Ankita Nag
Title: Deflection of cantilever beam (different section types)

1. Summary:
In this discussion, a cantilever beam is analysed . The measure to which a structural member gets deviated from its initial position is called deflection. Here we have a cantilever beam with a point load applied at the free end. Using Ansys workbench we pictorially got the variation of total deformation, directional deformation about X,Yand Z axis , total bending moment, directional bending moment , direct stress , minimum and maximum combined stress. Also by parametric study we got the variation of maximum combined stress and directional deformation with length and young's modulus . Also the interchanging of breadth and height of the element are interchanged and corresponding variation is shown.

2. Introduction:
Describe background information about the analysis.

3. Objectives:
Explain what information is required and how this data will be obtained.

Data given

Material: Steel
Young's modulus E =200 GPa
Poison's ratio μ=0.3

Geometry: L= 7 m
b= 25 cm;
d= 75 cm

Load:
P= 10 kN

Things need to be found :

1. Total deformation
2. Directional deformation about 3 axes
3. Total bending moment
4. Directional bending moment
5. Direct stress
6. Minimum and maximum combined stress
7. Parametric study of length and young's modulus and variation of maximum combined stress and directional deformation.
8. Interchange of breadth and height of element and it's effect.

4. Analytical solutions (if available):

Moment of Inertia, I =bd^3/12
Section Modulus, Z=bd^2/6
End deflection, delta=PL^3/3EI
Bending stress (max at top/bottom faces), σ= PL/Z
Calculating all values we get .

E	200	Gpa
nu	0.3	
L	7000	mm
b	250	mm
d	750	mm
F	10000	N
I	8789062500	mm^4
Z	23437500	mm^3

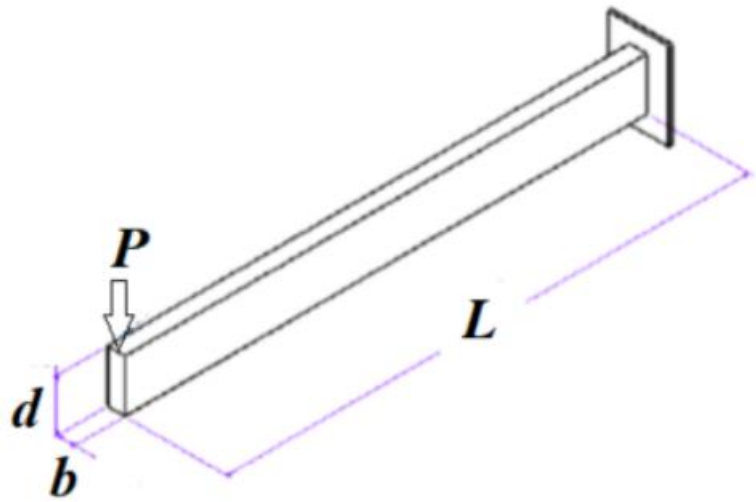
Delta	0.65042963	mm
sigma	2.986666667	Mpa

5. Model Details:

Models details are given as following,

Property	Value	Unit
Length	7000	mm
breadth	250	mm
depth	750	mm
Force	10000	N
Area moment of inertia	8789062500	mm^4
Section Modulus	23437500	mm^3

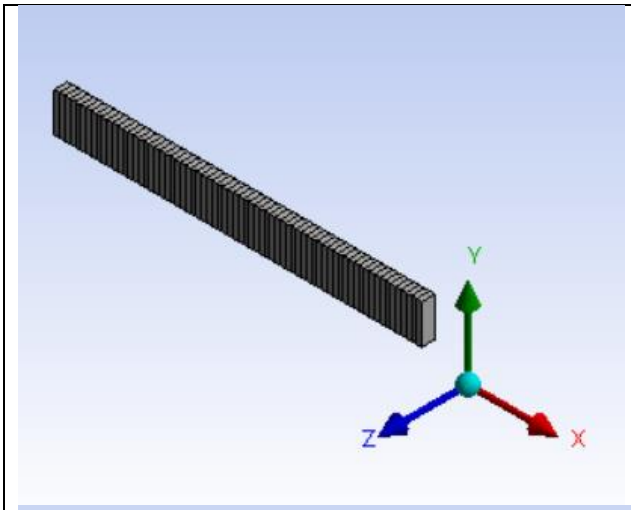
Diagram:

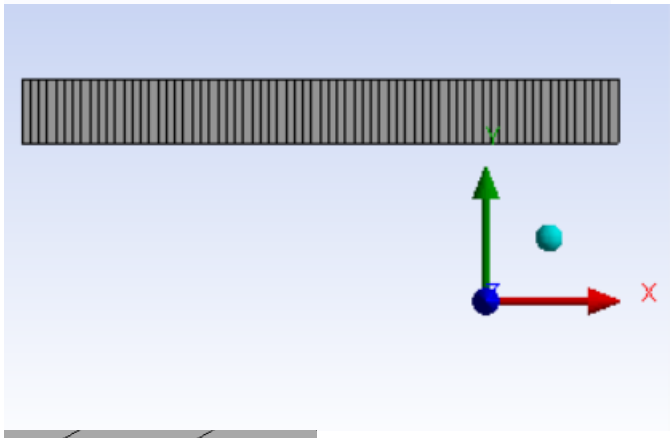


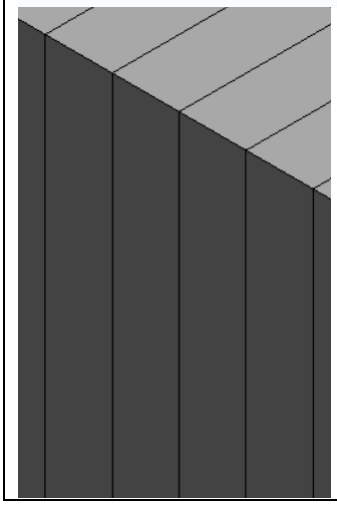
5.1 Element details:

Number of nodes: 141
Number and type of elements:73 and Beam element , condensed parts

The models in figure after meshing both zoomed in and out views are shown :

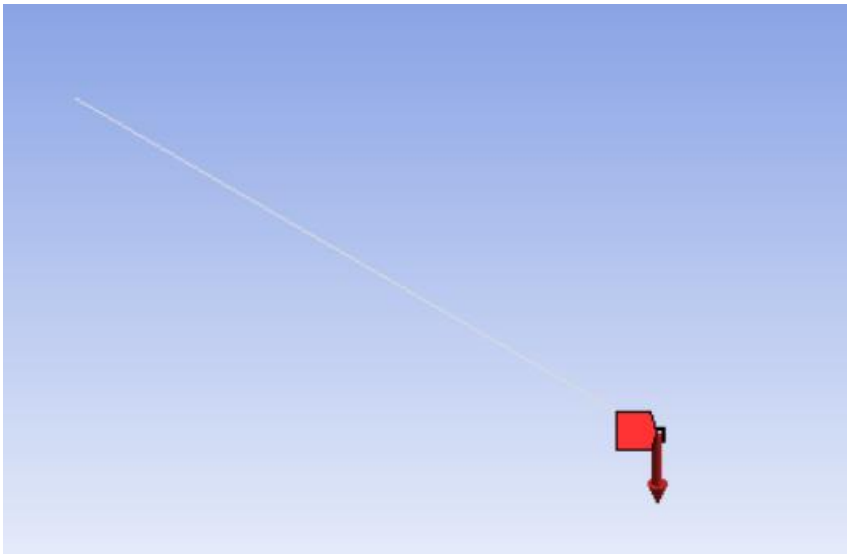






5.2 Type of Analysis:
3d static structural analysis
5.3 Material Data:
Young's Modulus: 200 Gpa
Poisson's Ratio:0.3
Density: N/A

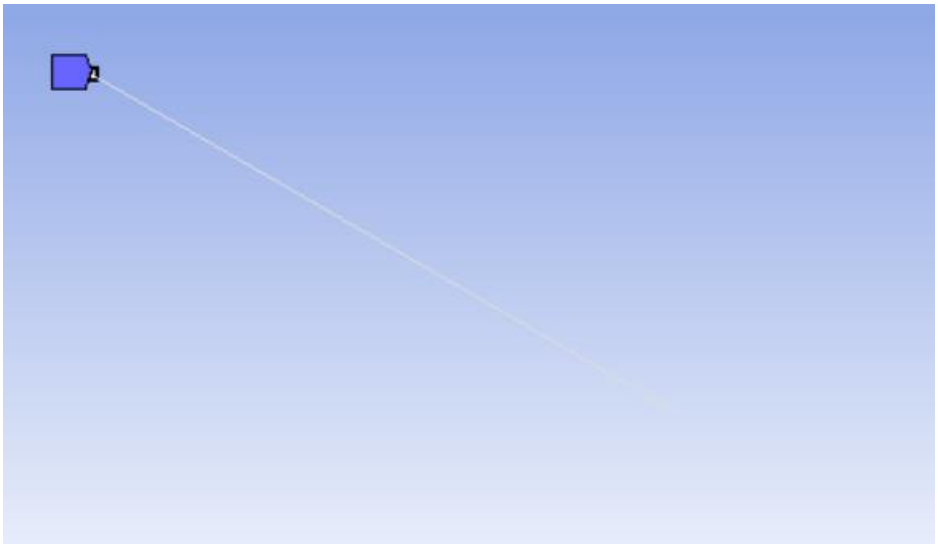
5.4 Loads:
Load is applied as shown .
Here beam is shown by a thin line and load is shown by arrow , value of load is 10000 N in -ve Y direction.



5.5 Boundary conditions:

Show the locations of constraints and describe the degrees of freedom (DOF). May be with figures

Fixed support is at the end of beam.
Degree of freedom: Two
Each end of the beam has one rotational and two translational degrees of freedom. In the unrestricted state, these are the beam's complete degrees of freedom.



Here the beam is shown by a thin line and fixed support is shown by blue block.

6. Calculations using Analytical solutions (if available):

Mentions the parameters with value as input considered in FEA (if not mentioned before) and corresponding results from analytical solutions.

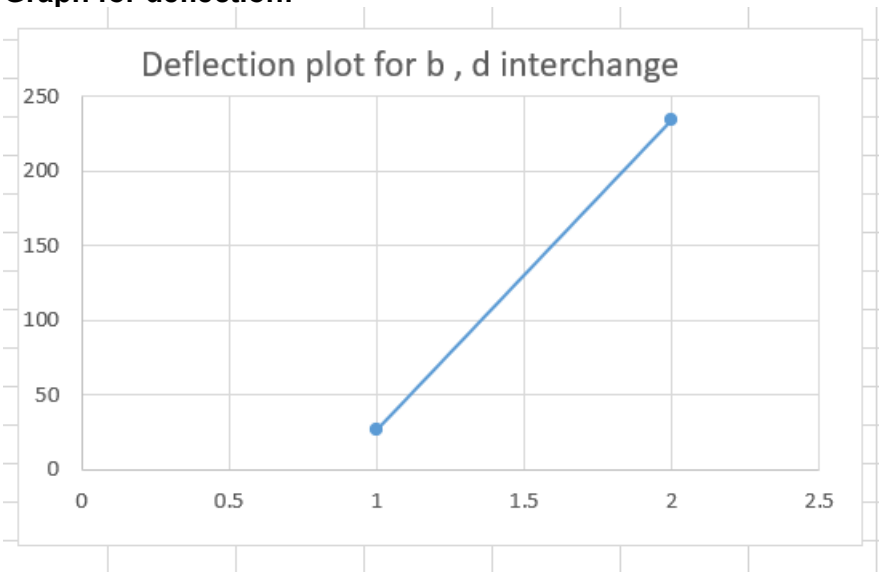
E	200	Gpa
nu	0.3	
L	7000	mm
b	250	mm

d	750	mm
F	10000	N
I	8789062500	mm^4
Z	23437500	mm^3
Delta	0.65042963	mm
sigma	2.986666667	Mpa

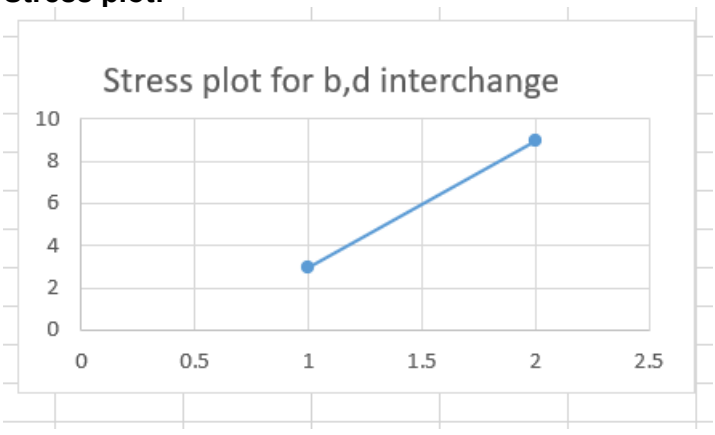
1)Interchanging b& d:

	b & d interchange	
E	5	5
nu	0.3	0.3
L	7000	7000
b	250	750
d	750	250
F	10000	10000
I	8.79E+09	9.77E+08
Z	23437500	7812500
Delta	26.01719	234.1547
sigma	2.986667	8.96

a) Graph for deflection:



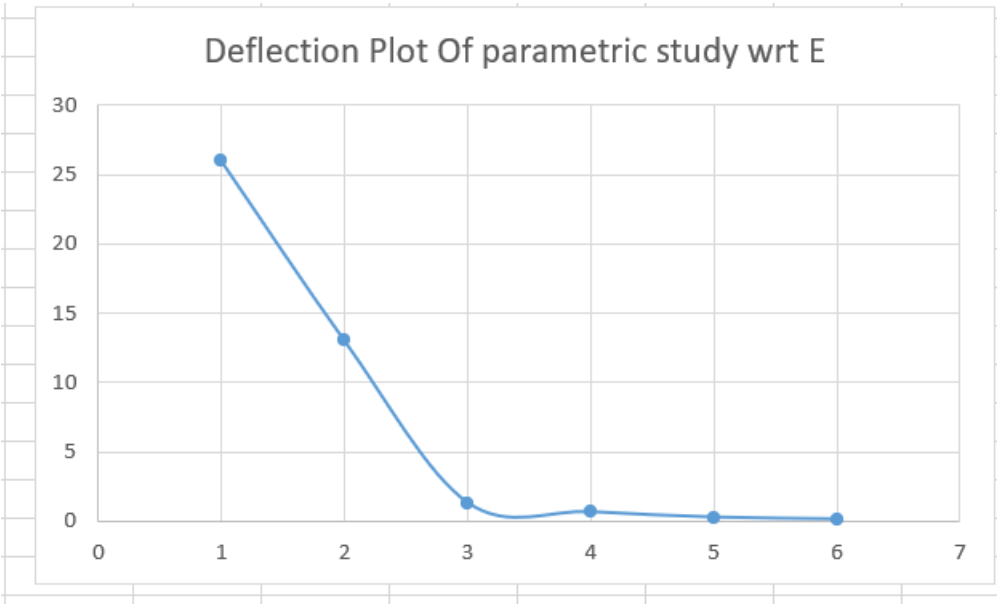
b) Stress plot:



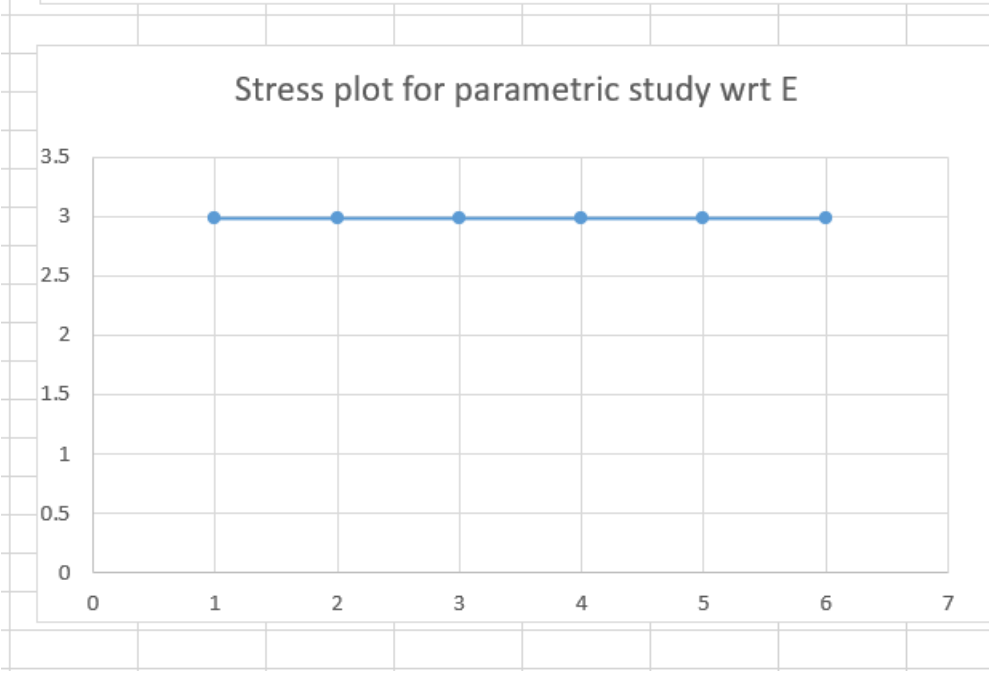
2) Parametric study wrt Young's Modulus:

	Parametric study wrt E					
E	5	10	100	200	500	1000
nu	0.3	0.3	0.3	0.3	0.3	0.3
L	7000	7000	7000	7000	7000	7000
b	250	250	250	250	250	250
d	750	750	750	750	750	750
F	10000	10000	10000	10000	10000	10000
I	8.79E+09	8.79E+09	8.79E+09	8.79E+09	8.79E+09	8.79E+09
Z	23437500	23437500	23437500	23437500	23437500	23437500
Delta	26.01719	13.00859	1.300859	0.65043	0.260172	0.130086
sigma	2.986667	2.986667	2.986667	2.986667	2.986667	2.986667

a) Deflection plot:



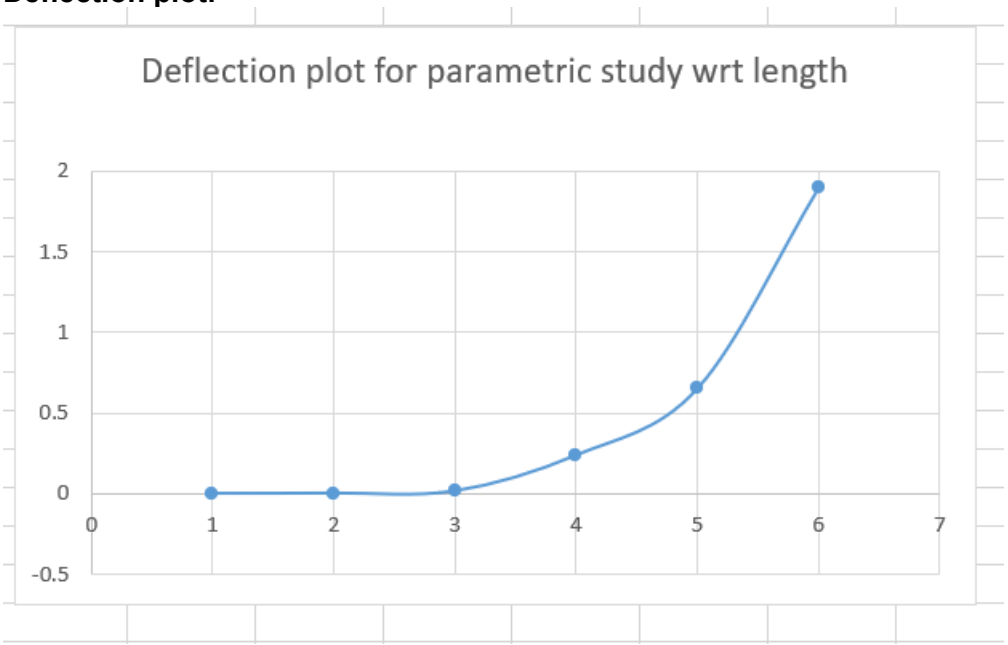
b) Stress plot:



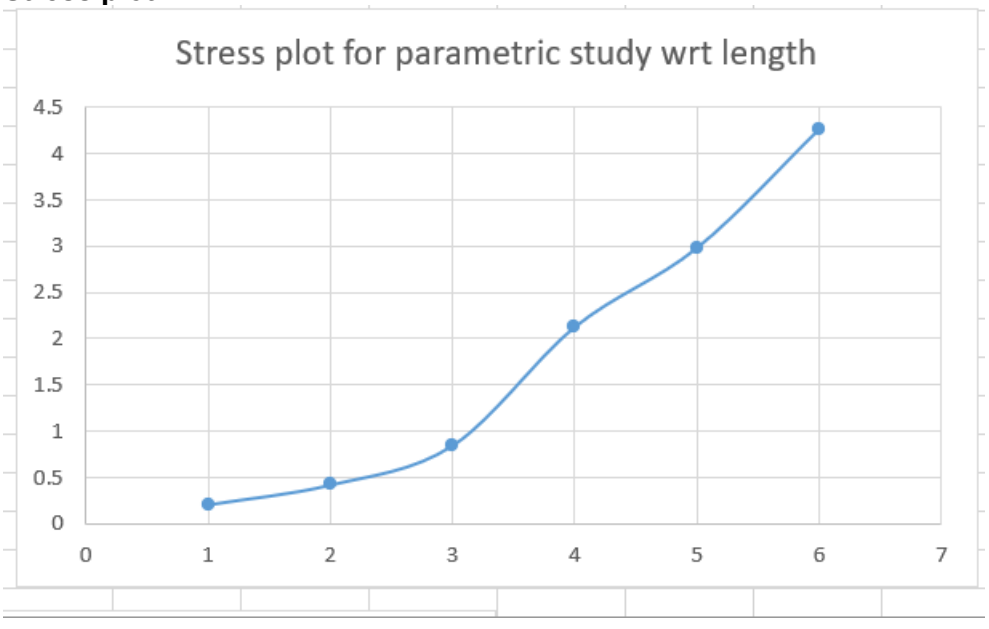
3) Parametric study wrt length:

	Parametric study wrt to length					
E	200	200	200	200	200	200
nu	0.3	0.3	0.3	0.3	0.3	0.3
L	500	1000	2000	5000	7000	10000
b	250	250	250	250	250	250
d	750	750	750	750	750	750
F	10000	10000	10000	10000	10000	10000
I	8.79E+09	8.79E+09	8.79E+09	8.79E+09	8.79E+09	8.79E+09
Z	23437500	23437500	23437500	23437500	23437500	23437500
Delta	0.000237	0.001896	0.01517	0.237037	0.65043	1.896296
sigma	0.213333	0.426667	0.853333	2.133333	2.986667	4.266667

a) Deflection plot:

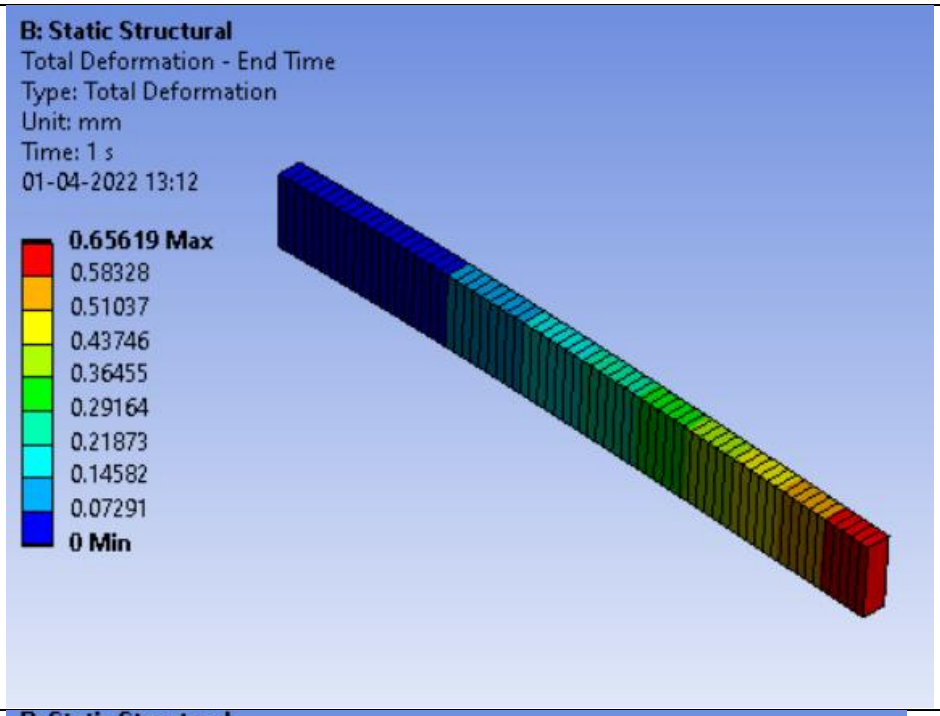
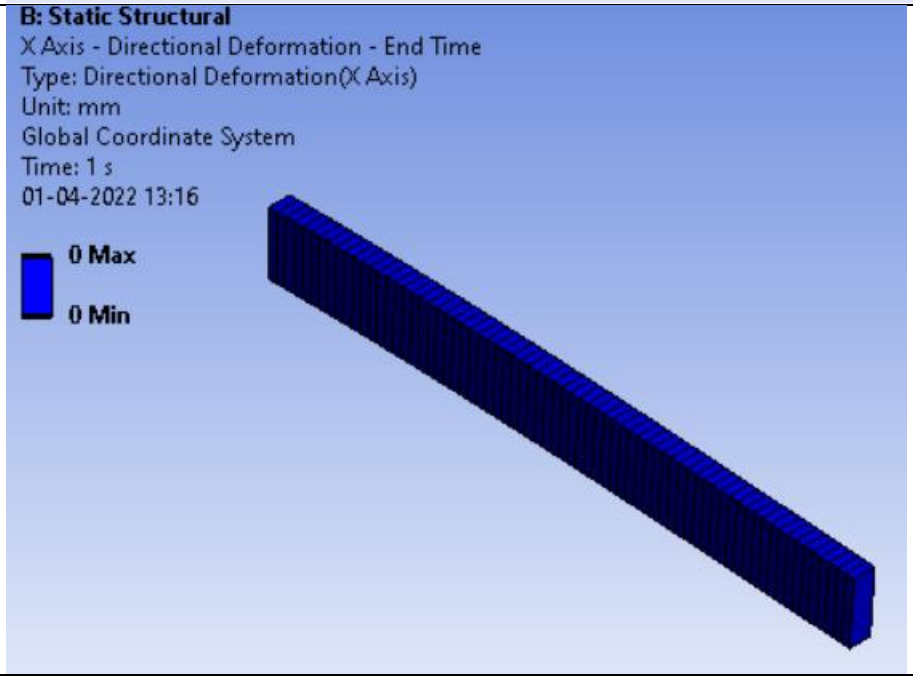


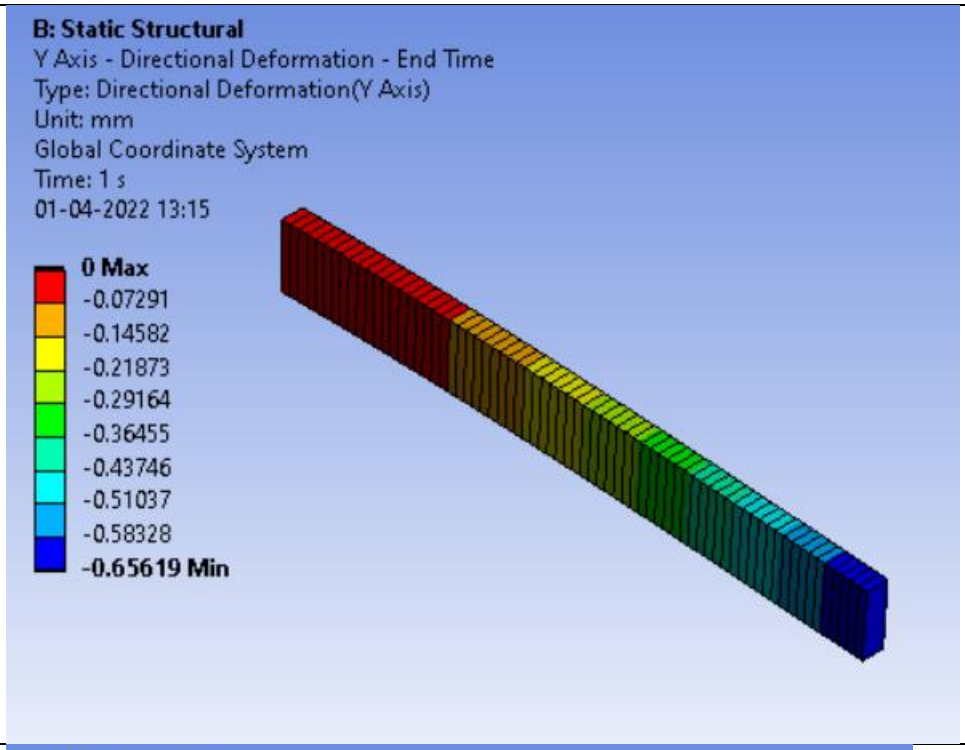
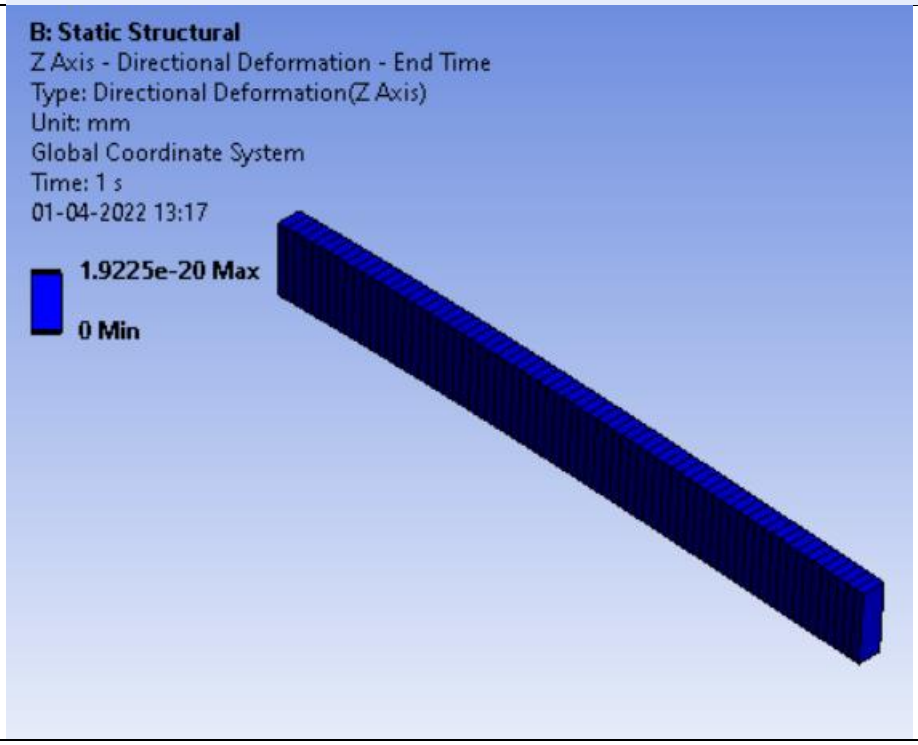
b) Stress plot:

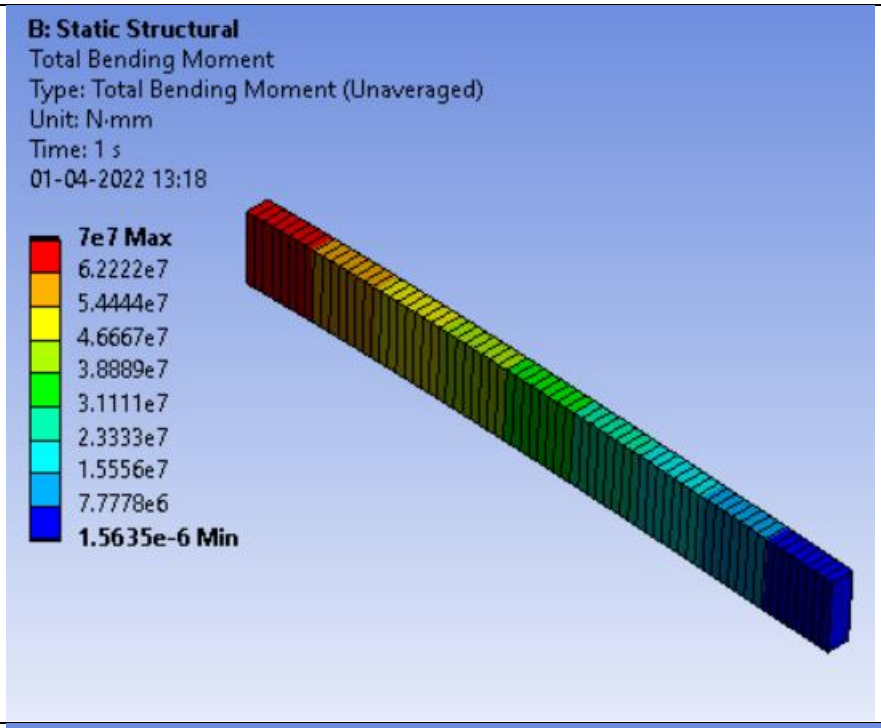
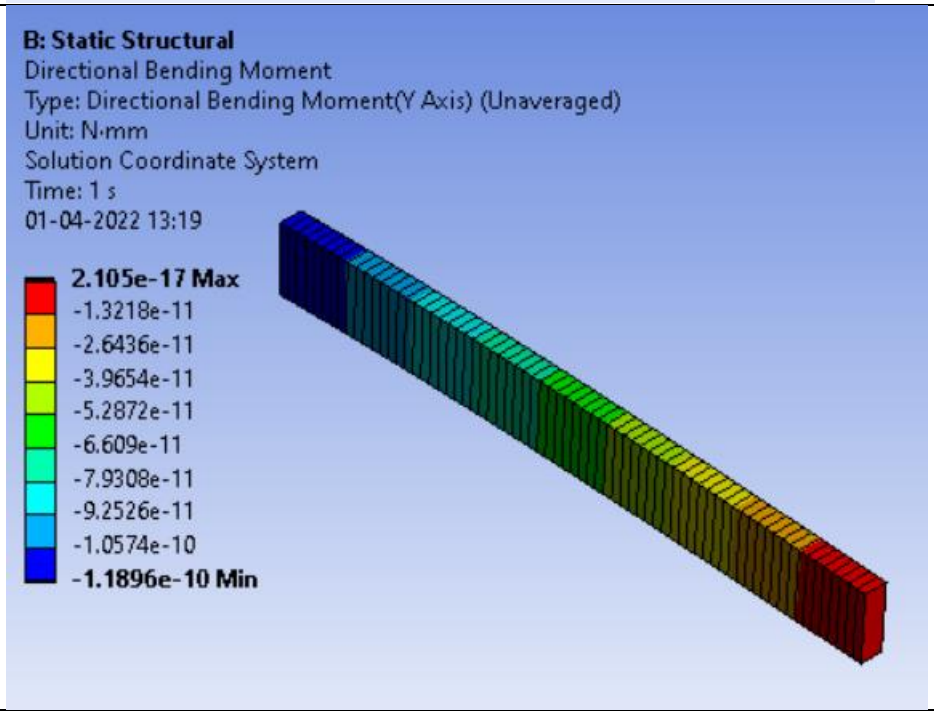


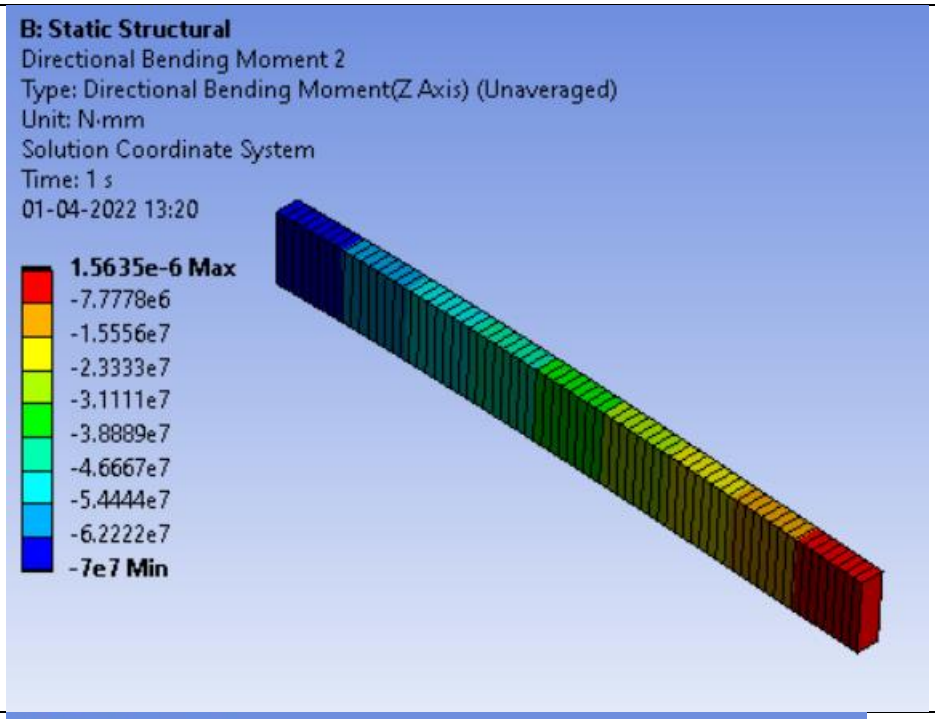
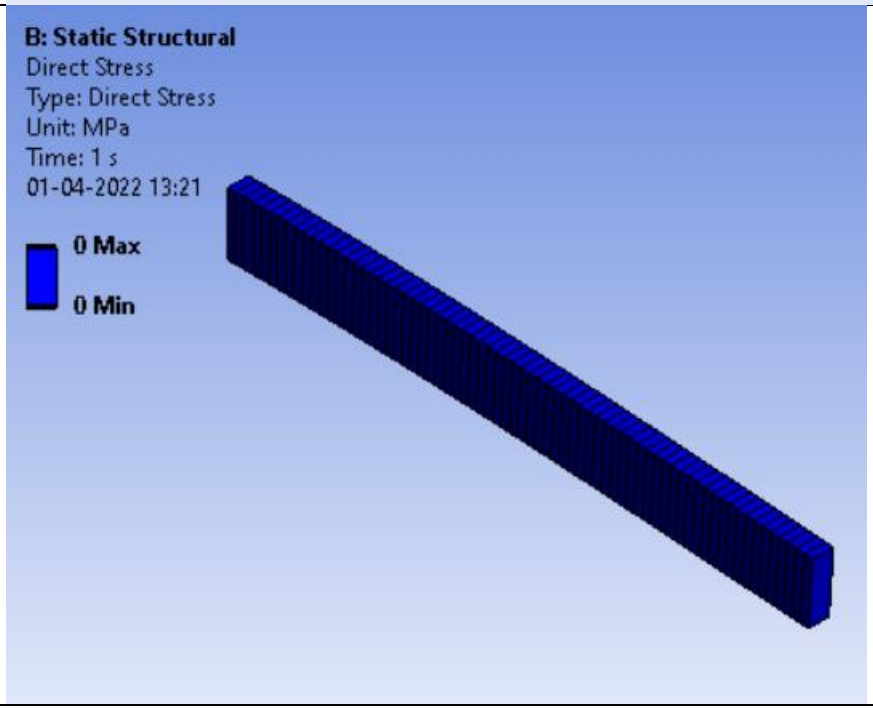
7. Results:

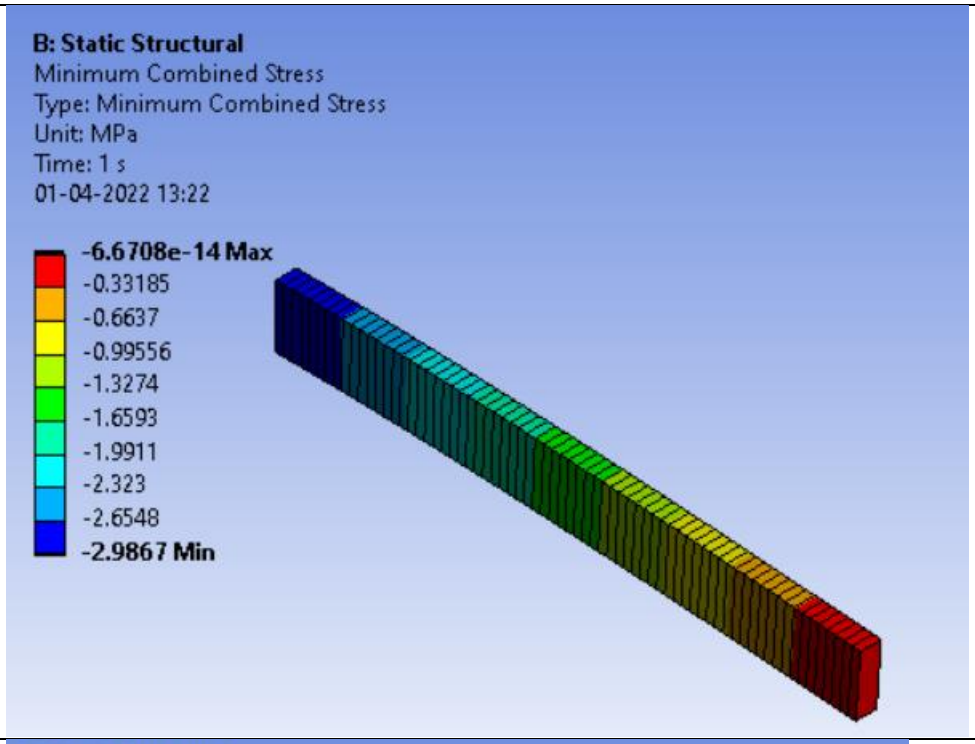
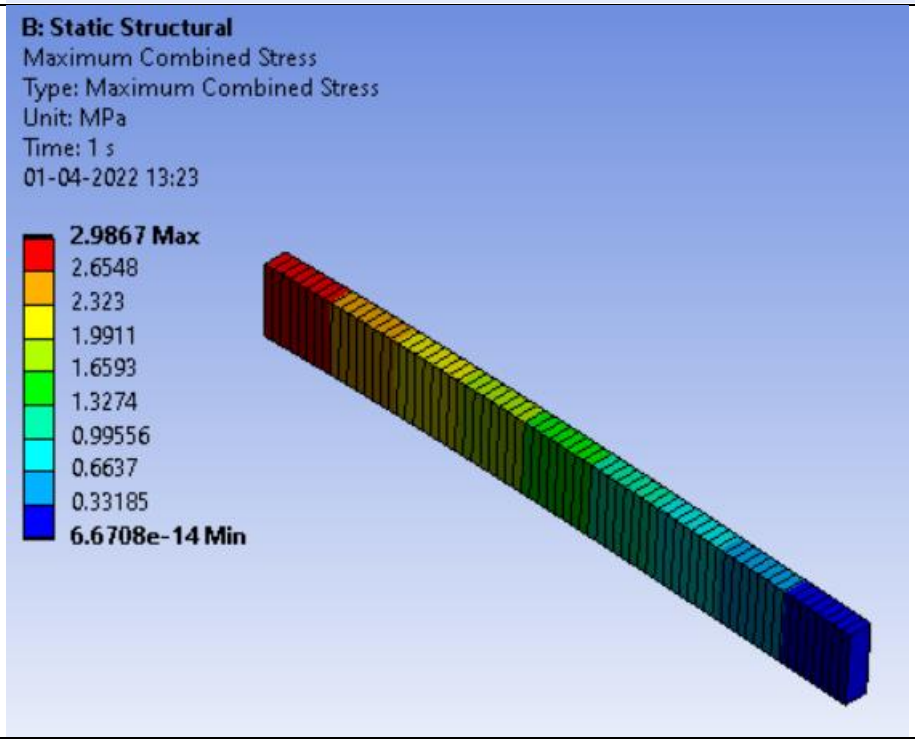
Include pictures of key stress and displacement plots. It is useful to tabulate or graph results when reporting a high number of load cases (can use more no. of column/rows).

Total stress	
Directional Deformation (X axis)	

Directional deformation(Y axis)	
Directional deformation(Z axis)	

Total Bending moment	
Directional BM Y axis	

Directional BM Z axis	
Direct stress	

Minimum combined stress	
Maximum combined stress	

Parametric study table

	A	B	C	D	E	F
1	Name	P1 - d	P2 - b	P5 - Young's Modulus	P6 - length	P3 - Maximum Combined Stress Maximum
2	Units	mm	mm	MPa	mm	MPa
3	DP 0 (Current)	750	250	2E+05	7000	2.9867
4	DP 1	250	750	2E+05	7000	8.96
5	DP 2	750	250	5000	7000	2.9867
6	DP 3	750	250	10000	7000	2.9867
7	DP 4	750	250	50000	7000	2.9867
8	DP 5	750	250	70000	7000	2.9867
9	DP 6	750	250	1E+05	7000	2.9867
10	DP 7	750	250	5E+05	7000	2.9867
11	DP 8	750	250	1E+06	7000	2.9867
12	DP 9	750	250	2E+05	500	0.21333
13	DP 10	750	250	2E+05	1000	0.42667
14	DP 11	750	250	2E+05	5000	2.1333
15	DP 12	750	250	2E+05	10000	4.2667
*						

Use Table for results with value/s and compare with analytical solution (if available)

Property	Analytical	FEA	Error(%)	
Deflection(mm)	0.65042963	0.65619	0.88	
Stress(Mpa)	2.986666667	2.9867	0.0011	

Mesh sensitivity study: (can use more no. of rows) - NA

Steps	Global mesh size	No. of nodes	No. of elements
Step 1	**100 mm**	**141**	**73**
Step 2	**50**	**281**	**143**
Step 3	**20**	**701**	**353**
Step 4	**100**	**141**	**73**
Step 5	**50**	**281**	**143**

For error in deflection in step 1 to 3 , error in stress in step 4 to 5

Steps	Analytical solution	FEA results	% of Error
Step 1	0.65042963	0.65619	0.88
Step 2	0.65042963	**0.65619**	**0.88**
Step 3	0.65042963	**0.65619**	**0.88**
Step 4	2.986666667	2.9867	0.0011
Step 5	2.986666667	2.9867	0.0011

Deflection in error and stress remains same for each case.

8. Conclusions:

Report the key findings of the analysis and confirm if the objectives have been met. Recommendations for product improvement are always welcome.

By this modelling and simulation we can easily visualize the deflection of beam , many important parameters such as stress , deflection , bending moment can be calculated and pictorially we can get the variation . Ansys is a very powerful tool to visualize such analysis.

9. References:

List the references used for material data, loads and any hand calculation equations (if any).

1) Excel sheet is used for the analytical calculation
2) All data provided in assignment document