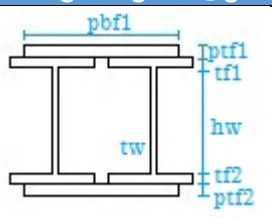
>> IN THE NAME OF GOD <<

Moment-Curvature Analysis of Double I steel sections with Plates on Flanges, with and without Axial Load effect In MATLAB.

This program is written by salar delavar ghashghaei -2015.05.12
E-mail:salar.d.ghashghaei@gmail.com

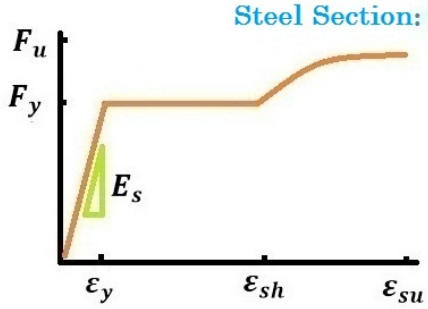


Section Properties:

```
Ptarget =+500000;% [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;% Yeild steel strain
esh=0.025;% Strain at steel strain-hardening
esu=0.35;% Ultimate steel strain
Esh=(fu-fy)/(esu-esh);
```

Analysis Report:

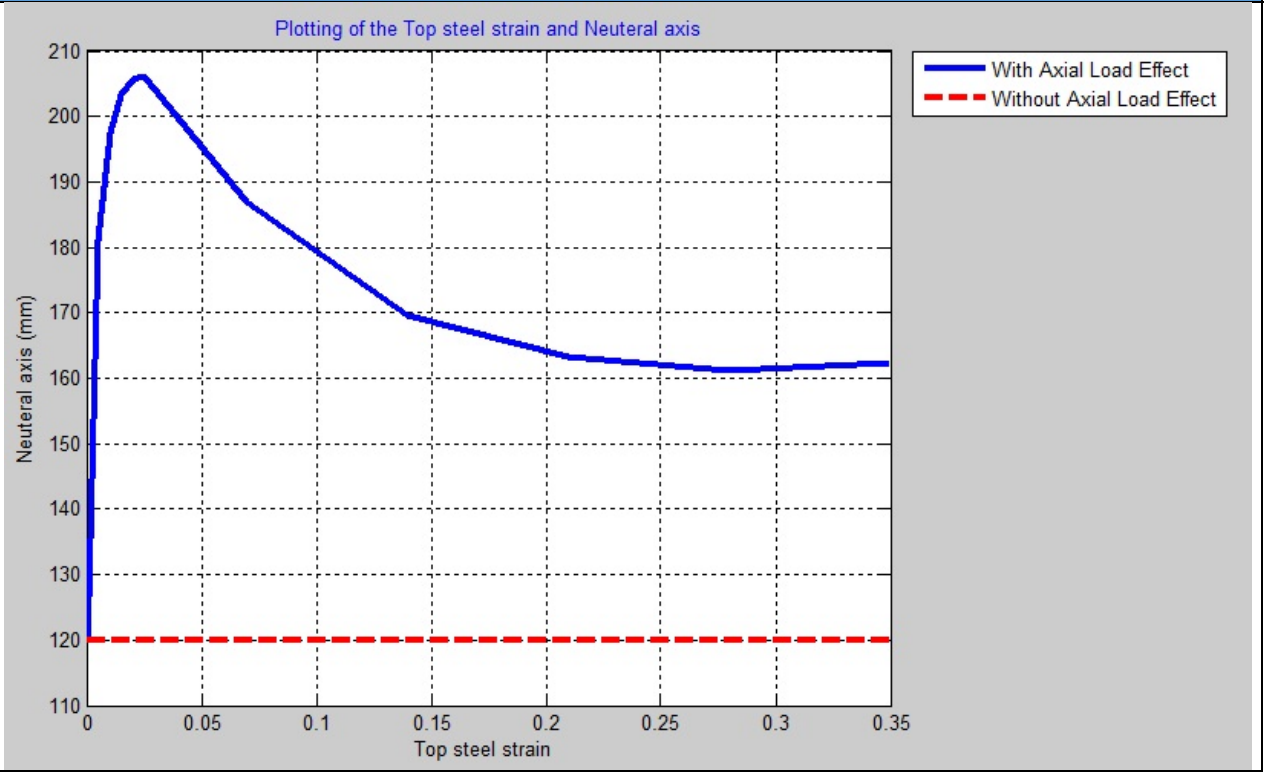
```
################################
# SECTION WITH AXIAL LOAD EFFECT #
################################
(+)It is converged in 2 iterations - Initial axial strain: 0.000265 - Initial axial stress: 53.040 (N/mm^2)

(+)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
```

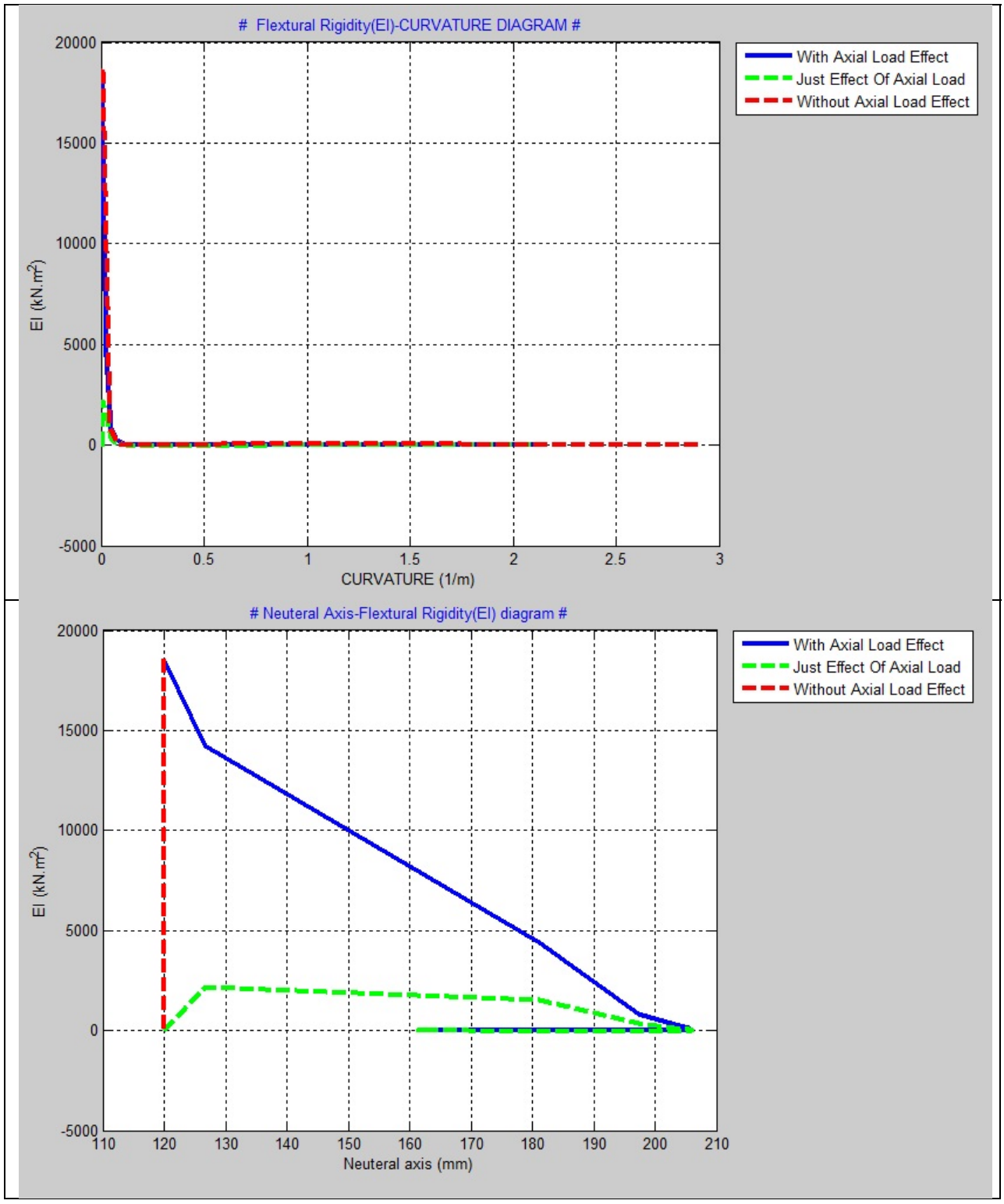
```
(+)Increment 3 : It is converged in 1 iterations - strain: 0.00072 - x: 120.00 - Phi: 0.00600 - Moment: 111.31
(+)Increment 4 : It is converged in 4 iterations - strain: 0.00096 - x: 120.08 - Phi: 0.00799 - Moment: 148.25
(+)Increment 5 : It is converged in 5 iterations - strain: 0.00120 - x: 126.57 - 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 ##

####################################
# SECTION WITHOUT AXIAL LOAD EFFECT #
####################################
(+)Increment 1 : It is converged in 6 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 ##

+============================================================+
  WithAxial Load Effect     |  Without Axial Load Effect
= Steel Section curve fitted  = Steel Section curve fitted =
   Curvature    Moment        Curvature    Moment
    (1/m)     (kN.m)          (1/m)     (kN.m)
------------------------------------------------------------
    0      0      0      0
  0.0146  270.4671   0.0124  229.6579
  2.1551  332.0403   2.9167  316.0717
+============================================================+
+-----------------------------------------------------------------------------+
 With Axial Load effect - Steel Material Ductility Rito : 14.00
 With Axial Load effect - Elastic EI (Exact): 18551.08 (kN.m^2)
 With Axial Load effect - Plastic EI (Exact): 28.77 (kN.m^2)
 With Axial Load effect - Steel Section Ductility Rito (Exact) : 147.82
 With Axial Load effect - Steel Section Over Strength Factor (Exact) :  1.23
 Without Axial Load effect - Elastic EI (Exact): 18551.08 (kN.m^2)
 Without Axial Load effect - Plastic EI (Exact): 29.75 (kN.m^2)
 Without Axial Load effect - Steel Section Ductility Rito (Exact) : 235.60
 Without Axial Load effect - Steel Section Over Strength Factor (Exact) :  1.38
+-----------------------------------------------------------------------------+
+==============================+
     With Axial Load Effect
=Steel Section Moment-Curvature=
     Curvature    Moment
       (1/m)      (kN.m)
--------------------------------
   0.00000      0.000
   0.00200     37.102
```

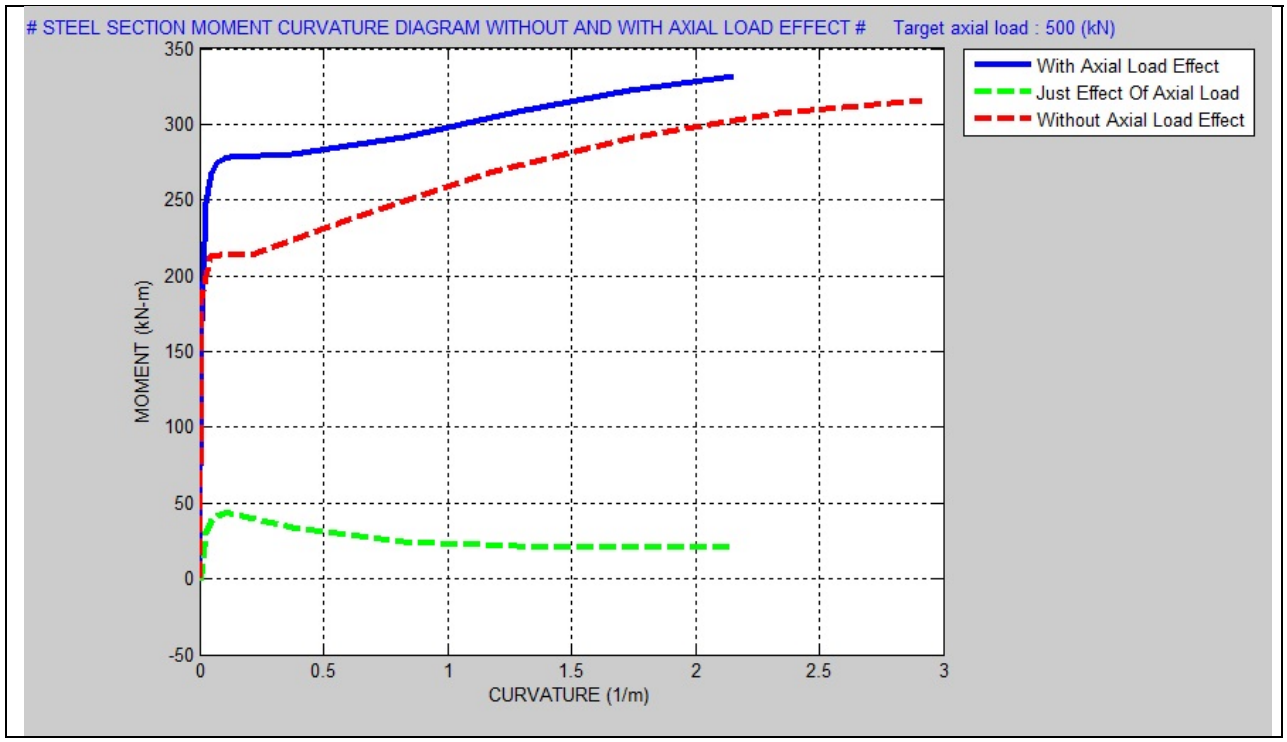
```
   0.00400     74.204
   0.00600    111.306
   0.00799    148.248
   0.00948    169.391
   0.02761    248.684
   0.05066    268.212
   0.07380    274.788
   0.09730    277.312
   0.12131    277.903
   0.37447    280.065
   0.82518    291.571
   1.28536    308.350
   1.73637    322.541
   2.15511    332.040
+==============================+
     Without Axial Load Effect
=Steel Section Moment-Curvature=
     Curvature    Moment
       (1/m)      (kN.m)
--------------------------------
   0.00000      0.000
   0.00200     37.102
   0.00400     74.204
   0.00600    111.306
   0.00800    148.409
   0.01000    185.511
   0.04167    213.190
   0.08333    213.777
   0.12500    213.886
   0.16667    213.924
   0.20833    213.942
   0.58333    236.204
   1.16667    267.619
   1.75000    291.438
   2.33333    307.592
   2.91667    316.072
+============================================================+
       Axial Load Effect      |  Without Axial Load Effect
= Steel Section curve fitted  = Steel Section curve fitted =
     Curvature    Moment          Curvature    Moment
       (1/m)      (kN.m)            (1/m)      (kN.m)
--------------------------------------------------------------
    0.0000      0.000               0.0000      0.000
    0.0146    270.467               0.0124    229.658
    2.1551    332.040               2.9167    316.072
+============================================================+

+==================== SECTION WITH AXIAL LOAD EFFECT ==========================+
 Increment   Top strain   Neuteral axis(x)    Curvature   Flextural Rigidity(EI)
================================================================================
  (i)           (1)           (mm)              (1/m)            (kN.m^2)
--------------------------------------------------------------------------------
   1           0.00024        120.00          0.002000          18551.08
   2           0.00048        120.00          0.004000          18551.08
   3           0.00072        120.00          0.006000          18551.08
   4           0.00096        120.08          0.007995          18519.66
   5           0.00120        126.57          0.009481          14229.69
   6           0.00500        181.11          0.027608           4374.15
   7           0.01000        197.39          0.050662            847.11
   8           0.01500        203.25          0.073802            284.16
   9           0.02000        205.55          0.097299            107.42
  10           0.02500        206.08          0.121309             24.62
  11           0.07000        186.93          0.374474              8.54
  12           0.14000        169.66          0.825177             25.53
  13           0.21000        163.38          1.285358             36.46
  14           0.28000        161.26          1.736368             31.46
  15           0.35000        162.40          2.155112             22.69
+==================== SECTION WITHOUT AXIAL LOAD EFFECT =======================+
 Increment   Top strain   Neuteral axis(x)    Curvature   Flextural Rigidity(EI)
================================================================================
  (i)           (1)           (mm)              (1/m)            (kN.m^2)
```

1	0.00024	120.00	0.002000	18551.08
2	0.00048	120.00	0.004000	18551.08
3	0.00072	120.00	0.006000	18551.08
4	0.00096	120.00	0.008000	18551.08
5	0.00120	120.00	0.010000	18551.08
6	0.00500	120.00	0.041667	874.08
7	0.01000	120.00	0.083333	14.09
8	0.01500	120.00	0.125000	2.61
9	0.02000	120.00	0.166667	0.91
10	0.02500	120.00	0.208333	0.42
11	0.07000	120.00	0.583333	59.37
12	0.14000	120.00	1.166667	53.85
13	0.21000	120.00	1.750000	40.83
14	0.28000	120.00	2.333333	27.69
15	0.35000	120.00	2.916667	14.54

Plotting :




Flextural Rigidity(EI)-CURVATURE DIAGRAM
With Axial Load Effect
Just Effect Of Axial Load
Without Axial Load Effect
EI (kN.m2)
CURVATURE (1/m)
20000
15000
10000
5000
0
-5000
0
0.5
1
1.5
2
2.5
3
Neuteral Axis-Flextural Rigidity(EI) diagram
With Axial Load Effect
Just Effect Of Axial Load
Without Axial Load Effect
EI (kN.m2)
Neuteral axis (mm)
20000
15000
10000
5000
0
-5000
110
120
130
140
150
160
170
180
190
200
210


STEEL SECTION MOMENT CURVATURE DIAGRAM WITHOUT AND WITH AXIAL LOAD EFFECT
Target axial load : 500 (kN)
With Axial Load Effect
Just Effect Of Axial Load
Without Axial Load Effect
MOMENT (kN-m)
CURVATURE (1/m)
350
300
250
200
150
100
50
0
-50
0
0.5
1
1.5
2
2.5
3