>> IN THE NAME OF GOD <<

Moment-Curvature Analysis Of Unconfined I Concrete Section In MATLAB

This program is written by salar delavar ghashghaei-2015.05.21

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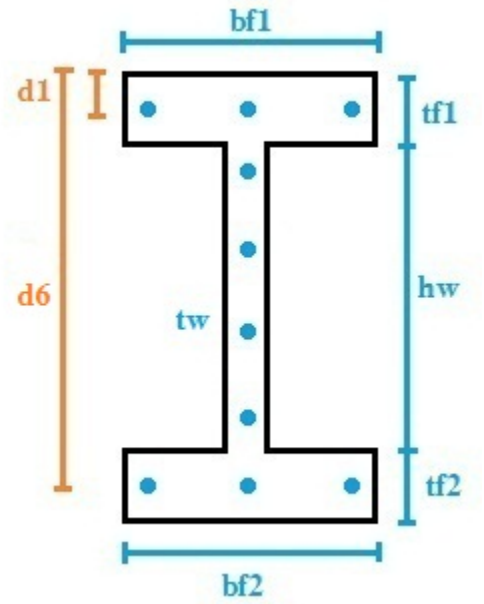
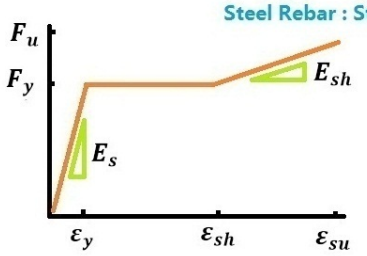


Section Properties:

```
tf1=150;% [mm] I section thickness on Top flange
bf1=1100;% [mm] I section width on Top flange
tw=200;% [mm] I section thickness of Web
hw=1900;% [mm] Height of web
tf2=150;% [mm] I section thickness on Bottom flange
bf2=1100;% [mm] I section width on Bottom flange
h=tf1+tf2+hw;% [mm] Height of Section
%As:  As1      As2     As3     As4    As5      As6
As=[3500 1000 1000 1000 1000 3500];
%d:d1  d2  d3  d4  d5  d6
d=[75 625 1050 1625 2050 2125];
```

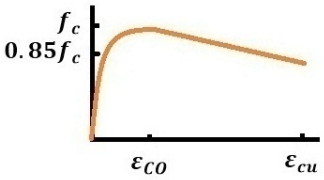
Stress-Strain of materials

Steel Rebar : Stress-Strain Relationship



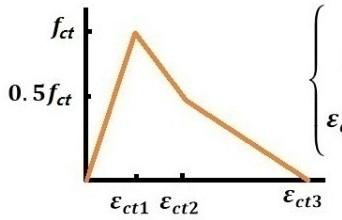
$$\begin{cases} \varepsilon_s < \varepsilon_y & f_s = E_s\varepsilon_s \\ \varepsilon_y \le \varepsilon_s < \varepsilon_{sh} & f_s = F_y \\ \varepsilon_{sh} \le \varepsilon_s < \varepsilon_{su} & f_s = F_y + E_{sh}(\varepsilon_s - \varepsilon_{sh}) \end{cases}$$

Unconfined Concrete compressive : Stress-Strain Relationship



$$\begin{cases} \varepsilon_c < \varepsilon_{C0} & f_c = f_c\left[\left(\frac{2\varepsilon_c}{\varepsilon_{C0}}\right) - \left(\frac{\varepsilon_c}{\varepsilon_{C0}}\right)^2\right] \\ \varepsilon_{C0} \le \varepsilon_c < \varepsilon_{cu} & f_c\left[1 - \left(\frac{0.15(\varepsilon_c - \varepsilon_{C0})}{\varepsilon_{cu} - \varepsilon_{C0}}\right)\right] \end{cases}$$

Unconfined Concrete Tensile: Stress-Strain Relationship



$$\begin{cases} \varepsilon_c \le \varepsilon_{ct1} & f_{ct} = 0.5E_c\varepsilon_c \\ \varepsilon_{ct1} < \varepsilon_c \le \varepsilon_{ct2} & f_{ct} = f_{ct} - \left[\frac{0.5f_{ct}}{\varepsilon_{ct2} - \varepsilon_{ct1}}\right](\varepsilon_c - \varepsilon_{ct1}) \\ \varepsilon_{ct2} < \varepsilon_c \le \varepsilon_{ct3} & f_{ct} = 0.5f_{ct} - \left[\frac{0.5f_{ct}}{\varepsilon_{ct3} - \varepsilon_{ct2}}\right](\varepsilon_c - \varepsilon_{ct2}) \end{cases}$$

Concrete Properties:

```
fc =25;% [N/mm^2] Unconfined concrete strength
ecu=0.004;% Ultimate concrete strain
Ec=5000*sqrt(fc);
ec0=(2*fc)/Ec;
fct=-0.7*sqrt(fc);% Concrete tension stress
ect1=(2*fct)/Ec;ect2=(2.625*fct)/Ec;ect3=(9.292*fct)/Ec;% Concrete tension
strain
```

steel Reinforcing Properties:

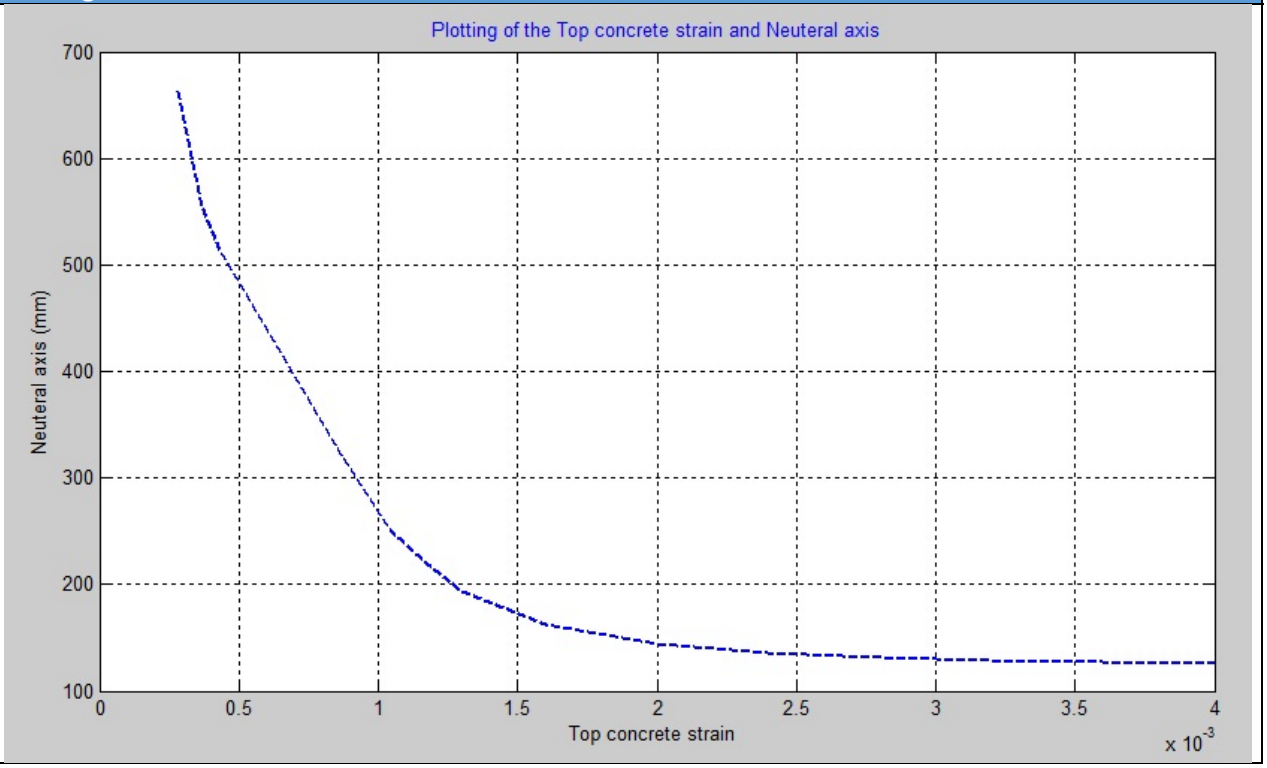
```
fy =400;% [N/mm^2] Yield strength of reinforcing steel
Es =2e5;% [N/mm^2] Modulus of elasticity of steel
fu=1.5*fy;% Ultimate steel stress
ey=fy/Es;% Yeild steel strain
esh=0.01;% Strain at steel strain-hardening
esu=0.09;% Ultimate steel strain
Esh=(fu-fy)/(esu-esh);
```

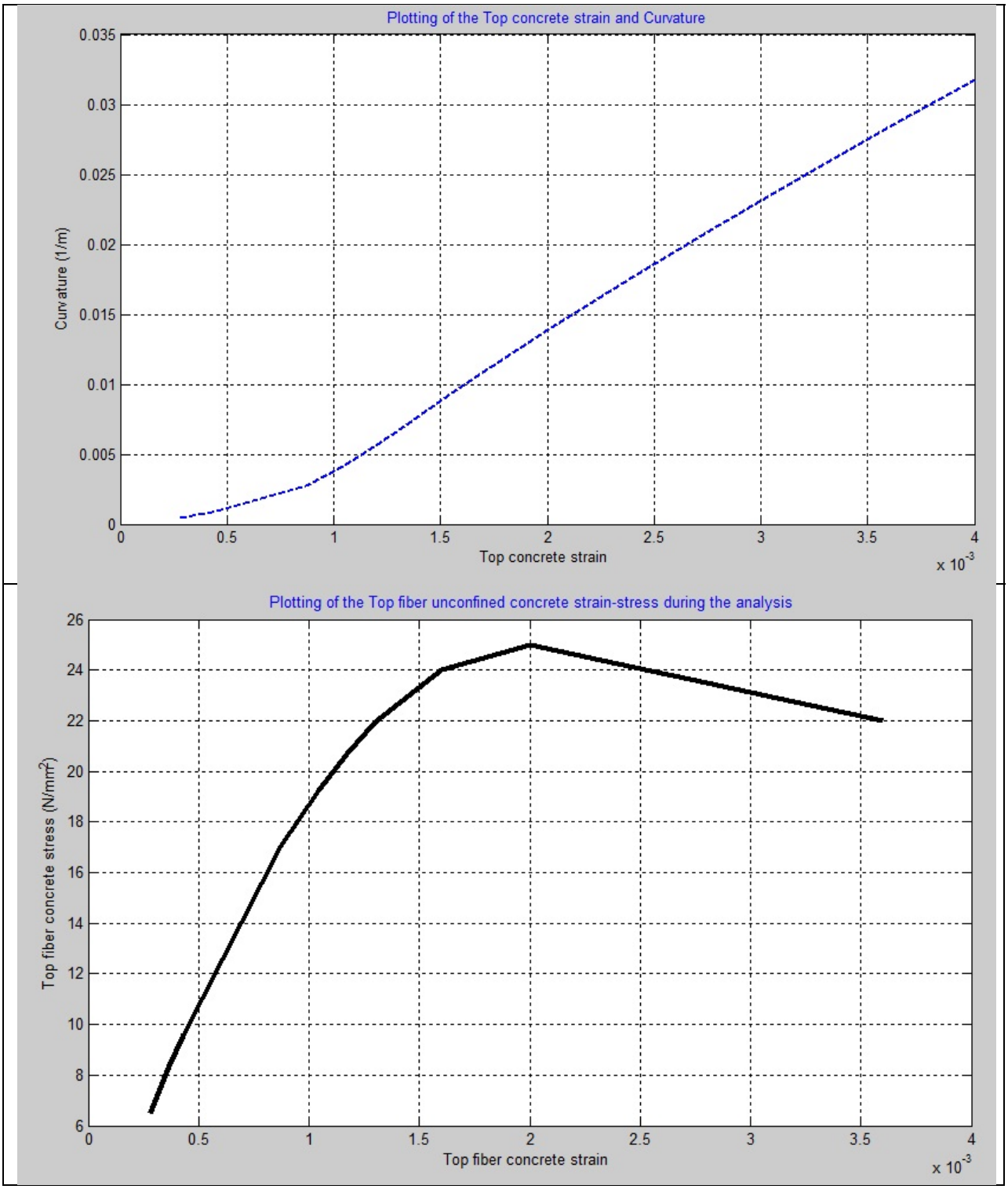
Analysis Report:

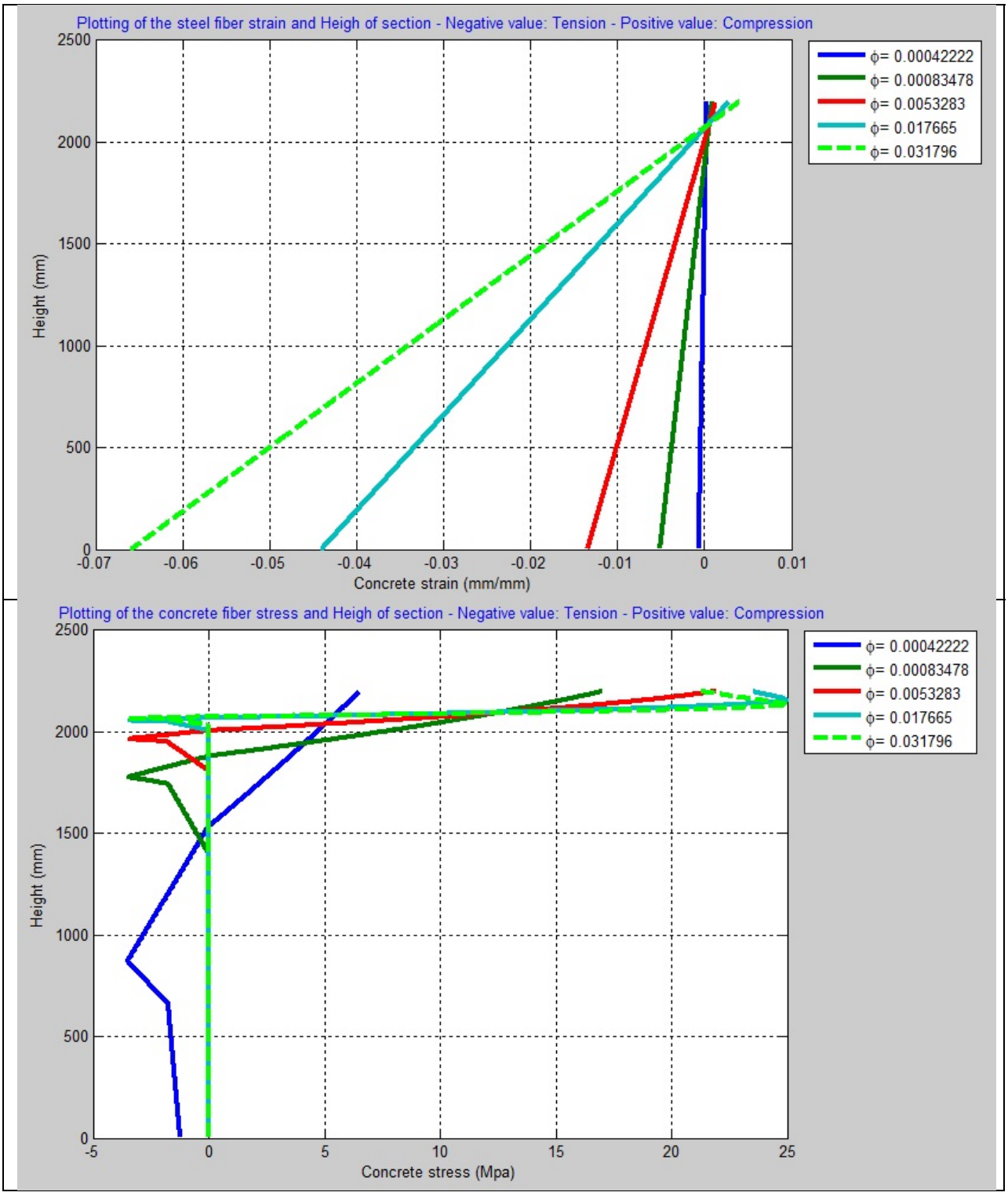
(+)Increment 1 : It is converged in 13 iterations - strain: 0.000280 - x: 663.16 - Phi: 0.00042 - Moment: 2317.00
(+)Increment 2 : It is converged in 11 iterations - strain: 0.000367 - x: 554.00 - Phi: 0.00066 - Moment: 2784.10
(+)Increment 3 : It is converged in 11 iterations - strain: 0.000429 - x: 514.26 - Phi: 0.00083 - Moment: 3146.04
(+)Increment 4 : It is converged in 17 iterations - strain: 0.000872 - x: 319.74 - Phi: 0.00273 - Moment: 4797.13
(+)Increment 5 : It is converged in 20 iterations - strain: 0.001041 - x: 250.94 - Phi: 0.00415 - Moment: 4871.68
(+)Increment 6 : It is converged in 24 iterations - strain: 0.001171 - x: 219.73 - Phi: 0.00533 - Moment: 4925.46
(+)Increment 7 : It is converged in 25 iterations - strain: 0.001301 - x: 193.65 - Phi: 0.00672 - Moment: 4992.68
(+)Increment 8 : It is converged in 30 iterations - strain: 0.001600 - x: 162.31 - Phi: 0.00986 - Moment: 5164.64
(+)Increment 9 : It is converged in 34 iterations - strain: 0.002000 - x: 144.19 - Phi: 0.01387 - Moment: 5389.47

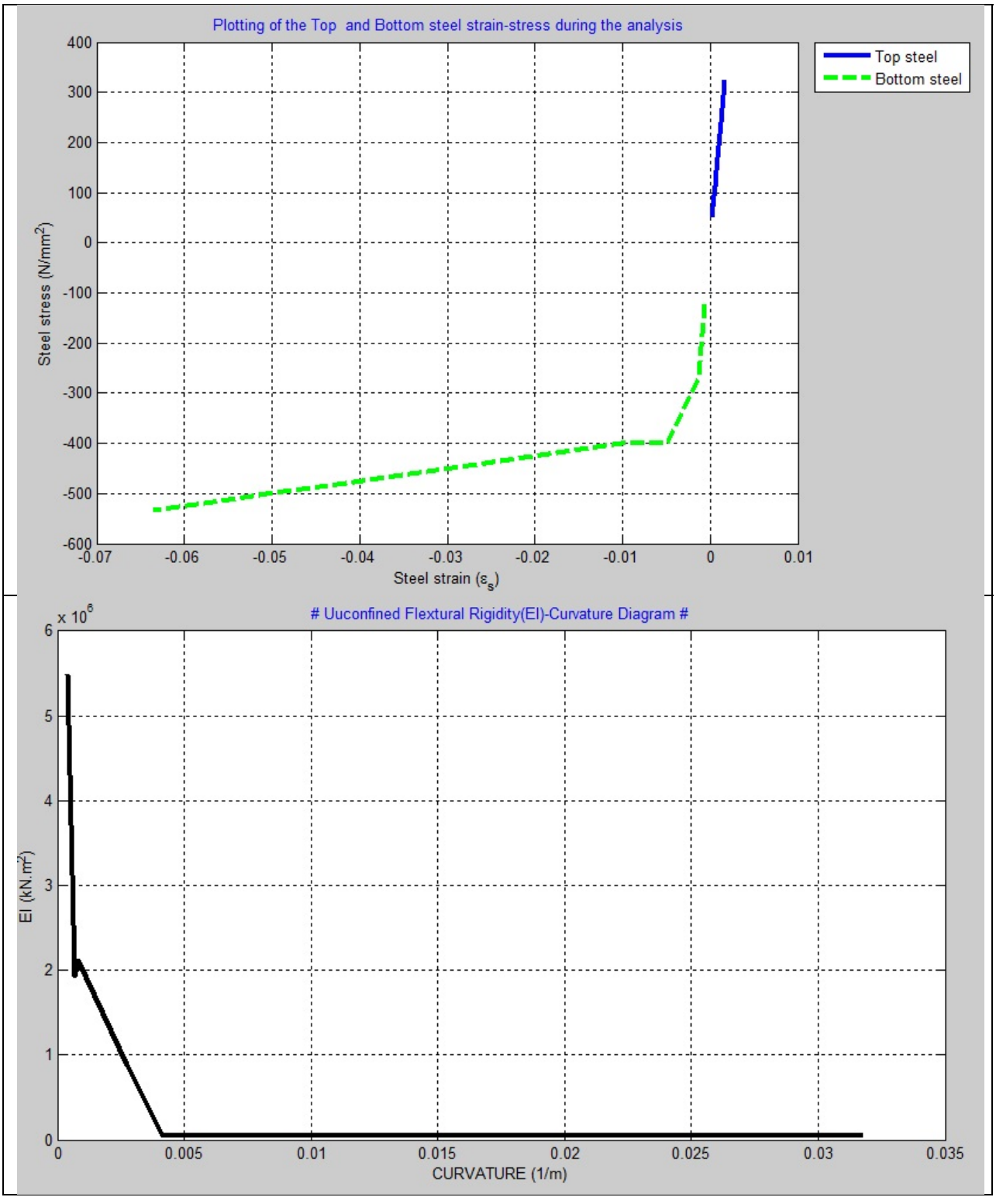
```
(+)Increment 10 : It is converged in 37 iterations - strain: 0.002400 - x: 135.86 - Phi: 0.01766 - Moment: 5599.13
(+)Increment 11 : It is converged in 42 iterations - strain: 0.002800 - x: 131.35 - Phi: 0.02132 - Moment: 5797.59
(+)Increment 12 : It is converged in 46 iterations - strain: 0.003200 - x: 128.60 - Phi: 0.02488 - Moment: 5990.90
(+)Increment 13 : It is converged in 49 iterations - strain: 0.003600 - x: 126.89 - Phi: 0.02837 - Moment: 6178.92
(+)Increment 14 : It is converged in 52 iterations - strain: 0.004000 - x: 125.80 - Phi: 0.03180 - Moment: 6362.81

    ## Unconfined Concrete Strain Reached to Ultimate Strain: 0.0040 ##

+===========================+
= Unconfined curve fitted =
  Curvature    Moment
    (1/m)      (kN.m)
-----------------------------
 1.0e+003 *

       0       0
  0.0000  4.5708
  0.0000  6.3628

+===========================+
+-----------------------------------------------------------+
 Elastic EI : 5487688.71 (kN.m^2)
 Plastic EI : 57876.60 (kN.m^2)
 Unconfined Section Ductility Rito : 38.17
+-----------------------------------------------------------+
```

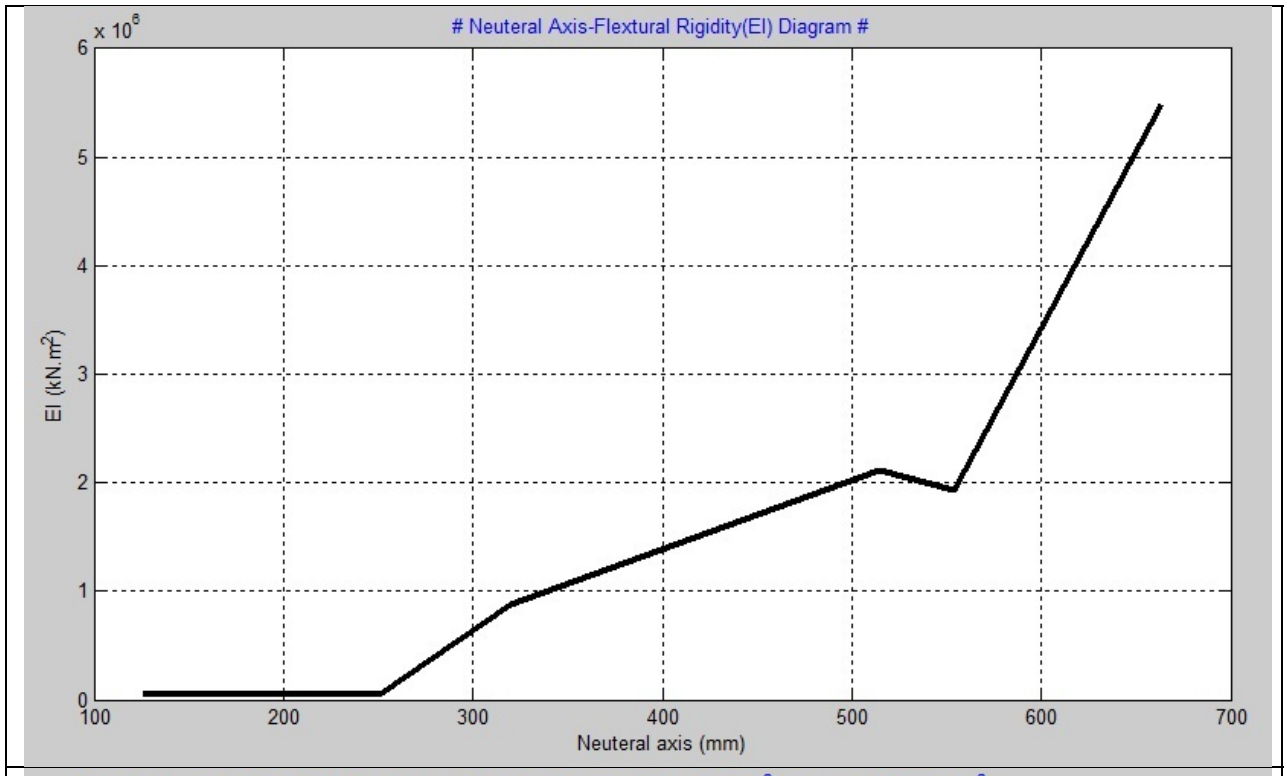
Plotting :

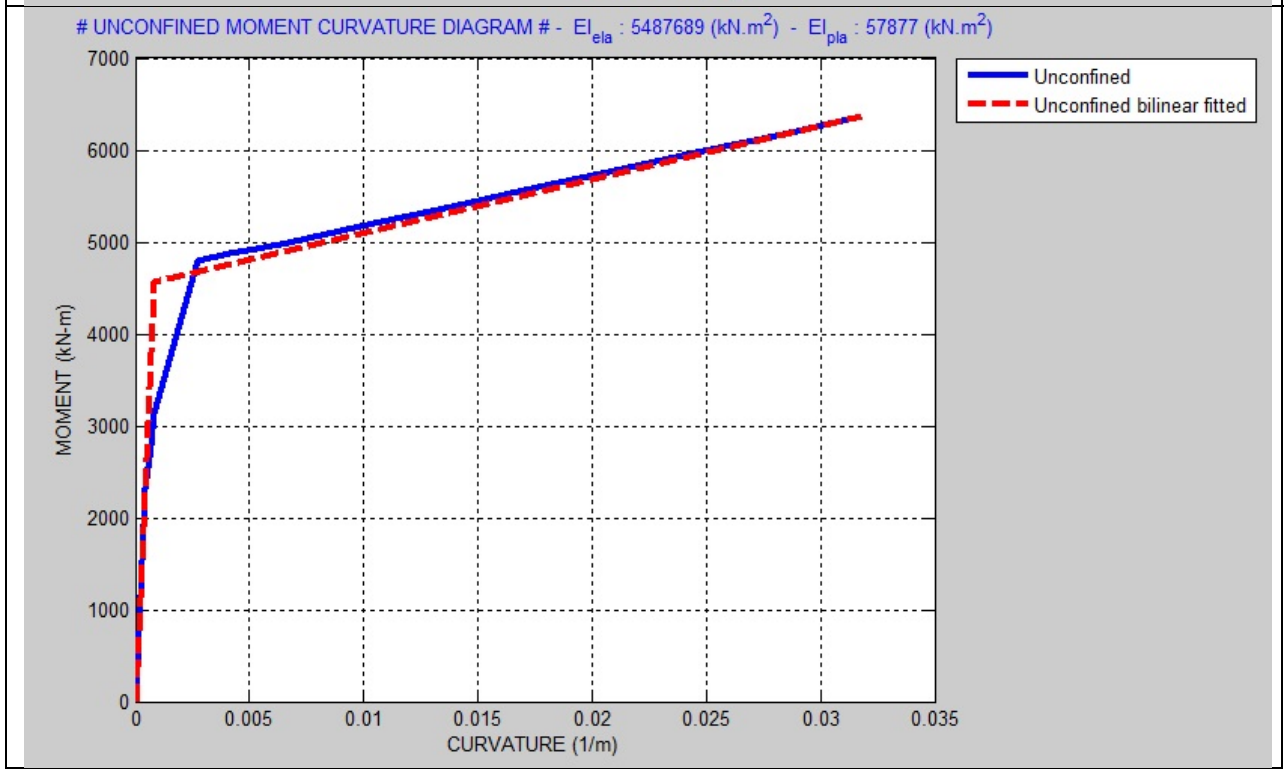



Plotting of the Top concrete strain and Curvature
Curvature (1/m)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Top concrete strain
x 10^-3
Plotting of the Top fiber unconfined concrete strain-stress during the analysis
Top fiber concrete stress (N/mm^2)
26
24
22
20
18
16
14
12
10
8
6
0
0.5
1
1.5
2
2.5
3
3.5
4
Top fiber concrete strain
x 10^-3


Plotting of the steel fiber strain and Heigh of section - Negative value: Tension - Positive value: Compression
Height (mm)
Concrete strain (mm/mm)
ϕ= 0.00042222
ϕ= 0.00083478
ϕ= 0.0053283
ϕ= 0.017665
ϕ= 0.031796
Plotting of the concrete fiber stress and Heigh of section - Negative value: Tension - Positive value: Compression
Height (mm)
Concrete stress (Mpa)
ϕ= 0.00042222
ϕ= 0.00083478
ϕ= 0.0053283
ϕ= 0.017665
ϕ= 0.031796


Plotting of the Top and Bottom steel strain-stress during the analysis
Top steel
Bottom steel
Steel stress (N/mm²)
Steel strain (εs)
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-0.07
-0.06
-0.05
-0.04
-0.03
-0.02
-0.01
0
0.01
Uuconfined Flextural Rigidity(EI)-Curvature Diagram
x 10⁶
EI (kN.m²)
CURVATURE (1/m)
6
5
4
3
2
1
0
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035


Neuteral Axis-Flextural Rigidity(EI) Diagram
x 10^6
EI (kN.m^2)
Neuteral axis (mm)
0
1
2
3
4
5
6
100
200
300
400
500
600
700


UNCONFINED MOMENT CURVATURE DIAGRAM # - EI_ela : 5487689 (kN.m^2) - EI_pla : 57877 (kN.m^2)
Unconfined
Unconfined bilinear fitted
MOMENT (kN-m)
CURVATURE (1/m)
0
1000
2000
3000
4000
5000
6000
7000
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035