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Analysis of Different Beams

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***Abstract*— The present work focus on the statically analysis for the beams in terms of different loading condition (namely point load and uniformly distributed loading condition). The beam under analysis has generalised support condition i.e. simply supported, cantilever and fixed support through Finite Element Method. The beam analysed has "rectangular" shape cross section. The maximum deflection for all the above beams has been determined using NX Cad and Finite Element Method.**

Keywords—Finite Element Analysis, Beam. Nx Cad, Simply Supported Beam, Cantilever Beam, Fixed Beam.

I. INTRODUCTION

Beams belong to the basic structural members used in the modelling abstraction of mechanical systems [1]. In this paper behaviour of beam and solid elements are discussed on the basis of Deflection occurred on beam due to various types of load i.e point load and uniformly distributed load applied on rectangular section beam. A member subjected to bending moment and shear force undergoes certain deformations. The material of the member will offer resistance or stresses against these deformations [2]. It is possible to estimate these stresses with certain assumptions. The beam cannot have any translational movements at its support points, but no restriction is placed on rotations at the supports. The deflected distance of a member under a load is directly related to the slope of the deflected shape of the member under that load. While the beam gets deflected under the loads, bending moment occurs in the same plane due to which stresses are developed. Here the deflection of the beam element is calculated by using the Euler-Bernoulli's beam equation [3]

The cross section use in the analysis is rectangular as shown in fig . The height of the beam(b) is 50mm, width of the beam(c) is 100mm and the length of the beam(a) is 200mm. The cross sectional area of the beam is 5000mm2, Ix(second moment of area about x axis)=1041666.666mm4, Iy (second moment of area about y axis)=4166666.667mm4, E(young's modulus)= 210 GPA.

II. THEORETICAL ANALYSIS

Different beam shows different deflection depending on the loading condition. In our analysis we have focussed on two loading condition namely Point load and Uniformly distribution load on three different beams namely cantilever beam, fixed beam and simply supported beam. Their maximum deflection formulas are as follows:

(a) POINT LOADING CONDITION

- CANTILEVER BEAM

Maximum DEFLECTION=WL3/3EI

- FIXED BEAM

Maximum DEFLECTION=WL3/192EI

- SIMPLY SUPORTTED BEAM

Maximum DEFLECTION=WL3/48EI

(b) UNIFORMALY DISTRIBUTED CONDITION

- CANTILEVER BEAM

Maximum Deflection = W'L4 / 8EI

- FIXED BEAM

MAXIMUM DEFLECTION = W'L4 / 384EI

- SIMPLY SUPORTTED BEAM

MAXIMUM DEFLECTION= 5W'L4 / 384EI

Here w is the load with value equal to 5000 KN and w' is the UD load equal to 25 KN/mm.".

I.1 Design of beam

The current study involves geometric modelling of rectangular cross sectional beam using NX 10.0. the material which is assumed is Iron-60 with mass density of 7.69e-006 kg/mm^3. Various other properties of Iron-60 are shown in the figure below:

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                    MATERIAL INFORMATION

------------------------------------------------------------

Library Material : Iron_60
Category            METAL
SubCategory         Cast Iron
Library Reference   physicalmateriallibrary.xml
    Category                             : METAL
    Sub-Category                         : Cast Iron
    Material Type                        : IsotropicMaterial
    Version                              : 4.0
    Mass Density (RHO)                   : 7.469e-006kg/mm^3

     ======== Mechanical
    Young's Modulus (E)                  : 131000000mN/mm^2(kPa)
    Poisson's Ratio (NU)                 : 0.25
    Type of Nonlinearity (TYPE)          : 1
    Yield Function Criterion (YF)        : 1
    Hardening Rule (HR)                  : 1

     ======== Strength
    Yield Strength                       : 130000mN/mm^2(kPa)

     ======== Formability
    Initial Strain                       : 0.02mm/mm
    Hardening Exponent                   : 0.22
    Strength Coefficient                 : 52437.64N/mm^2(MPa)
    R0                                   : 1.8
    R45                                  : 2.2
    R90                                  : 2.4

     ======== Thermal/Electrical
    Thermal Expansion Coefficient (A)    : 1.08e-0051/C
    Thermal Conductivity (K)             : 52000microW/mm-C
    Specific Heat (CP)                   : 447000000microJ/kg-K
```

FIG1: IRON-60 MECHANICAL PROPERTIES

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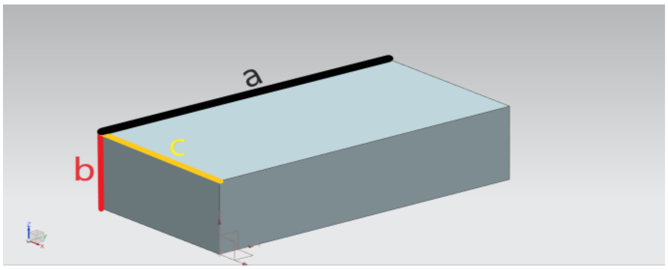

Fig 2: cross-sectional of rectangular beam

2.2 CANTILEVER BEAM

A cantilever is a beam fixed at only one end. The beam carries the load to the support. At the support it is forced against by a moment and shear stress. Cantilever construction allows for overhanging structures without the need of external bracing. Cantilevers are sometimes constructed with trusses or slabs.

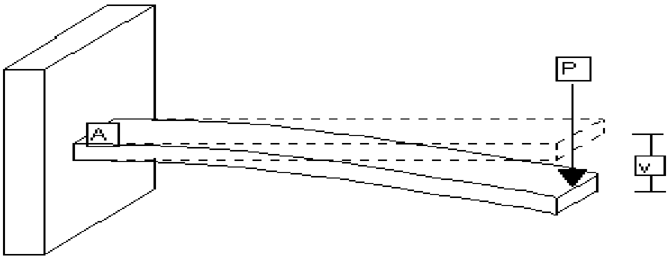

Fig 3: Cantilever Beam

Main advantages are:-

- The life can be greater than that of a simple supported beam, because a beam can be added to the cantilever arms.
- Because the beam is resting simply on the arms, thermal expansion and ground movement are fairly simple to withstand.
- Cantilever arms are very firm, because of their depth.

Main disadvantages are-

- They maintain their shape by the opposition of huge tensile and compressive forces, as well as shear, and are therefore the beam are relatively massive.
- Truss construction is used in order to reduce the weight.

2.3. FIXED BEAM

A fixed beam is one with ends controlled from rotation. In actuality a beams ends are never completely fixed, as they are frequently modelled for simplicity. However, they can easily be control enough relative to the stiffness of the beam and column to be considered fixed.

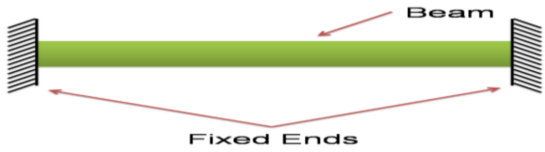

Fig 4 : Fixed Beam

Advantages

- Very Useful when finding support moments of an indeterminate beams such as continuous beams.
- Reduced deflection because of reduced sagging moments.

Disadvantages

- Difficult to maintain the two ends of the beam.
- Large stresses because of temperature variations.

2.4. Simply Supported Beam

A simply supported beam is simply supported at the supports and is stable in nature. The only way in which you can support a fully stable beam without any degree of indeterminacy [1] is to have a pin-joint at one support and a roller at the other support. Line diagram for simply supported beam is:

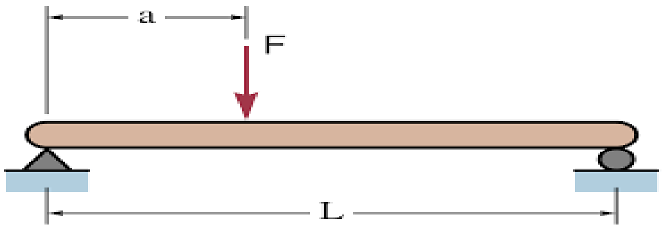

Fig 5 : simply supported beam

Main Advantages Are:-

- It's simple and quick to analyse a simply supported beam.
- A simply supported beam does not transfer moments at its supports. This is a big benefit where the supporting member may need to be slender and because of this it is only capable of carrying axial loads.
- Simply supported beams does not require any complicated connection for the supporting member.
- It transfers less load into a central supporting member compared to a continuous beam.
- Simply supported beams transfer more load to the end supports than a continuous beam, which is advantageous in certain situations.
- Simply supported beams may have to be larger and deeper to carry the same load, which increases their shear capacity.

III. FINITE ELEMENT ANALYSIS

NX 10.0 software has been used for finite element analysis of different types of beam namely the Fixed Beam, Simply Supported Beam and Cantilever Beam under two loading condition i.e. uniformly distributed load and point load condition. After modelling one of the most important stage is the meshing. In meshing an element is divided into finite number of small element and then ever small element is solved individually [4]. There are two ways we can mesh an element i.e. 2D or 3D. meshing is also called as "grid

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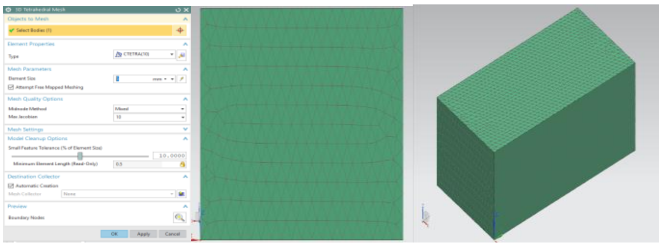
generation". The accuracy of the result can also be improved by changing the size of the element but increasing the number of elements also increases the computational time by insignificant change in accuracy.



(a) (b) (c)

Fig 6 : (a) the mesh size and configuration (b) "Rectangular" shape cross section made on nx cad (c) triangular meshing of the beam

IV. RESULTS

4.1. POINT LOAD

A point load is an equivalent load applied to a single point, which you can determine by calculating the total load over the object's surface or length and attributing the entire load to its centre.

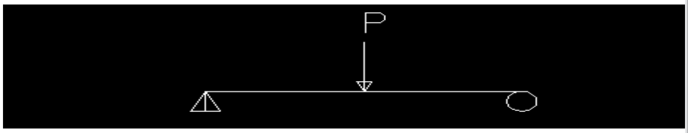
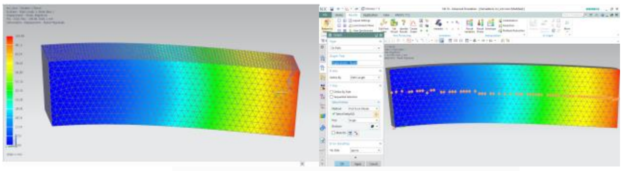


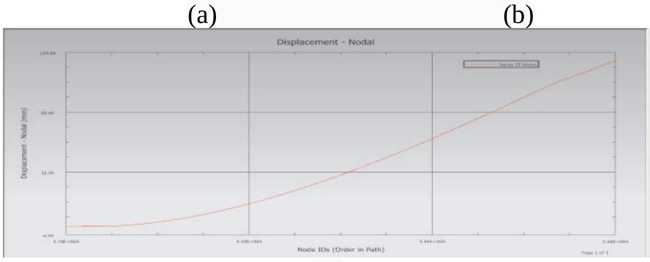
Fig 7: Point Load

In case of cantilever beam the load is applied at the free end where as in case of simply supported beam and fixed beam the load is applied at the centre i.e. at 100mm form each end. The load applied equal to 5000KN in all three cases.

4.1.1. CANTILEVER BEAM



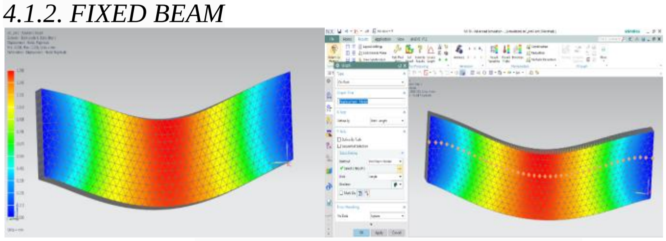
(a) (b)



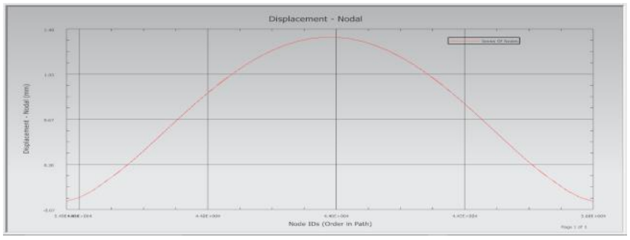
(c)

Fig 8: (a)displacement after the application of load on cantilever beam with point load, (b)show the different nodal point, (c) shows the graph between displacement and nodal point on the beam.

4.1.2. FIXED BEAM



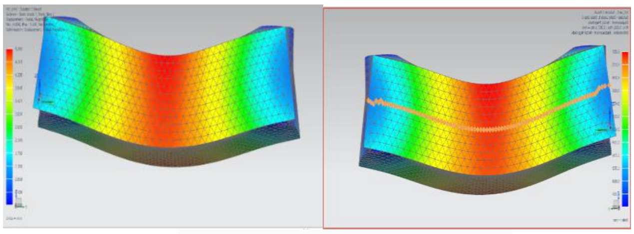
(a) (b)



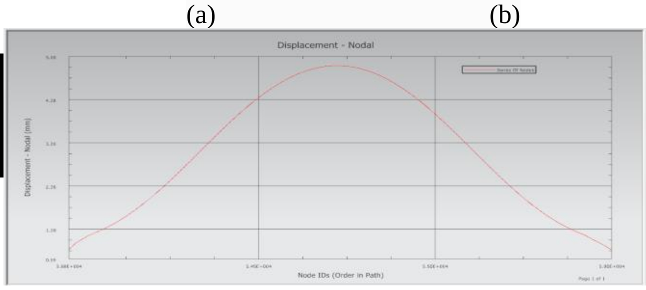
(c)

Fig 9: (a)displacement after the application of load on fixed beam with point load, (b)show the different nodal point, (c) shows the graph between displacement and nodal point on the beam.

4.1.3. SIMPLY SUPORTTED BEAM



(a) (b)



(c)

Fig 10: (a)displacement after the application of load on simply supported beam with point load, (b)shows the different nodal point, (c) shows the graph between displacement and nodal point on the beam.

4.2. Uniformly Distributed Load

Uniformly distributed load is that whose magnitude remains uniform throughout the length.

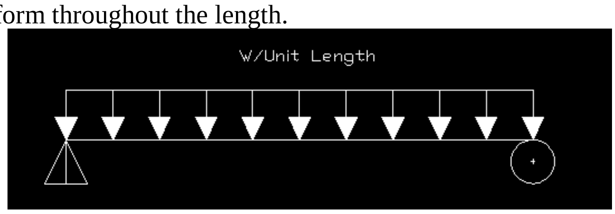
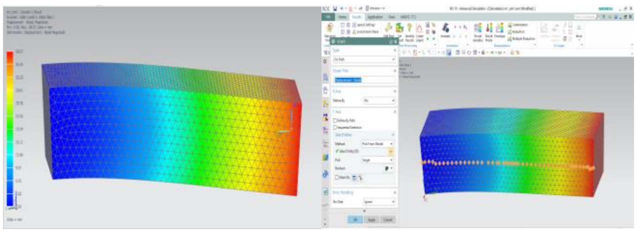


Fig 11: uniformly distributed load

The uniformly distributed load applied equal to 50KN/mm in all the three cases.

4.2.1. CANTILEVER BEAM



(a) **(b)**

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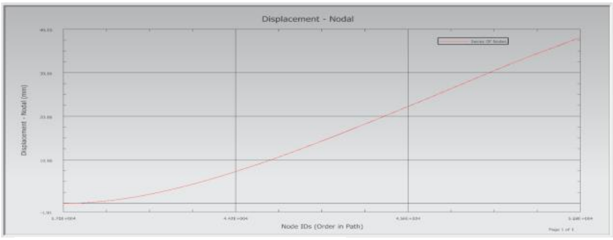
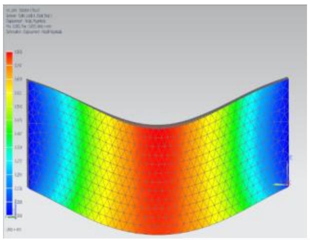
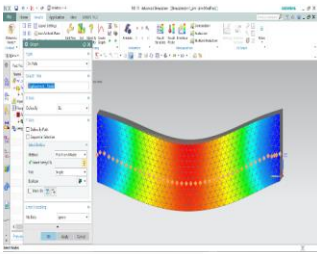


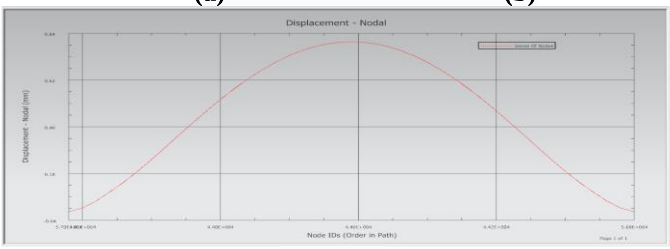
(c)

Fig 12: (a)displacement after the application of load for cantilever beam with uniformly distributed load, (b)show the different nodal point, (c) shows the graph between displacement and nodal point on the beam.

4.2.2. FIXED BEAM

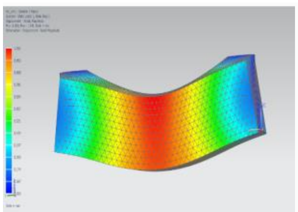
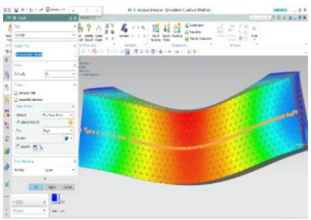
(a) **(b)**



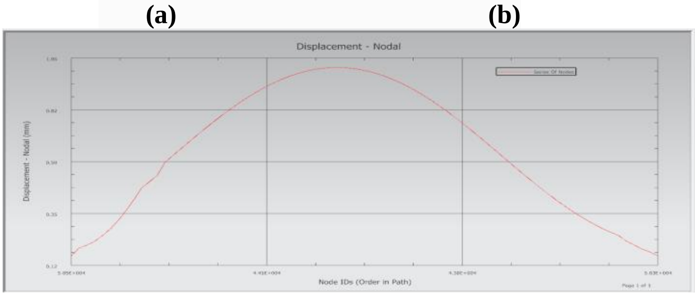
(c)

Fig 13: (a)displacement after the application of load on fixed beam with uniformly distributed load, (b)show the different nodal point, (c) shows the graph between displacement and nodal point on the beam.

4.2.3. SIMPLY SUPORTTED BEAM

(a) **(b)**



(c)

Fig 14: (a)displacement after the application of load on simply supported beam with uniformly distributed load, (b)show the different nodal point, (c) shows the graph between displacement and nodal point on the beam.

	TYPE OF LOAD					
	POINT LOAD			UNIFORMLY DISTRIBUTED LOAD		
DEFLECTION VALUE(mm) ↓	CANTILEVER BEAM	FIXED BEAM	SIMPLY SUPORTTED BEAM	CANTILEVER BEAM	FIXED BEAM	SIMPLY SUPORTTED BEAM
EXPERIMENTAL	104.84	1.358	5.28	38.67	0.841	1.06
Theoretical	80.953	1.904	4.0938	30.452	0.563	0.987

TABLE 1: Maximum Deflection for different beam under different loading conditions both experimental determined by NX Cad and using theoretical formula.

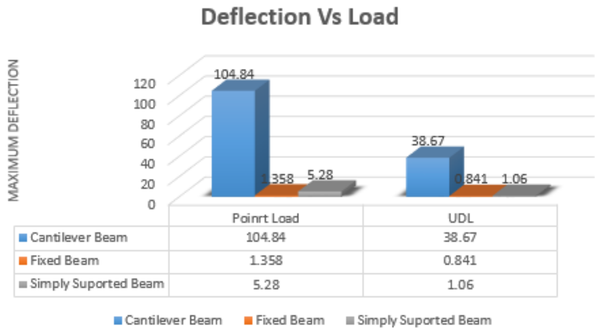


Fig 15: Maximum Deflection for different beam under different load condition.

4.3. CONCLUSION

This paper deals with the estimation of maximum deflection of beams for different support condition i.e. fixed support, cantilever beam and simply supported beam for each case under uniformly distributed and point loading condition. After analyzing all the beam conditions, it is evident that fixed beam shows the minimum deflection under similar loading condition for both uniformly distributed and point load condition while cantilever beam shows maximum deflection.

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