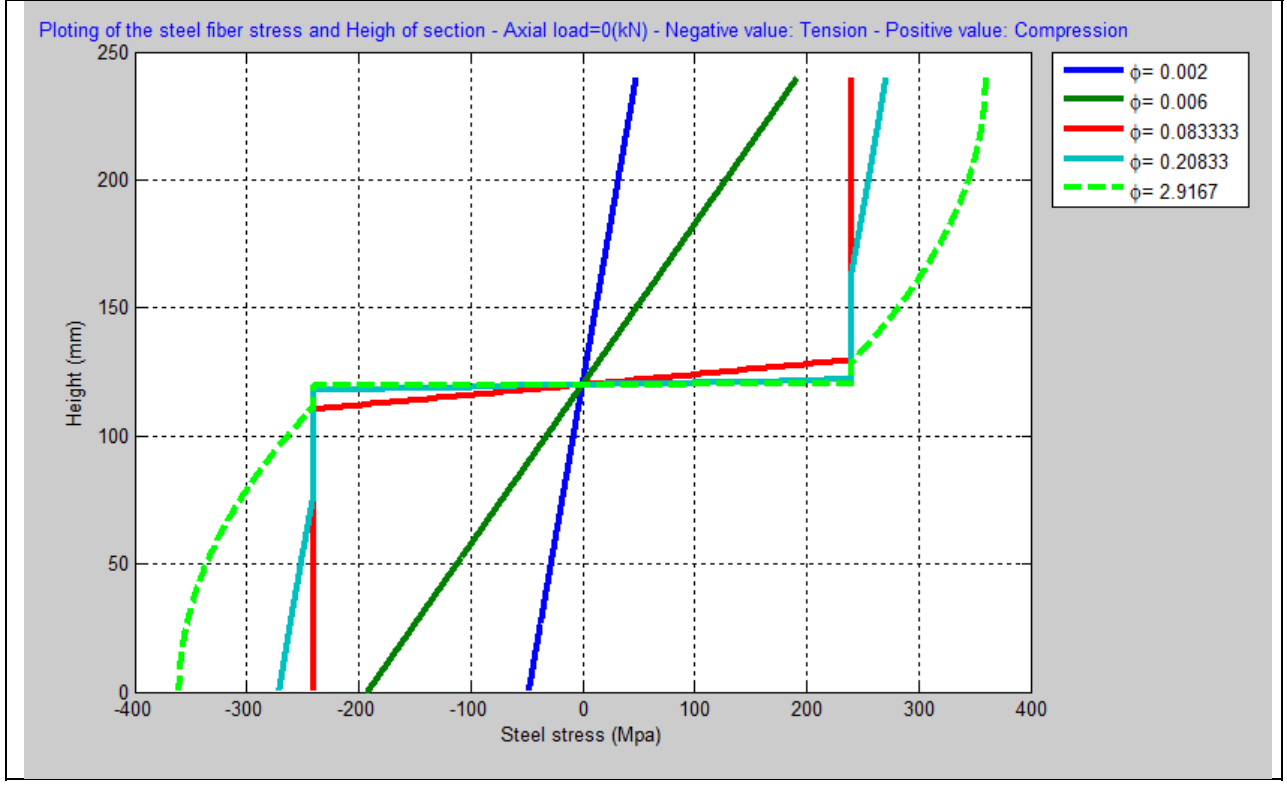
```
(+)Increment 10 : It is converged in 4 iterations - strain: 0.02500 - x: 206.08 - Phi: 0.12131 - Moment: 277.90
(+)Increment 11 : It is converged in 5 iterations - strain: 0.07000 - x: 186.93 - Phi: 0.37447 - Moment: 280.07
(+)Increment 12 : It is converged in 14 iterations - strain: 0.14000 - x: 169.66 - Phi: 0.82518 - Moment: 291.57
(+)Increment 13 : It is converged in 19 iterations - strain: 0.21000 - x: 163.38 - Phi: 1.28536 - Moment: 308.35
(+)Increment 14 : It is converged in 25 iterations - strain: 0.28000 - x: 161.26 - Phi: 1.73637 - Moment: 322.54
(+)Increment 15 : It is converged in 30 iterations - strain: 0.35000 - x: 162.40 - Phi: 2.15511 - Moment: 332.04

    ## Strain Reached to Ultimate Strain: 0.3500 ##

+========================+
= Steel Section curve fitted  =
   Curvature    Moment
    (1/m)     (kN.m)
--------------------------------
      0       0
  0.0146  270.4671
  2.1551  332.0403
+========================+
+-----------------------------------------------------------------------+
 Elastic EI : 18551.08 (kN.m^2)
 Plastic EI : 28.77 (kN.m^2)
Steel Section Ductility Rito : 147.82
 Steel Section Over Strength Factor :  1.23
+-----------------------------------------------------------------------+
                                                        ############################
                                                        # AXIAL LOAD = 600.00  (kN)  #
                                                        ############################
(+)It is converged in 2 iterations - Initial axial strain: 0.000318 - Initial axial stress: 63.648 (N/mm^2)

(+)Increment 1 : It is converged in 7 iterations - strain: 0.00024 - x: 120.00 - Phi: 0.00200 - Moment: 37.10
(+)Increment 2 : It is converged in 2 iterations - strain: 0.00048 - x: 120.00 - Phi: 0.00400 - Moment: 74.20
(+)Increment 3 : It is converged in 1 iterations - strain: 0.00072 - x: 120.00 - Phi: 0.00600 - Moment: 111.31
(+)Increment 4 : It is converged in 4 iterations - strain: 0.00096 - x: 120.77 - Phi: 0.00795 - Moment: 147.04
(+)Increment 5 : It is converged in 5 iterations - strain: 0.00120 - x: 129.00 - Phi: 0.00930 - Moment: 165.92
(+)Increment 6 : It is converged in 7 iterations - strain: 0.00500 - x: 183.43 - Phi: 0.02726 - Moment: 253.71
(+)Increment 7 : It is converged in 6 iterations - strain: 0.01000 - x: 200.55 - Phi: 0.04986 - Moment: 277.47
(+)Increment 8 : It is converged in 7 iterations - strain: 0.01500 - x: 207.18 - Phi: 0.07240 - Moment: 286.18
(+)Increment 9 : It is converged in 6 iterations - strain: 0.02000 - x: 210.65 - Phi: 0.09494 - Moment: 290.64
(+)Increment 10 : It is converged in 6 iterations - strain: 0.02500 - x: 212.79 - Phi: 0.11749 - Moment: 293.35
(+)Increment 11 : It is converged in 5 iterations - strain: 0.07000 - x: 203.85 - Phi: 0.34339 - Moment: 306.52
(+)Increment 12 : It is converged in 13 iterations - strain: 0.14000 - x: 180.94 - Phi: 0.77372 - Moment: 308.34
(+)Increment 13 : It is converged in 17 iterations - strain: 0.21000 - x: 172.87 - Phi: 1.21477 - Moment: 321.77
(+)Increment 14 : It is converged in 22 iterations - strain: 0.28000 - x: 169.78 - Phi: 1.64916 - Moment: 334.26
(+)Increment 15 : It is converged in 24 iterations - strain: 0.35000 - x: 170.87 - Phi: 2.04831 - Moment: 342.62

    ## Strain Reached to Ultimate Strain: 0.3500 ##

+======================+
= Steel Section curve fitted  =
   Curvature    Moment
    (1/m)     (kN.m)
--------------------------------
      0       0
  0.0157  291.3360
  2.0483  342.6243
+======================+
+-----------------------------------------------------------------------+
 Elastic EI : 18551.08 (kN.m^2)
 Plastic EI : 25.23 (kN.m^2)
Steel Section Ductility Rito : 130.43
 Steel Section Over Strength Factor :  1.18
+-----------------------------------------------------------------------+
```

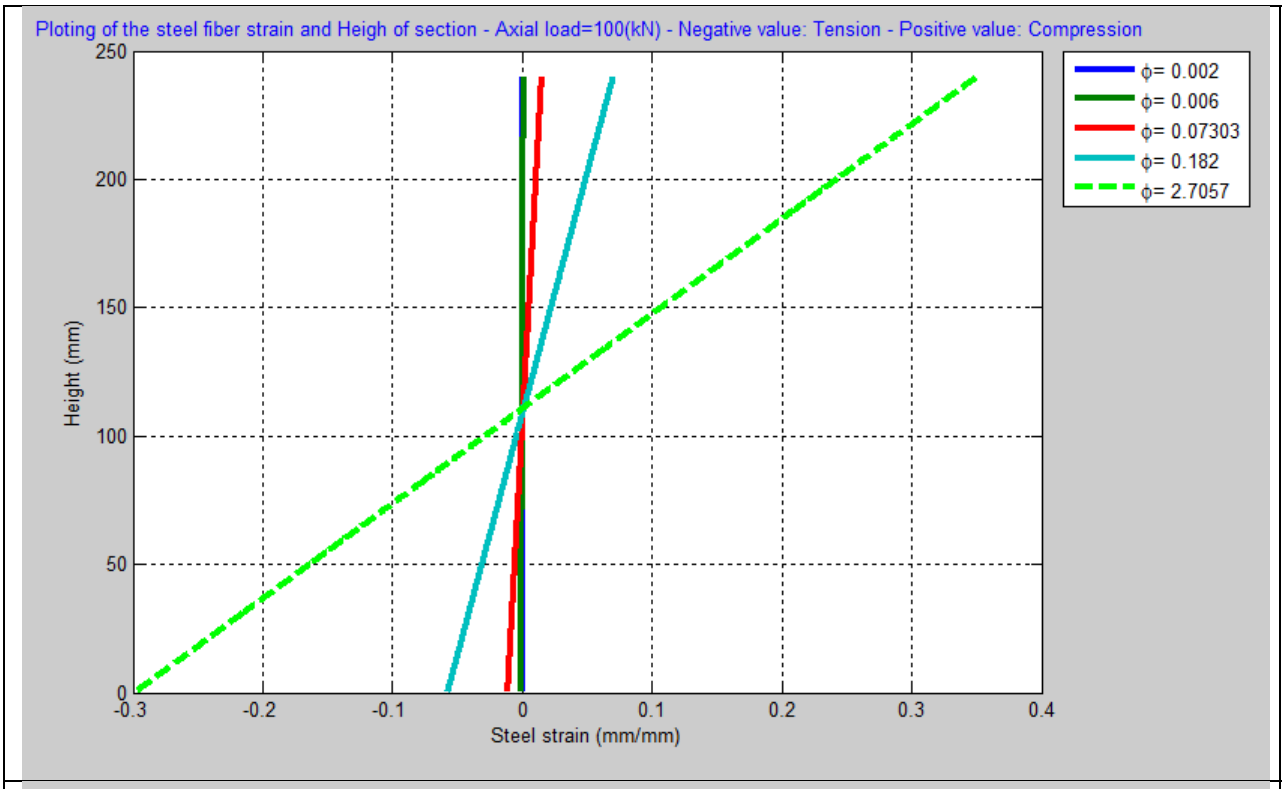
Plot :

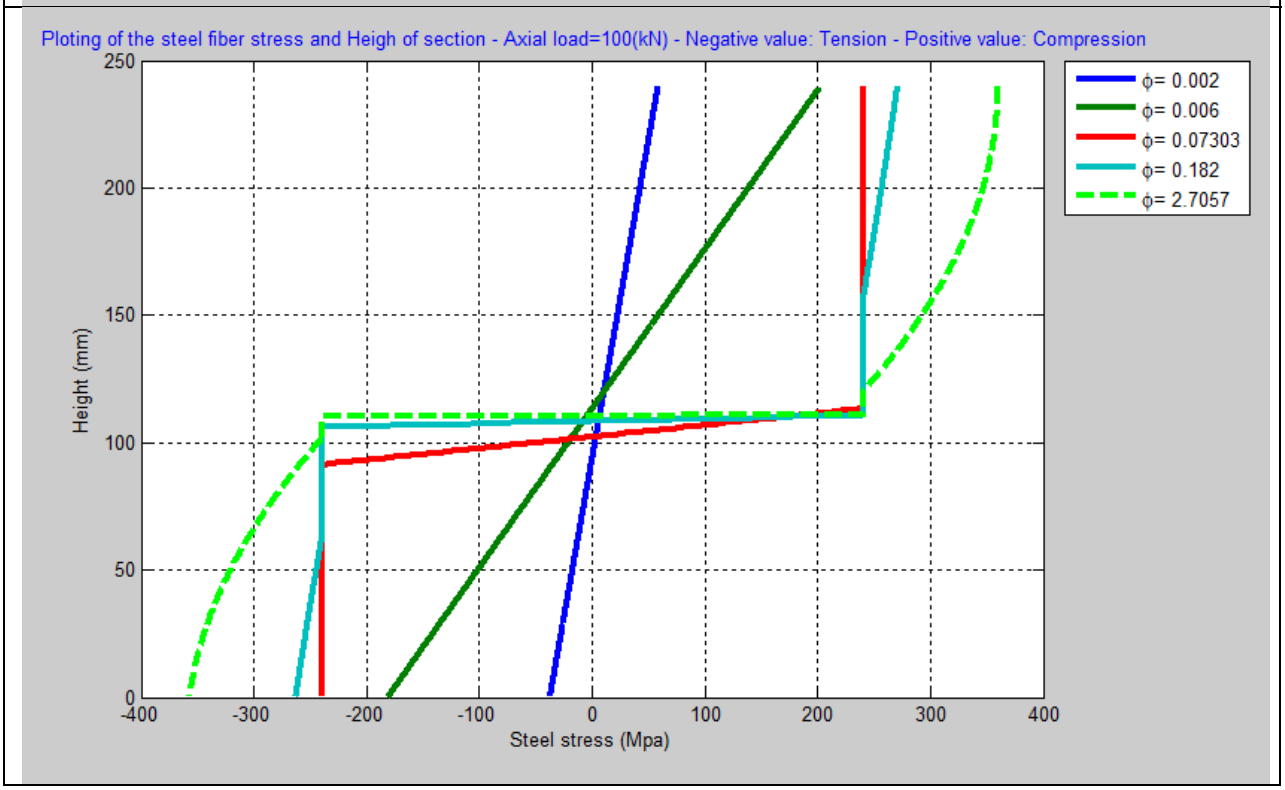

Top fiber steel section stress-strain diagram
Stress (kN/mm2)
Strain
0
50
100
150
200
250
300
350
400
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35

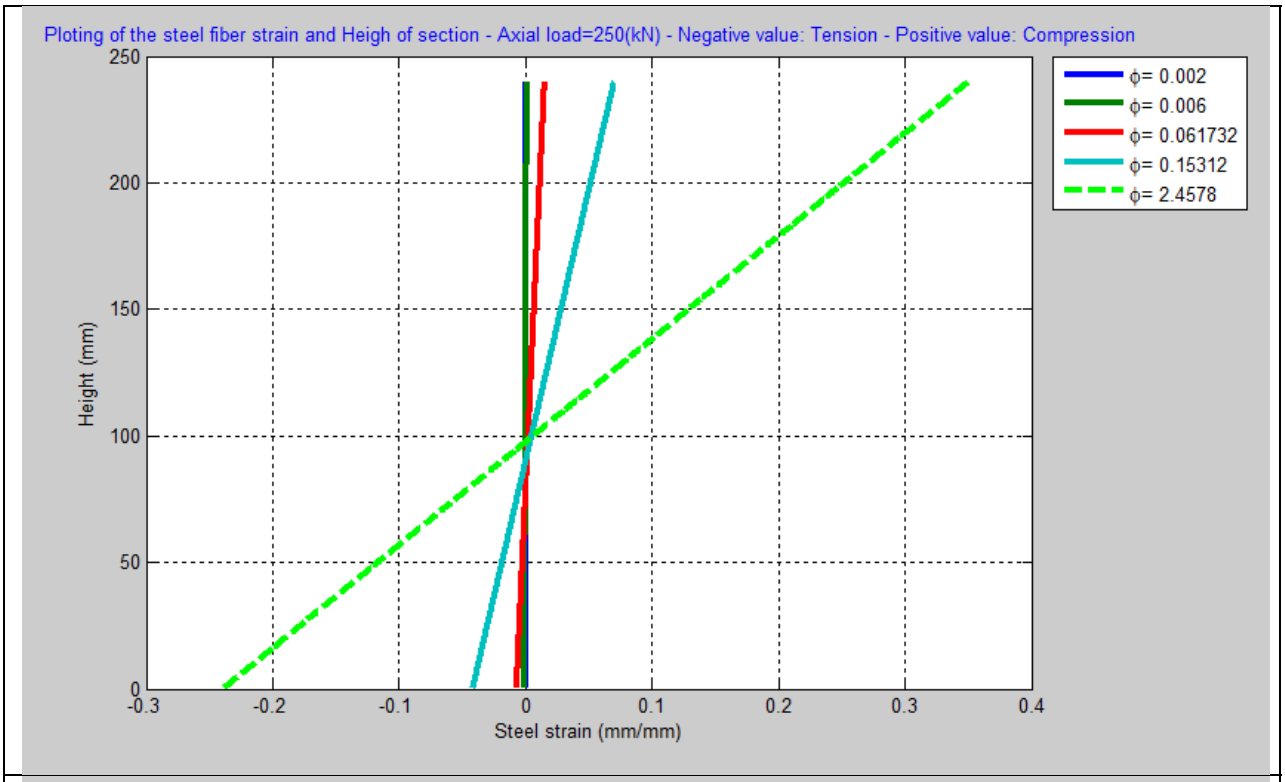

Ploting of the Top fiber steel strain and Neuteral axis
Neuteral axis (mm)
Top steel strain
P= 0(kN)
P= 100(kN)
P= 250(kN)
P= 500(kN)
P= 600(kN)
120
130
140
150
160
170
180
190
200
210
220
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35

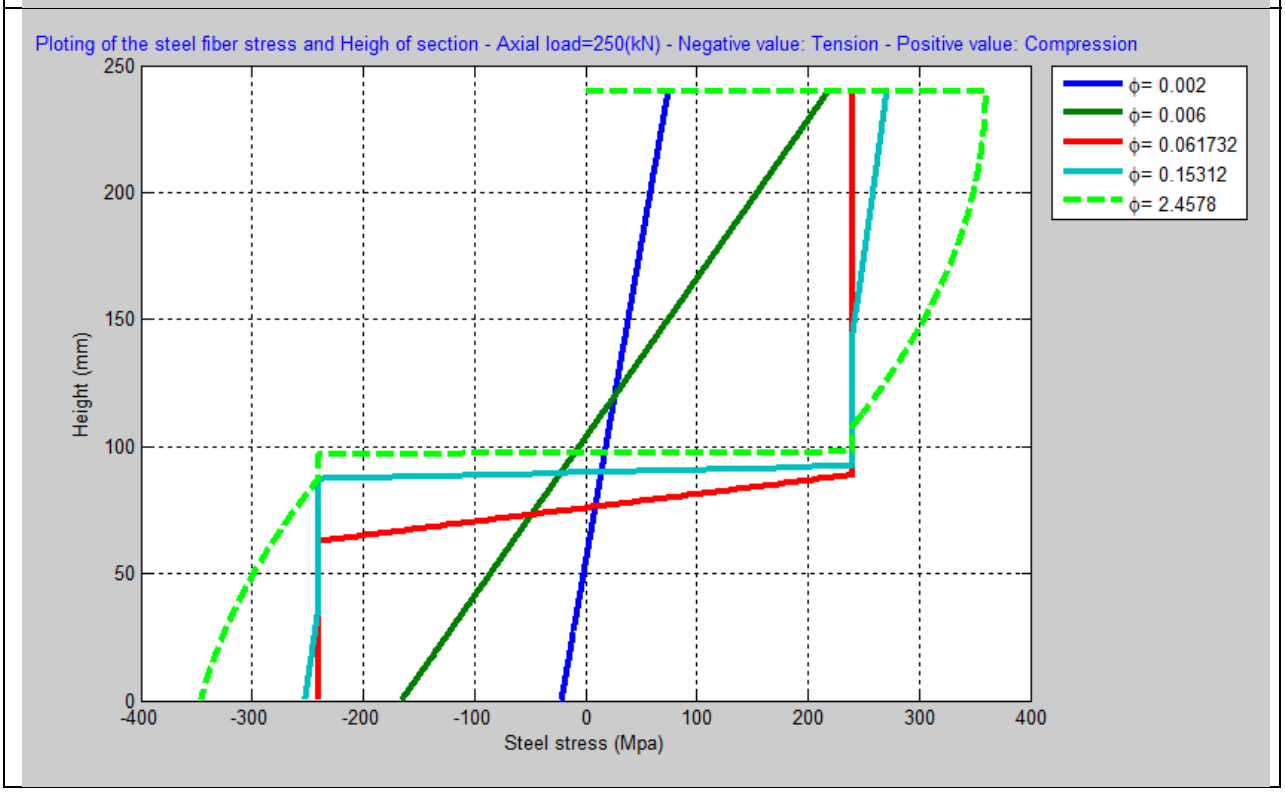

Ploting of the steel fiber strain and Heigh of section - Axial load=0(kN) - Negative value: Tension - Positive value: Compression
Height (mm)
Steel strain (mm/mm)
ϕ= 0.002
ϕ= 0.006
ϕ= 0.083333
ϕ= 0.20833
ϕ= 2.9167

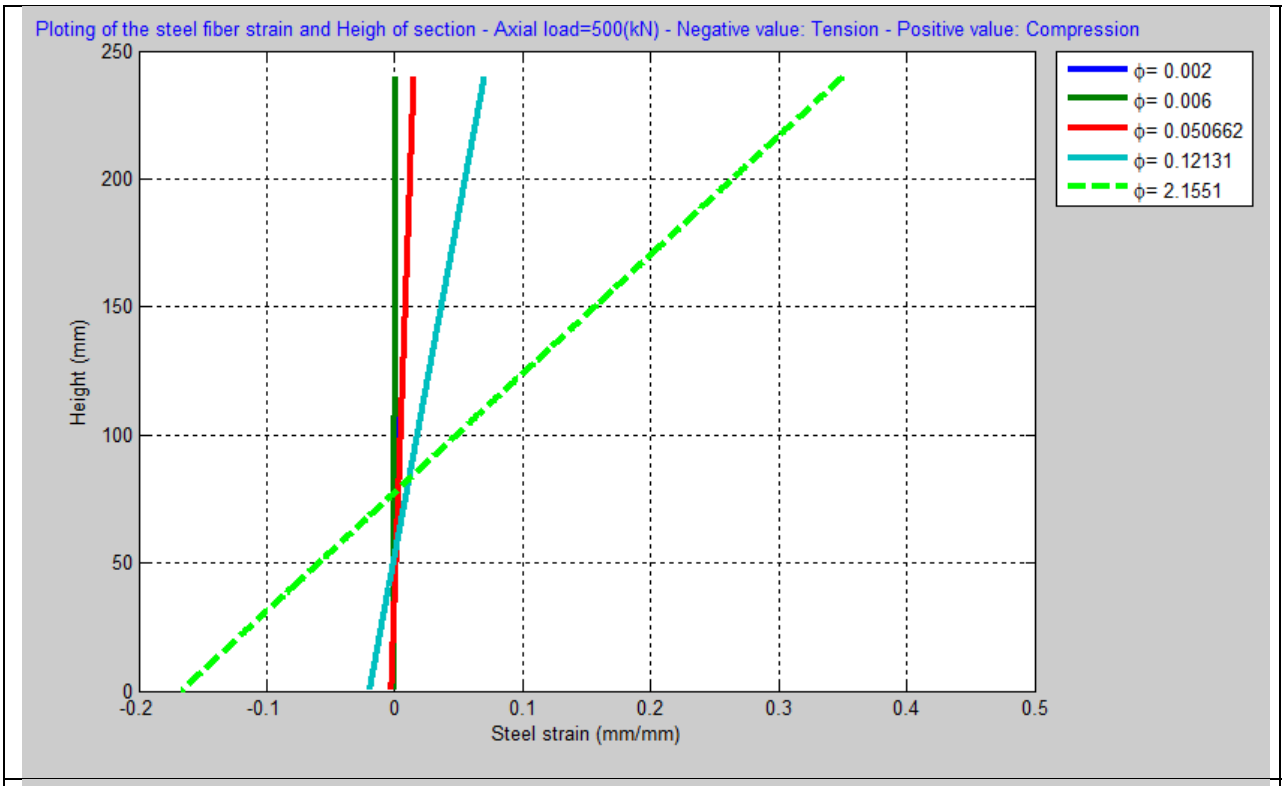

Ploting of the steel fiber stress and Heigh of section - Axial load=0(kN) - Negative value: Tension - Positive value: Compression
Height (mm)
Steel stress (Mpa)
ϕ= 0.002
ϕ= 0.006
ϕ= 0.083333
ϕ= 0.20833
ϕ= 2.9167

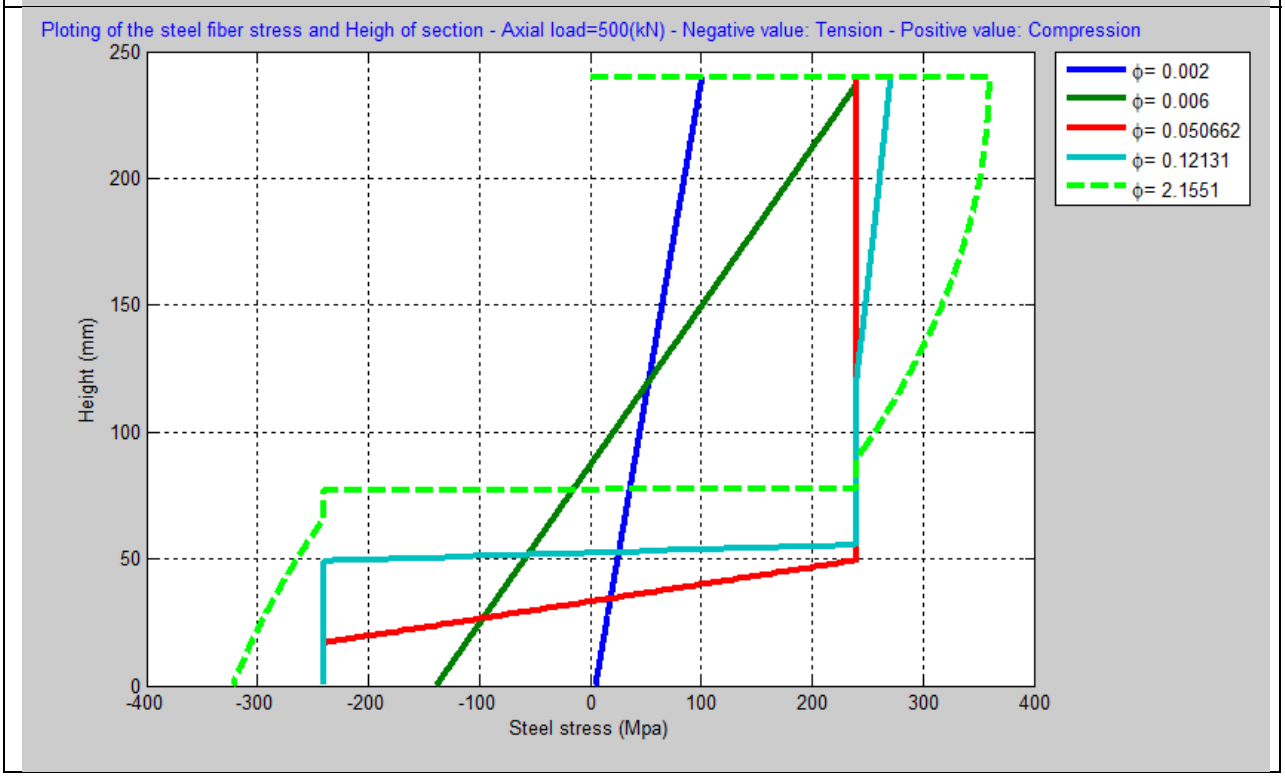

Ploting of the steel fiber strain and Heigh of section - Axial load=100(kN) - Negative value: Tension - Positive value: Compression
Height (mm)
Steel strain (mm/mm)
ϕ= 0.002
ϕ= 0.006
ϕ= 0.07303
ϕ= 0.182
ϕ= 2.7057

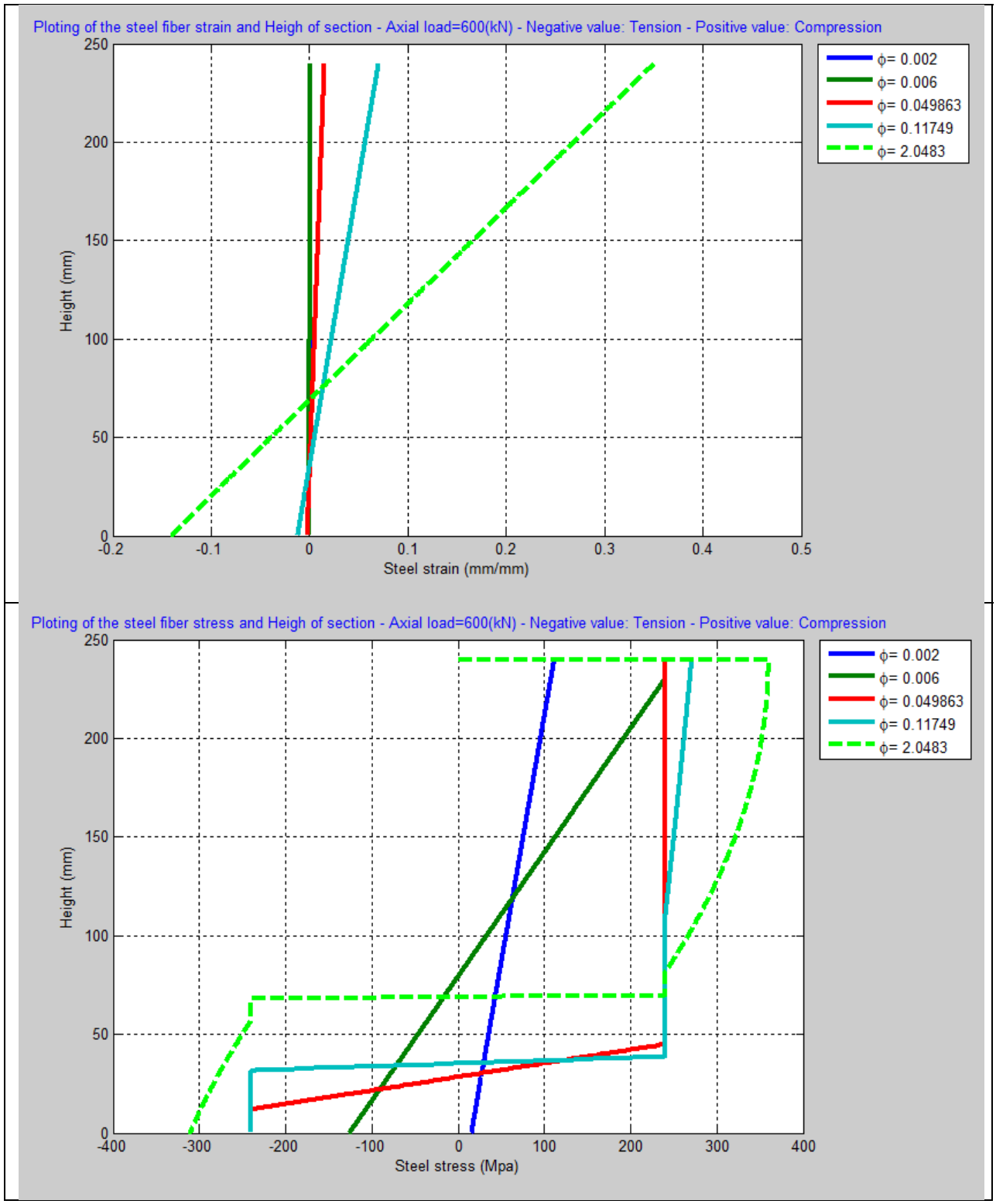

Ploting of the steel fiber stress and Heigh of section - Axial load=100(kN) - Negative value: Tension - Positive value: Compression
Height (mm)
Steel stress (Mpa)
ϕ= 0.002
ϕ= 0.006
ϕ= 0.07303
ϕ= 0.182
ϕ= 2.7057

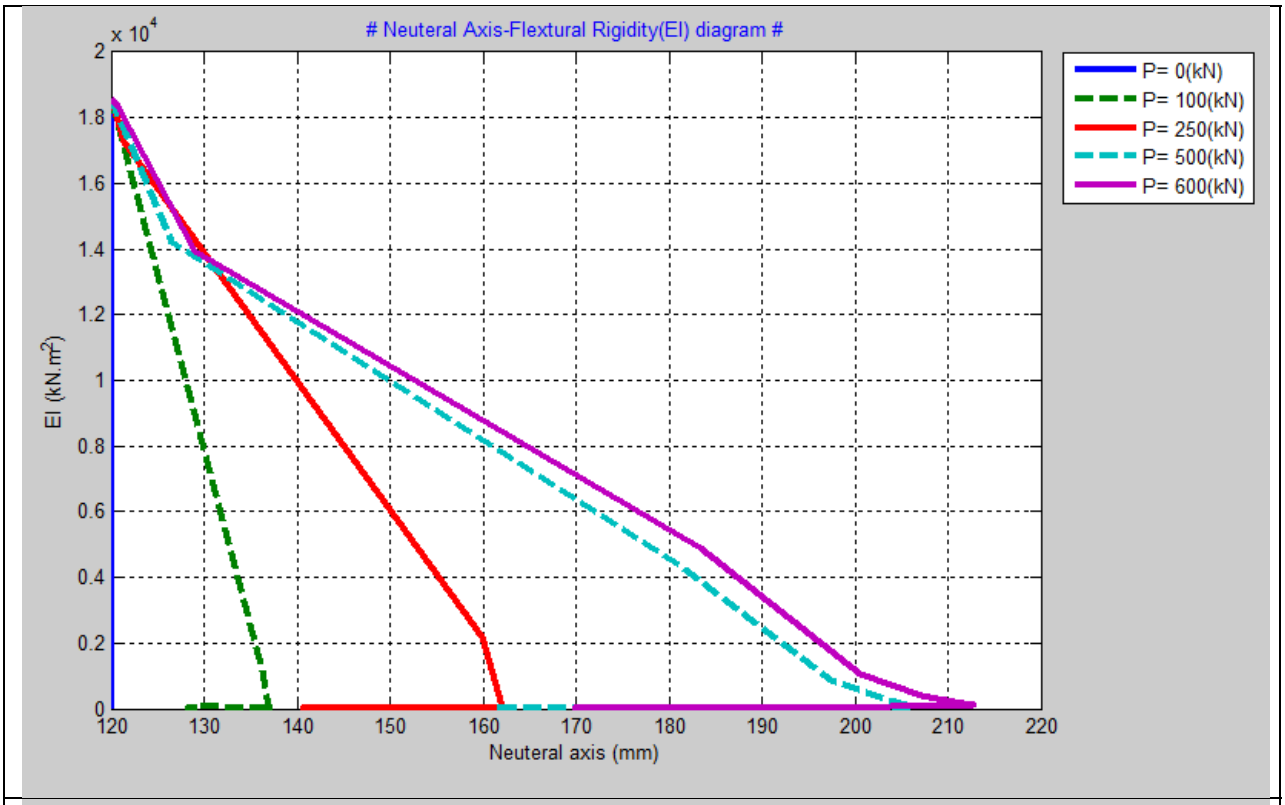

Ploting of the steel fiber strain and Heigh of section - Axial load=250(kN) - Negative value: Tension - Positive value: Compression
Height (mm)
Steel strain (mm/mm)
ϕ= 0.002
ϕ= 0.006
ϕ= 0.061732
ϕ= 0.15312
ϕ= 2.4578

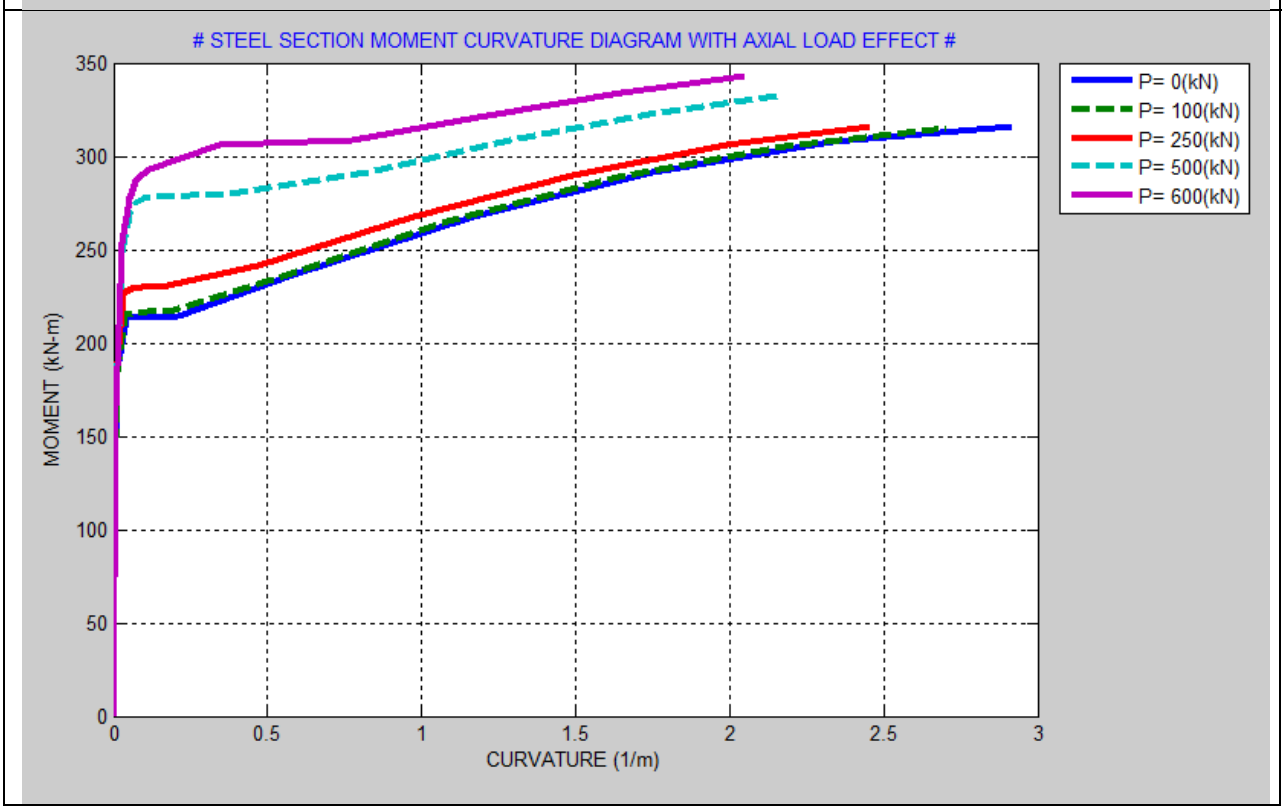

Ploting of the steel fiber stress and Heigh of section - Axial load=250(kN) - Negative value: Tension - Positive value: Compression
Height (mm)
Steel stress (Mpa)
ϕ= 0.002
ϕ= 0.006
ϕ= 0.061732
ϕ= 0.15312
ϕ= 2.4578

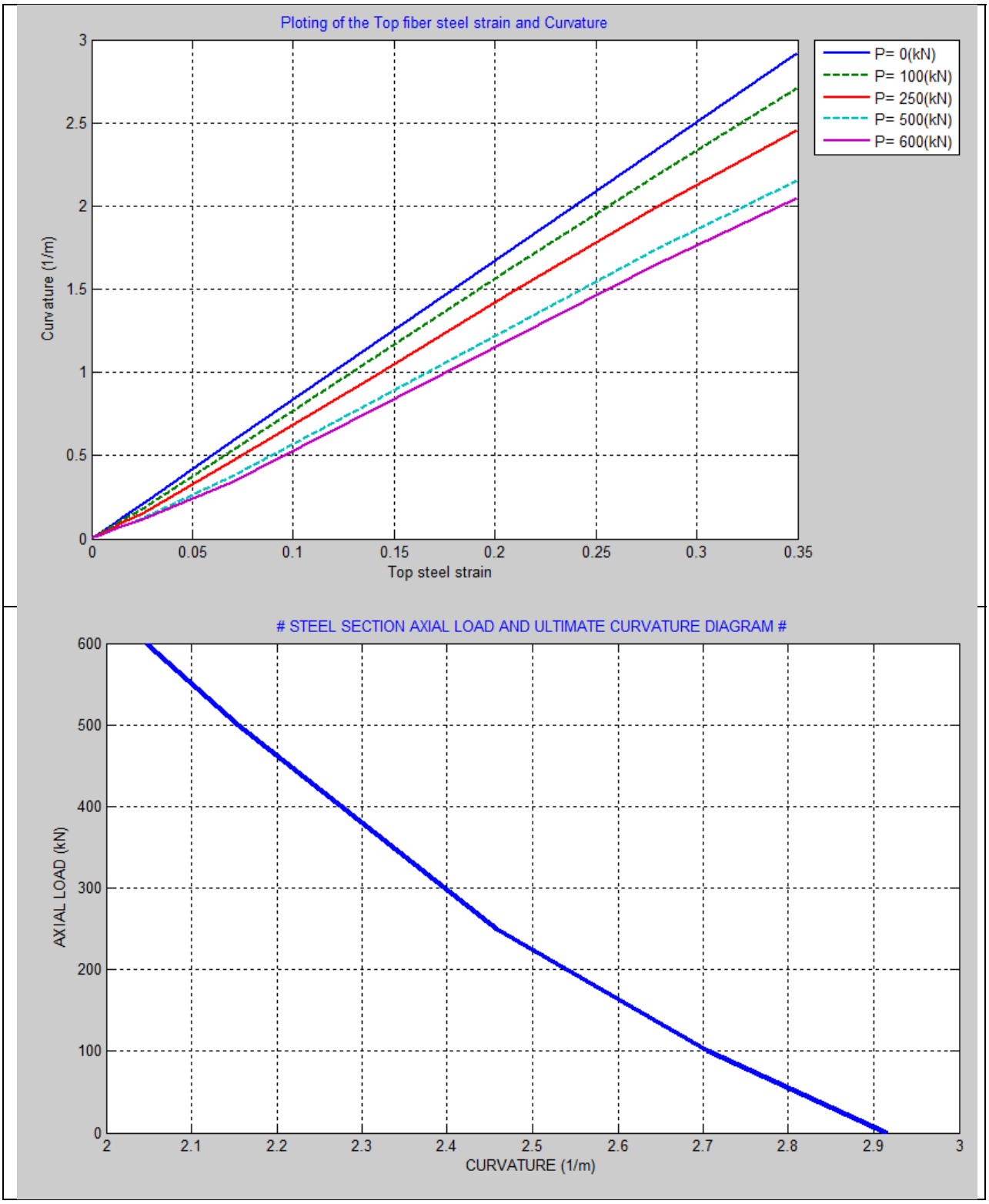

Ploting of the steel fiber strain and Heigh of section - Axial load=500(kN) - Negative value: Tension - Positive value: Compression
Height (mm)
Steel strain (mm/mm)
ϕ= 0.002
ϕ= 0.006
ϕ= 0.050662
ϕ= 0.12131
ϕ= 2.1551


Ploting of the steel fiber stress and Heigh of section - Axial load=500(kN) - Negative value: Tension - Positive value: Compression
Height (mm)
Steel stress (Mpa)
ϕ= 0.002
ϕ= 0.006
ϕ= 0.050662
ϕ= 0.12131
ϕ= 2.1551


Ploting of the steel fiber strain and Heigh of section - Axial load=600(kN) - Negative value: Tension - Positive value: Compression
Height (mm)
Steel strain (mm/mm)
ϕ= 0.002
ϕ= 0.006
ϕ= 0.049863
ϕ= 0.11749
ϕ= 2.0483
Ploting of the steel fiber stress and Heigh of section - Axial load=600(kN) - Negative value: Tension - Positive value: Compression
Height (mm)
Steel stress (Mpa)
ϕ= 0.002
ϕ= 0.006
ϕ= 0.049863
ϕ= 0.11749
ϕ= 2.0483


Neuteral Axis-Flextural Rigidity(EI) diagram
x 10^4
EI (kN.m^2)
Neuteral axis (mm)
P= 0(kN)
P= 100(kN)
P= 250(kN)
P= 500(kN)
P= 600(kN)


STEEL SECTION MOMENT CURVATURE DIAGRAM WITH AXIAL LOAD EFFECT
MOMENT (kN-m)
CURVATURE (1/m)
P= 0(kN)
P= 100(kN)
P= 250(kN)
P= 500(kN)
P= 600(kN)


Ploting of the Top fiber steel strain and Curvature
Curvature (1/m)
Top steel strain
P= 0(kN)
P= 100(kN)
P= 250(kN)
P= 500(kN)
P= 600(kN)
# STEEL SECTION AXIAL LOAD AND ULTIMATE CURVATURE DIAGRAM #
AXIAL LOAD (kN)
CURVATURE (1/m)