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Parametric Study of Deep Beam Using Ansys Software

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ABSTRACT:

Now a days Reinforced concrete Deep beams have gained lot of attentions in professionals and academics due to its wider use in various type of structures like tall buildings, bridges, tanks etc. Thatswhy, parametric study of deep beam becomes an important aspect for designing & to understand behavior of such structure. This paper presents the analysis of a deep beam using the finite element method, which includes the convergence analysis of the deflection, bending stress, and shear stress at a critical point of the beam. A deep beam can be analysed using a variety of analytical methods. Ansys provides the best alternative among all the analytical techniques that are available.In this study, two alternative types of loading—Point load and UDL—are used along with simply supported and fixed supported end conditions, with changing L/D or L/H ratios for constant depth. Reviewing the impact of the following factors on the stress metrics.

Keywords: Simply Supported Beam, Fixed Beam, ANSYS, Point load, Deep Beam

I. INTRODUCTION

Deep Beam:

A deep beam is a beam having a depth comparable to the span length. Reinforced concrete deep beams have useful applications in tall buildings, offshore structures, and foundations. The transition from ordinary-beam behaviour to deep-beam behaviour is imprecise; for design purposes, it is often considered to occur at a span/depth ratio of about 2.5. The importance of the shear-span/depth ratio and for buckling and instability the depth/thickness ratio are very important. In practice, engineers typically encounter deep beams when designing transfer girders, pile supported foundations, or bridge bents. Until recently, the design of deep beams per IS 456-2000 design standards was based on empirically derived expressions and rules of thumb

Fig.1 Elements of Deep Beam

Behavior of Deep Beam:

Reinforced concrete deep beams have many useful applications in buildings, bridge structures such as transfer girders, wall footings, foundation, floor diaphragms, bunkers, and tanks. The use of deep beams at lower levels in tall buildings for both residential and commercial purposes is well known [1-4]. A beam is considered deep beam, if the depth of beam is large with respect to span of beam. According to (ECP 203-2018) [5]; Deep beams have effective span to depth ratios smaller than 1.25 for the simple beams and 2.50 for the continuous beams. On the other hand, deep beam is defined according to ACI 318-19 [6]; a structural element with clear span equal to or less than four times the overall depth, or with applied concentrated loads that are within a distance equal to or less than two times the depth from the face of the support. The behavior of deep beam depends on its properties of materials and strength characteristics. Concrete plays a vital role in the development of deep beam and other structural elements where the deep beams made of high strength concrete (HSC) would show higher ability in resisting heavy loads than those made of normal strength concrete (NSC) [7- 10]. As concrete is used to sustain compressive forces, it is essential that its strength and characteristics are determined and this has been studied in many previous researches, but the difference in this research is the study of the behavior of deep beams using different layers of various concrete compressive strengths and knowing the impact on its performance. Behavior of deep beams depends on various parameters like compressive strength of concrete, shear reinforcement, shear span to depth ratio etc. In this paper, the cost reduction of concrete has been studied by studying the behavior of simply supported deep beams casted on different layers of concrete consisting of high strength concrete (HSC) and normal strength concrete (NSC), and comparing this behavior with deep beams which are casted using one compressive strength.

Design Criteria of Deep Beam

Beams with large depths in relation to spans are called deep beams. As per the Indian Standard, IS 456:3500, Clause 29, a simply-supported beam is classified as deep when the ratio of its effective span L to overall depth D is less than 2. Continuous beams are considered as deep when the ratio L/D is less than 2.5. The effective span is defined as the centre-to-centre distance between the supports or 1.15 times the clear span whichever is less. They are structural elements loaded as simple beams in which a significant amount of the load is carried to the supports by a compression force combining the load and the reaction. As a result, the strain distribution is no longer considered linear, and the shear deformations become significant when compared to pure flexure. Because of their proportions deep beams are likely to have strength controlled by shear rather than flexure. On the other hand, their shear strength is expected to be significantly greater than predicted by the usual equations, because of a special capacity to redistribute internal forces before failure and to develop mechanisms of force transfer quite different from beams of common proportions

II. OBJECTIVE

The general objective of the present research is to analyze the behavior of reinforced concrete deep beams & to do a comparative study of different stress parameters by varying L/D ratio keeping depth constant. This objective has been achieved through developing 4 models with different support and loading conditions by using ansys software, taking into consideration.

1. Calculate maximum shear stress, maximum bending stress & deflection for simply supported deep beam for point load varying span of deep beam (3000mm to 4500mm)
2. Calculate maximum shear stress, maximum bending stress & deflection for simply supported deep beam for uniformly distributed load varying span of deep beam (3000mm to 4500mm)
3. Calculate maximum shear stress, maximum bending stress & deflection for fixed deep beam for point load varying span of deep beam (3000mm to 4500mm)
4. Calculate maximum shear stress, maximum bending stress & deflection for fixed deep beam for uniformly distributed load varying span of deep beam (3000mm to 4500mm)

III. MODELLING APPROACH

Modelling: Simply supported beam & fixed beam is considered having and different length (3m,3.5m,4m,4.5m). Size of the beam is 1150mm x 2300mm. In this conventional deep beam is analyzed in ANSYS 16.1. Following cases are considered for the analysis.

CASE 1: Simply Supported Deep Beam with point load

1. Simply supported deep beam with point load of 150 KN having a span of 3000 mm.
2. Simply supported deep beam with point load of 150 KN having a span of 3500 mm.
3. Simply supported deep beam with point load of 150 KN having a span of 4000 mm.
4. Simply supported deep beam with point load of 150 KN having a span of 4500 mm.

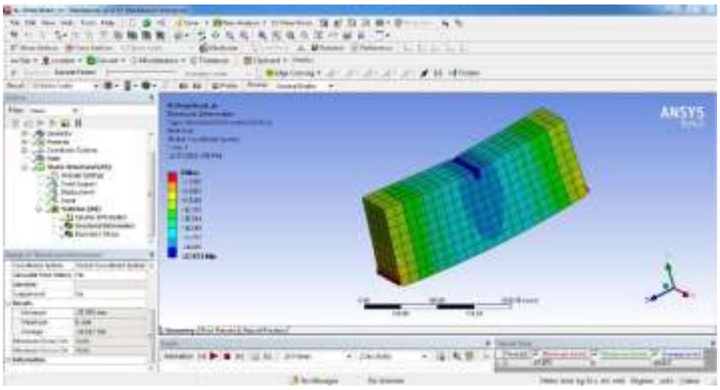


Fig 1: Simply Supported Deep Beam (Point Load)

CASE 2: Fixed Deep Beam with point load

- Fixed deep beam with point load of 150 KN having a span of 3000 mm.
- Fixed deep beam with point load of 150 KN having a span of 3500 mm.
- Fixed deep beam with point load of 150 KN having a span of 4000 mm.
- Fixed deep beam with point load of 150 KN having a span of 4500 mm.

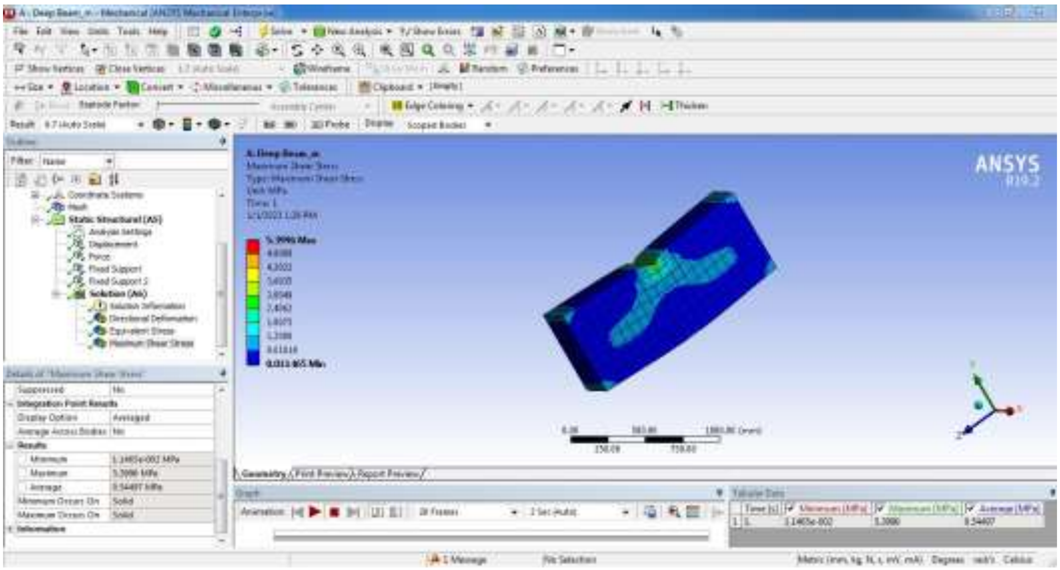


Fig 2: Fixed Deep Beam (Point Load)

CASE 3: Simply Supported Deep Beam with UDL

1. Simply supported deep beam with UDL of 75 kN/m having a span of 3000 mm.
2. Simply supported deep beam with UDL of 75 kN/m having a span of 3500 mm.
3. Simply supported deep beam with UDL of 75 kN/m having a span of 4000 mm.
4. Simply supported deep beam with UDL of 75 kN/m having a span of 4500 mm.

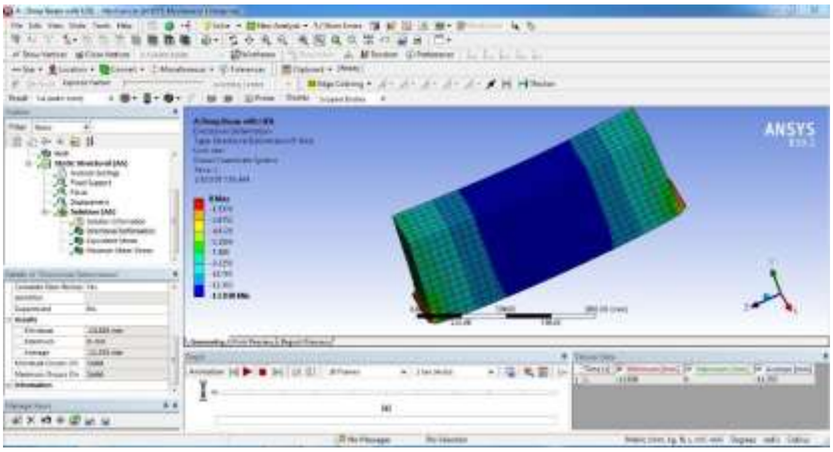


Fig 3: Simply Supported Deep Beam (UDL)

CASE 4: Fixed Deep Beam with UDL

- Fixed deep beam with UDL of 75 kN/m having a span of 3000 mm.
- Fixed deep beam with UDL of 75 kN/m having a span of 3500 mm.
- Fixed deep beam with UDL of 75 kN/m having a span of 4000 mm.
- Fixed deep beam with UDL of 75 kN/m having a span of 4500 mm.

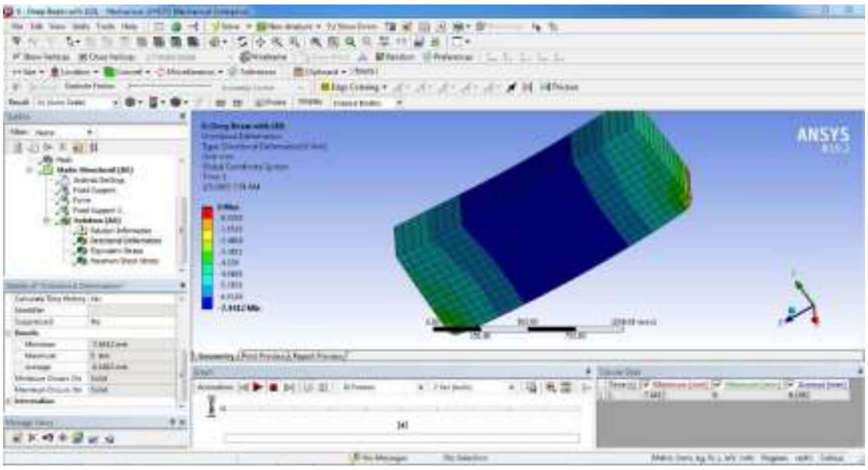


Fig 4: Fixed Deep Beam (UDL)

IV. RESULTS AND DISCUSSION

4.1 General: To obtain the results of the deep beam, the Ansys software is used. The depth of beam is fixed as 2300mm; where as the length of beam is considered as 3m,3.5m,4m,4.5m.

4.2 Analysis of simply supported deep beam (Point Load):

The same beam as mentioned above of depth 2300mm is analyzed with variation of length as 3m, 3.5m, 4m, 4.5m. 150 KN point load is applied on simply supported deep beam on the center of the span. The table 4.1 shows the results of the beam with varied length.

Table 4.1: Variation in deformation & stresses on simply supported deep beam

Length (mm)	**Deformation (mm)**	**Bending Stress (N/mm^2)**	**Shear Stress (N/mm^2)**
3000	27.973	11.429	10.25
3500	33.8	14.077	11.851
4000	41.45	16.389	14.424
4500	63.984	18.961	16.528

4.3 Analysis of Fixed deep beam (Point Load):

The same beam as mentioned above of depth 2300mm is analyzed with variation of length as 3m, 3.5m, 4m, 4.5m. 150 KN point load is applied on fixed deep beam on the center of the span. The table 4.2 shows the results of the beam with varied length.

Table 4.2: Variation in deformation & stresses on fixed deep beam

Length (mm)	**Deformation (mm)**	**Bending Stress (N/mm^2)**	**Shear Stress (N/mm^2)**
3000	12.191	5.827	3.291
3500	14.067	7.036	4.049
4000	16.39	8.098	4.675
4500	28.895	9.355	5.399

4.4 Analysis of simply supported deep beam (UDL):

The same beam as mentioned above of depth 2300mm is analyzed with variation of length as 3m, 3.5m, 4m, 4.5m . 75 KN/M UDL is applied on simply supported deep beam on the whole span. The table 4.3 shows the results of the beam with varied length.

Table 4.3: Variation in deformation & stresses on simply supported deep beam

Length (mm)	**Deformation (mm)**	**Bending Stress (N/mm^2)**	**Shear Stress (N/mm^2)**
3000	13.838	21.738	12.319
3500	19.603	25.36	14.371
4000	27.57	28.982	16.424
4500	52.741	36.226	20.528

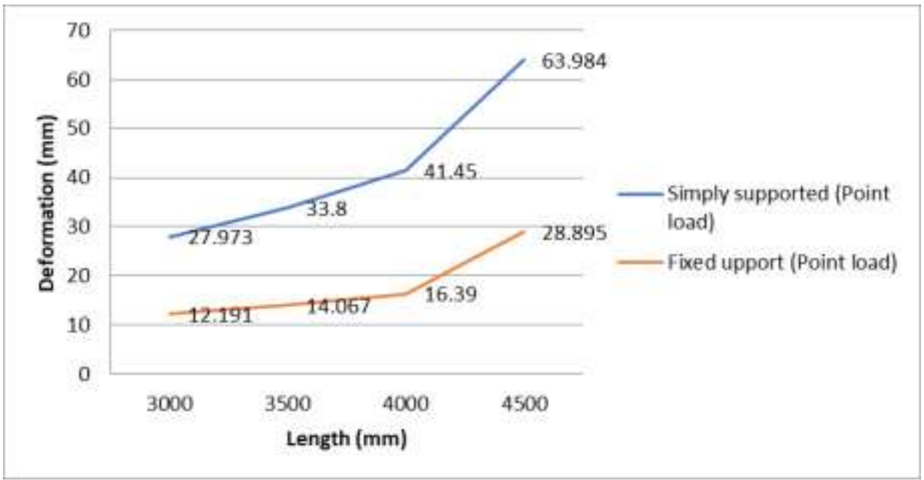
4.5 Analysis of Fixed deep beam (UDL):

The same beam as mentioned above of depth 2300mm is analyzed with variation of length as 3m, 3.5m, 4m, 4.5m. 75 KN/M UDL is applied on fixed deep beam on the whole span. The table 4.4 shows the results of the beam with varied length.

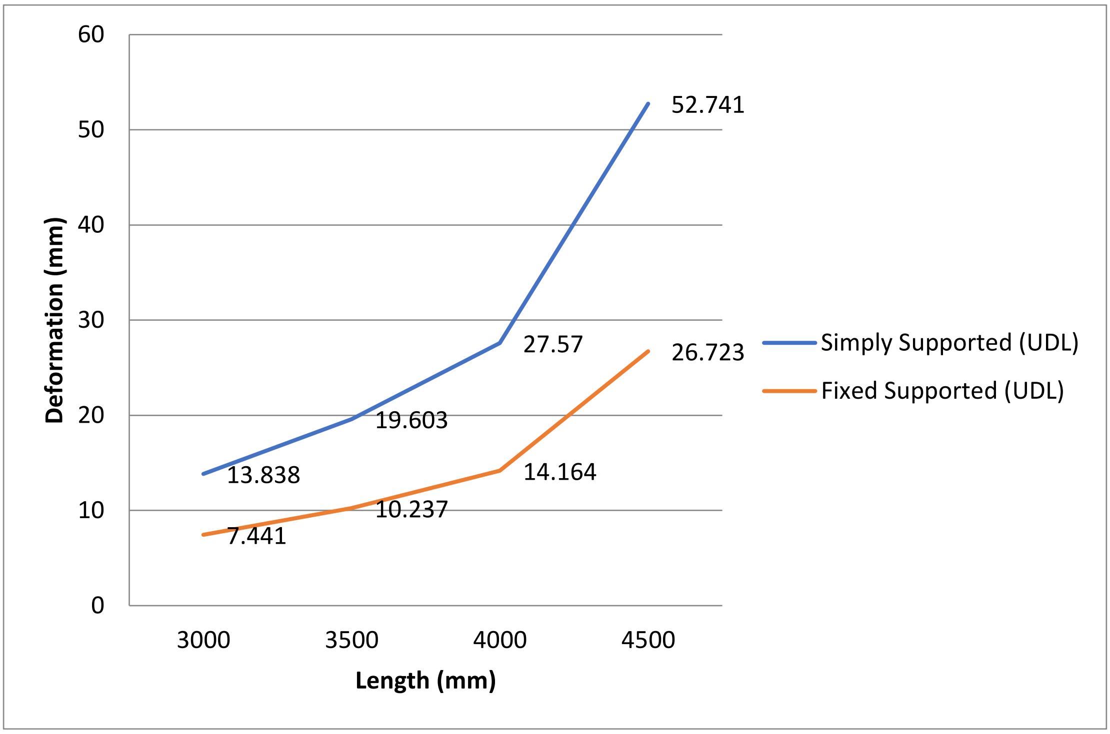
Table 4.4: Variation in deformation & stresses on fixed deep beam

Length (mm)	**Deformation (mm)**	**Bending Stress (N/mm^2)**	**Shear Stress (N/mm^2)**
3000	7.441	18.467	9.938
3500	10.237	21.769	11.688
4000	14.164	25.258	13.529
4500	26.723	33.069	17.653

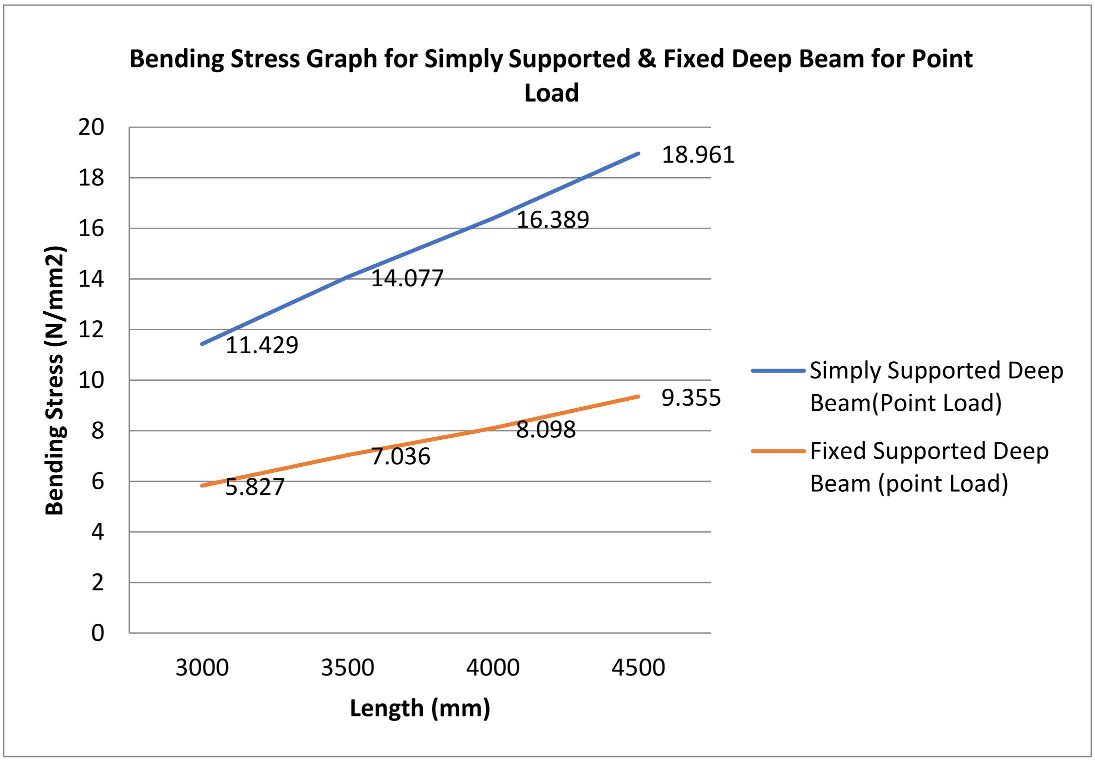
4.6 Graphs



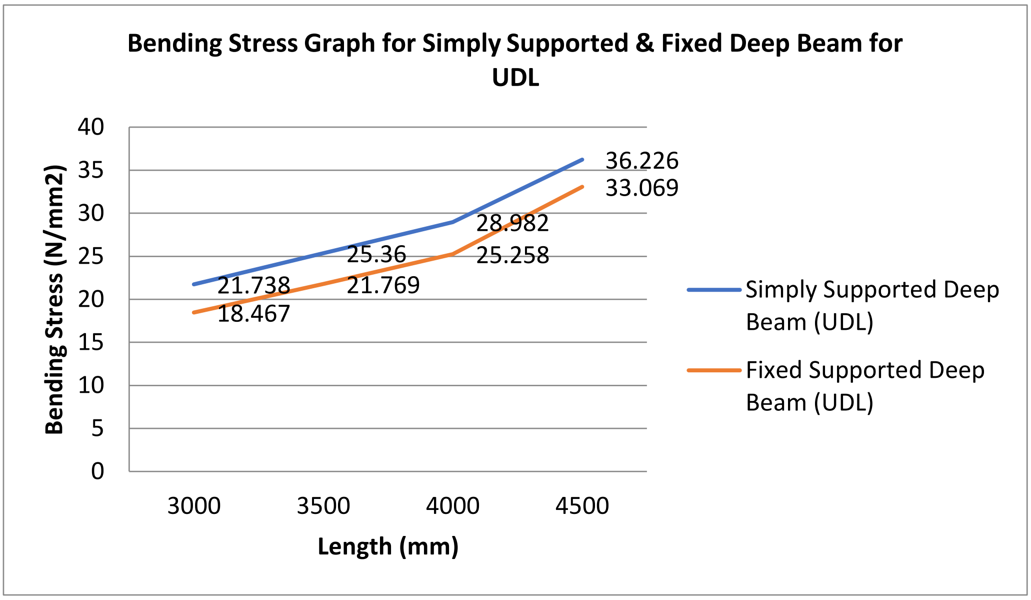
Graph 1: Deformation for Simply Supported & Fixed Deep Beam for Point Load



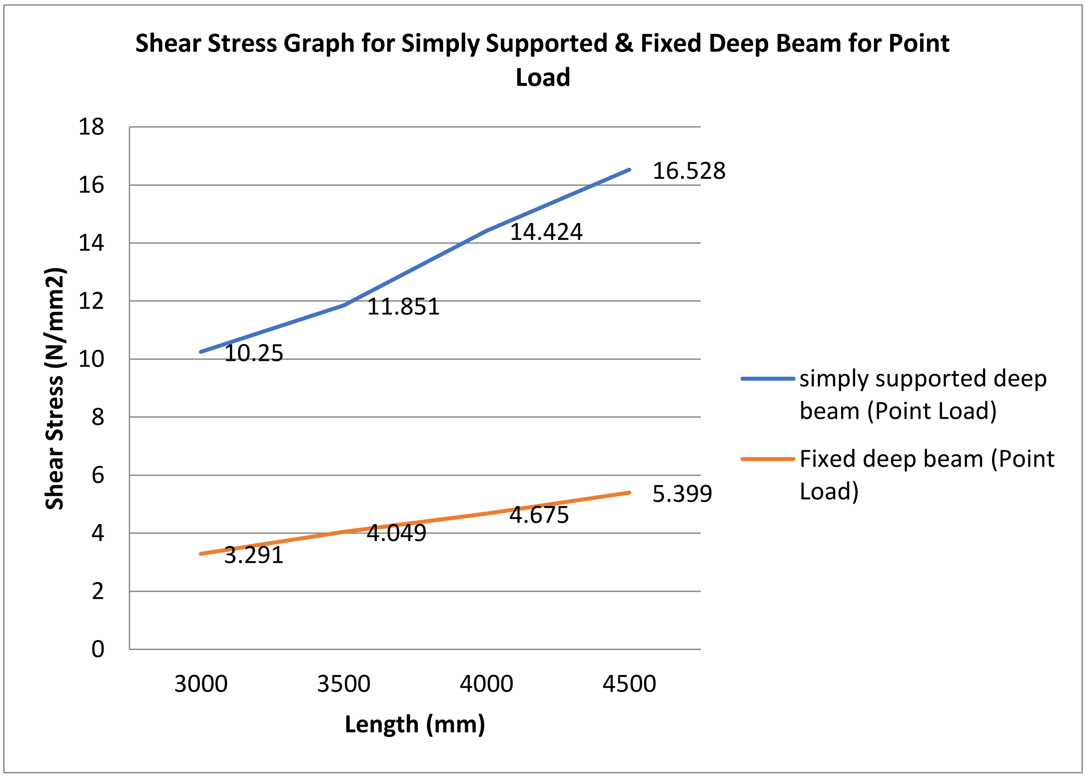
Graph 2: Deformation for Simply Supported & Fixed Deep Beam for UDL



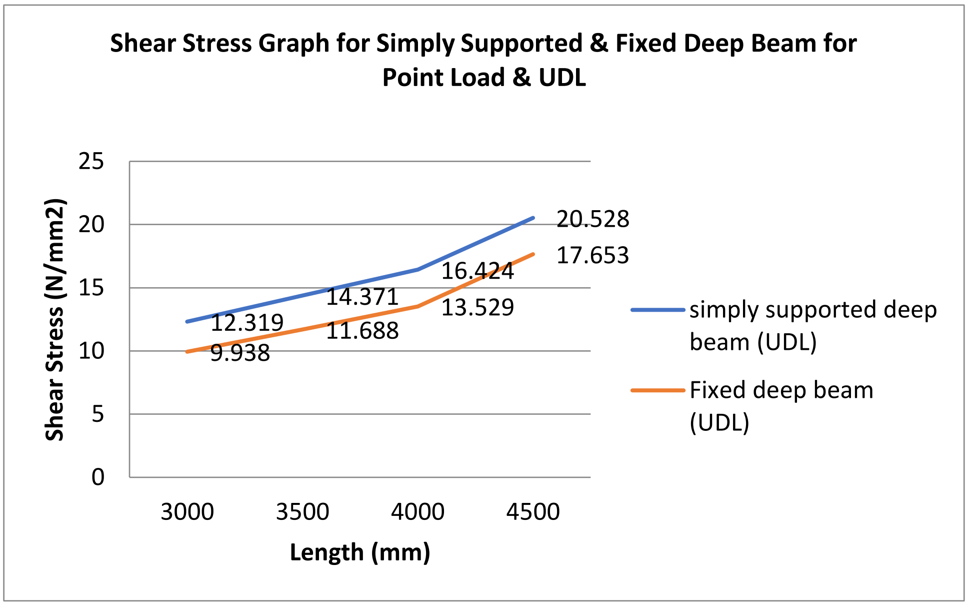
Graph 4: Maximum Bending Stress for Simply Supported & Fixed Deep Beam for Point Load



Graph 5: Maximum Bending Stress for Simply Supported & Fixed Deep Beam for UDL



Graph 7: Maximum Shear Stress for Simply Supported & Fixed Deep Beam for Point Load



Graph 8: Maximum Shear Stress for Simply Supported & Fixed Deep Beam for UDL

V. CONCLUSIONS

In this work, a deep beam is studied parametrically using an analytical method and the ANSYS programme. Understanding the variation in deflection along the length of the beam, the variation in bending stress throughout a section and the position of the maximum bending stress, as well as the variation in shear stress along the length, are all part of the study. The following results about deep beams were reached from the parametric study:

1. The result for a deep beam obtained using ANSYS software shows clearly that by increasing the L/D ratio for a simple support and a fixed support end condition, all stress parameters—deformation, bending stress, and shear stress—increase.
2. For a simply supported end condition, deformation increases up to 2.3 times, bending and shear stresses increase up to 1.6 times, while D remains constant at 2.3 metres. In contrast, for a fixedly supported end condition, deformation increases up to 1.7 times, bending and shear stresses increase up to 1.6 times for both Point Load and UDL.
3. It is noticeable from the numerical analysis's findings that for fixed end conditions compared to simply supported end conditions, the deformation, bending stress, and shear stress decrease by up to 50%.

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