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Parametric Study of Shaft Subjected To Pure Bending

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ABSTRACT

The methodology of this project is to finding the application for determining the properties of beams like bending strength. The process implies the testing of beams may be various type or any composite beams that determines how much mechanical energy is required for the failure of any material in bending. A material's ability to resist impact often is one of the determining factors in the service life of a part, or in the suitability of a designated material for a particular application. The various resistances can be the most difficult properties to quantify. The ability to quantify this great advantage in product liability and safety. In addition to providing information various machines are used but the best machines where the entire test can be done in universal testing machine (U.T.M), these test are quick and inexpensive. This study explores the influence of work material in bending and to find the maximum load at which the failure of materials occurs.

Index Terms- bending strength, universal testing machine (UTM), stress , strain ,modulus of elasticity etc.

INTRODUCTION

Shaft is a rotating member, used in engines, machines & equipment for transmitting power from one point to another. The power is delivered to the shafts by some tangential force & the resultant torque or twisting moment setup within the shafts permit the power to be transfer to the various machines linked up to the shafts.

Shafts are classified in to two types:-

1. Transmission shafts-: These are called line-shafts, counter-shafts, head- shafts. These are used to transmit power between the power sources i.e. the electric motor or IC engine& the machines to be operated.
2. Machine shafts-: A machine shafts is an integral part of machine. The examples being, the crank shaft of an IC engine, Lathe spindle & Milling machine arbour etc.

The shafts are usually cylindrical but may be square or cross-shaped in section. They are solid in cross- section but sometimes hollow shafts are also used.

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LITERATURE

2.1 Necessity of Mechanical Testing:-

1. A manufacturer producing a metal from the raw material into finished bars and sections has to check whether the mechanical properties are up to the Standard Specifications (I.S., B.S., A.S.T.M., etc.).
2. Specific service situations call for a knowledge of the hardness, Young's modulus, and ductility of the material; for instance ductility is relevant when the method of forming is considered.
3. To avoid failure in service from the use of materials with inadequate properties.
4. Production of new materials to meet the demands of modern industry by Research and Development (*R &D*) making use of standard mechanical tests.

Quality control in manufacture by conducting mechanical tests on the finished product of each batch to satisfy the customers' requirements. For example, the tensile strength of a casting can be altered by small changes in composition and heat treatment.

2.2Test Specimens:-

Mechanical testing is usually carried out on test specimens cut from a piece of material being used. Considerable care must be exercised in selecting the representative sample, the method of preparation of the test-piece, shape and dimensions, all conforming to the standard specifications (I.S., B.S., A.S.T.M., etc.) so that the results obtained by different test houses are comparable.

2.3 Mechanical Testing of Metals and Metallic Joints:-

Mechanical tests are employed to determine relevant material properties of metals and elements. They may be divided into two groups:

1. Large-scale, structurally representative tests.
2. Small-scale materials characterization tests which determine material properties or give results which are known to correlate with structural behavior.

2.4 Literature Review

There are many closed form solutions in the literature for calculation of shear area of circular beams. Young, W.C., and Budynas, R.G. (2002) [4] present a formula for calculation of shear area based on the principle of virtual work. The expression can be divided into flan,Timoshenko and Goodier (1970)[3] has developed expressions for form factors for a variety of sections.

Young and Budynas (2002) [4]have presented the simplified expression found in Young, W.C., and Budynas, R.G. (2002) [4] and Gere and Timoshenko, (1997) [2] have presented the expression in Timoshenko (1940)[3]as the shear area of the wide flange sections. The following sections will discuss in detail some of the solutions mentioned above.

But, William F. (1985)[5]. Mechanics of materials, conducted 34 bending and torsion tests on unbraced simply supported cold formed steel channel beams loaded eccentrically at midspan. They concluded that the strength of the unbraced Cold Formed Circular Sections depended on the eccentricity of loading. The Strength of the beam was higher when the eccentricity was

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towards the centroid side of the shear center and the failure occurred by local buckling of the compression-flange-web junction.

3. STEPWISE PROCEDURE:-

1. Ensure that all the switches and main switches are put on.
2. Ensure that release valve and the control valve mounted on control unit are closed.
3. Move the middle crosshead of loading unit up and down with the help of mechanical motors, there by the space from upper crosshead and middle crosshead decreases or increases. This helps us to adjust the gap between crossheads as per length of the specimen.
4. Now put the machine on and open the control valve slowly. Observe the upward movement of upper and lower crosshead. The middle crosshead will remain stationary. One can control the movement speed of crosshead using control valve.
5. As soon as the control valve is opened observe the changes on load dial/display along with displacement dial/display. The value for load will increase for some time and then remain stationary but the values for displacement will go on increasing. This load value is nothing but the dead weight of lower crosshead.
6. Now make the load reading zero with the help of tare switch. Shut down the machine. Close the control valve and open the release valve.
7. Note the backflow of hydraulic oil and observe slow lowering of the crosshead. The value for load will decrease for some time and then become negative and the values for displacement will go on decreasing. This is termed as adjustment of dead weight of crosshead. Teacher shall explain the disadvantages if this adjustment is not done properly.
8. Put the timber specimen between middle and lower crosshead. Ensure that there is a small gap within crossheads and the specimen. After selecting suitable range on load dial gauge close the release valve and slowly open the control valve.
9. Note the readings of load at three different instants.
10. Apply the load till failure of the specimen takes place, this is the maximum load or failure load generally denoted by P.
11. Put off the machine. Close the control valve and open the release valve.

4. ADVANCEMENT OF UTM:-

4.1. Electronic universal testing machines:-

Features:-

- Loading accuracy as high as ± 1% straining at variable speeds to suit a wide range of materials.
- Motor driven threaded columns for quick effort. Less adjustment of middle cross-head-to facilitate rapid fixing of test specimen.
- Simplicity in reading because of digital readouts.
- Wide range of standard and special accessories, including load stabilizer.

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- Easy change from plain to threaded and screwed specimens.
- Large effective clearance between columns enables testing of standard specimens as well as structures.
- Simple controls for ease of operation.
- Robust straining frame of an extremely rigid construction.
- Safe operation ensured by means of safety devices.
- Fully enclosed and protected pressure transducer.

Optional serial port to transfer data to computer for analysis /RE Electronic Universal Testing Machine is designed for testing metals and other materials under tension, Compression, bending, transverse and shear loads. Brinellhardness test (BHN) on metals can also be conducted.

5. **METHODOLOGY**-:

This project method purely based upon testing of various types of shaft .Here various parameter are used like diameter, length, shape.
These parameter divided into various parameter with various sub part which are given below

DIAMETER	LENGTH	SHAPE	CROSS SECTION
MAXIMUM	MAXIMUM	SOLID	CIRCULAR
MEAN	MEAN	HOLLOW	
MINIMUM	MINIMUM		

From these parameter various combination are made which contains 6 combinations. Here we done bending test .The job chart or various combinations of these jobs are given below.

<table>
<tr><th colspan="3">MAXIMUM COMBINATION WE CAN GET FOR</th></tr>
<tr><td colspan="3">D_1=MAXIMUM DIAMETER (32mm)
D_2=MEAN DIAMETER (26mm)
D_3=MINIMUM DIAMETER (20mm)</td></tr>
<tr><td colspan="3">L_1=MAXIMUM LENGTH (240mm)
L_2=MEAN LENGTH (170mm)
L_3=MINIMUM LENGTH (100mm)</td></tr>
<tr><td colspan="3">C=CIRCULAR</td></tr>
<tr><td colspan="3">SS = SOLID SHAFT
HS = HOLLOW SHAFT</td></tr>
<tr><td colspan="3">M = MILD STEEL</td></tr>
<tr><td>M-C-D_1-SS</td><td>M-C-D_2-SS</td><td>M-C-D_3-SS</td></tr>
<tr><td>M-C-L_1-HS</td><td>M-C-L_2-HS</td><td>M-C-L_3-HS</td></tr>
</table>

6. LIST OF FIGURES

Fig 1: mild steel with different diameter

Fig 2: hollow mild steel having different length

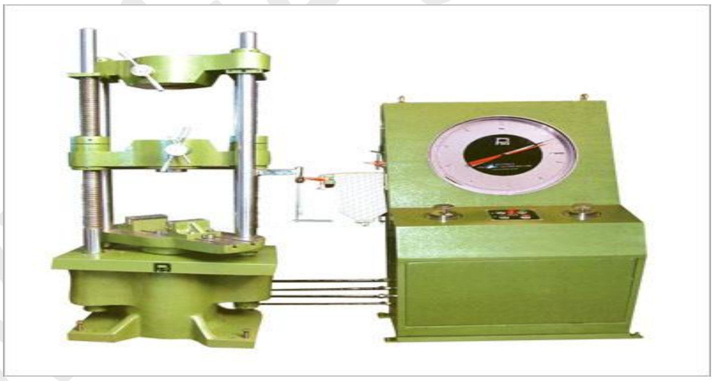

Fig 3 : universal testing machine (U.T.M)

7. CALCULATION AND GRAPHS

1. M-C-D_1-Ss:-

Constant Value For Beams:-

Length of beam (L) = 85 mm

Width of beam (b) = 70 mm

Thickness of beam (t) = 32 mm

$I = b * t^3/12 = 70 * 32^3/12 = 191146.666\ mm^4$

$L_i = 210$ mm, $D_1 = D_i = 32$ mm

Initial Area (A_i) = $\pi/4 * D_i^2 = \pi/4 * 32^2 = 804.24\ mm^2$

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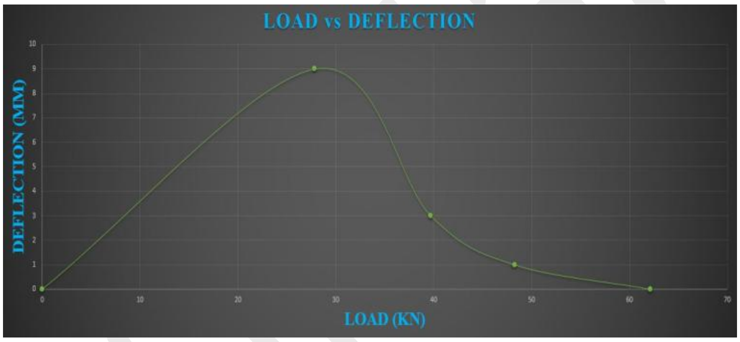
SL.	LOAD (W) (kN)	DEFLECTION (∇)mm	STRESS(σ) = $p/Ai(\frac{kN}{mm^2})$	STRAIN (ε) = $\frac{\nabla L}{Li}$
1.	0	0	0	0
2.	27.823	9	0.034595	0.03642
3.	39.693	3	0.04935	0.01214
4.	48.246	1	0.059985	0.0040476
5.	62.124	0	0.0772457	0.0017852

L_f = 198 mm, D_{fo} = 24 mm, D_{fi} = 13 mm
Final Area (A_f) = $\pi/4$ * ($D_{fo}^2 - D_{fi}^2$) = $\pi/4$ * ($24^2 - 13^2$) = 319.65 mm^2

RESULT: - The following results are obtained from the test data for Mild steel

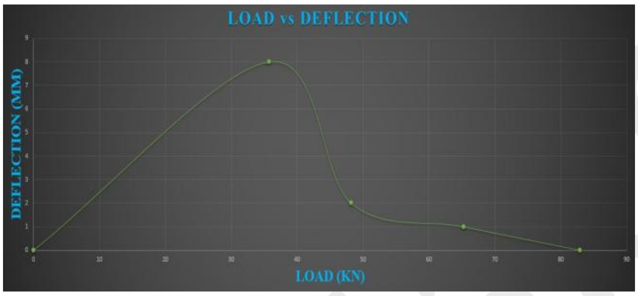
Modulus of Elasticity (E) = Stress/Strain = 0.359567/0.017708 = 20.308 kN/mm^2



L_f = 160 mm, D_f= 29.5 mm
Final Area (A_f) = $\pi/4$ * D_f^2= $\pi/4$ * 29.5^2 = 683.49 mm^2
RESULT: - The following results are obtained from the test data for Mild steel
Modulus of Elasticity (E) = Stress/Strain = 0.0772455/0.0017852 = 43.269 kN/mm^2

2. M-C-D_2-SS:-
CONSTANT VALUE FOR BEAMS:-
Length of beam (L) = 85 mm
Width of beam (b) = 70 mm
Thickness of beam (t) = 32 mm
I = b * t^3/12 = 70*32^3/12 = 191146.666 mm^4
L_i = 210 mm, $D_2 = D_i$ = 26 mm
Initial Area (A_i) = $\pi/4$ * D_i^2 = $\pi/4$ * 26^2 = 530.929 mm^2

SL.	LOAD (W) (kN)	DEFLECTION (∇)mm	STRESS(σ) = $p/Ai(\frac{kN}{mm^2})$	STRAIN (ε) = $\frac{\nabla L}{Li}$
1.	0	0	0	0
2.	35.729	8	0.067295	0.03238
3.	48.219	2	0.09082	0.008095
4.	65.242	1	0.122882	0.0040476
5.	82.912	0	0.156164	0.0069476



Area (A_f) = $\pi/4 * D_f^{\ 2}$ = $\pi/4 * 24^2 = 452.3893$ mm^2

RESULT: - The following results are obtained from the test data for Mild steel

Modulus of Elasticity (E) = Stress/Strain = 0.156164/0.0069476 = 22.447 kN/mm^2

3. M-C-D_3-SS:-

CONSTANT VALUE FOR BEAMS:-

Length of beam (L) = 85 mm

Width of beam (b) = 70 mm

Thickness of beam (t) = 20 mm

$I = b * t^3/12 = 70*32^3/12 = 191146.666$ mm^4

L_i = 210 mm, $D_3 = D_i$ = 20 mm

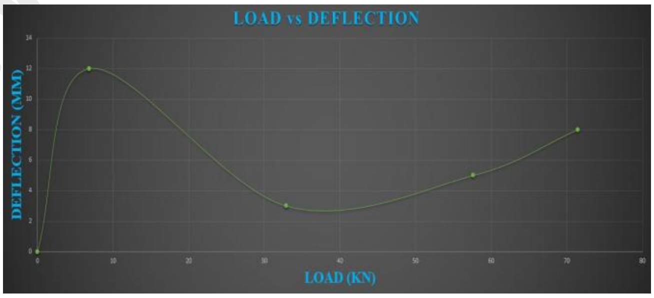
Initial Area (A_i) = $\pi/4 * D_i^{\ 2} = \pi/4 * 20^2 = 314.00$ mm^2

SL.	LOAD (W) (kN)	DEFLECTION (∇)mm	STRESS(σ) = $p/Ai(\frac{kN}{mm^2})$	STRAIN (ε) = $\frac{\nabla L}{Li}$
1.	0	0	0	0
2.	37.473	7	0.12496	0.0238
3.	54.738	1	0.18495	0.04761
4.	77.692	1	0.2624	0.06190
5.	98.096	0	0.3749	0.0017852

L_f= 180 mm, D_f= 13.4 mm
Final Area (A_f) = π/4 * D_f^2= π/4 * 13.4^2 = 140.95 mm^2
RESULT: - The following results are obtained from the test data for Mild steel
Modulus of Elasticity (E) = Stress/Strain = 0.39670/0.011764 = 33.7215 kN/mm^2

4. M-C-L_1-HS:-
CONSTANT VALUE FOR BEAMS:-
Length of beam (L) = 85 mm
Width of beam (b) = 70 mm
Thickness of beam (t) = 32 mm
I = $b*t^3/12 = 70*32^3/12$ = 191146.666 mm^4
$L_1 = L_i$ = 240 mm, D_i = 14 mm, D_0 = 20 mm
Initial Area (A_i) = π/4 * ($D_{ino}^2 - D_{ini}^2$) = π/4 * ($20^2 - 14^2$) = 160.242 mm^2

SL.	LOAD (W) (kN)	DEFLECTION (∇)mm	STRESS(σ) = $p/Ai(\frac{kN}{mm^2})$	STRAIN (ε) = $\frac{\nabla L}{Li}$
1.	0	0	0	0
2.	6.852	12	0.042760	0.0425
3.	32.92	3	0.285450	0.010625
4.	57.61	5	0.359537	0.017708
5.	71.42	8	0.4435708	0.028333



L_f = 198 mm, D_{fo} = 24 mm, D_{fi} = 13 mm
Final Area (A_f) = π/4 * ($D_{fo}^2 - D_{fi}^2$) = π/4 * ($24^2 - 13^2$) = 319.65 mm^2

RESULT: - The following results are obtained from the test data for Mild steel
Modulus of Elasticity (E) = Stress/Strain = 0.359567/0.017708 = 20.308 kN/mm^2

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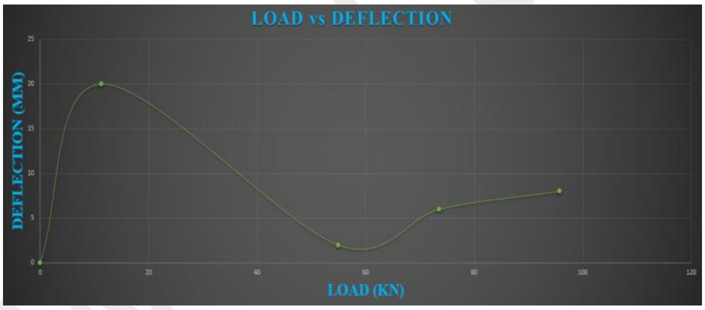
5. M-C-L_2-HS:-

CONSTANT VALUE FOR BEAMS:-

Length of beam (L) = 85 mm
Width of beam (b) = 70 mm
Thickness of beam (t) = 32 mm
$I = b*t^3/12 = 70*32^3/12 = 191146.666\ mm^4$
$L_1 = L_i = 170$ mm, $D_i = 14$ mm, $D_0 = 20$ mm
Initial Area (A_i) = $\pi/4 * (D_{ino}^2 - D_{ini}^2) = \pi/4 * (20^2 - 14^2) = 160.242\ mm^2$

SL.	LOAD (W) (kN)	DEFLECTION (∇)mm	STRESS(σ) = $p/Ai(\frac{kN}{mm^2})$	STRAIN (ε) = $\frac{\nabla L}{Li}$
1.	0	0	0	0
2.	11.265	20	0.004897	0.917614
3.	54.936	2	0.342831	0.0058823
4.	73.5688	6	0.39670	0.011764
5.	95.7456	8	0.597506	0.0035147



$L_f = 120$ mm, $D_{fo} = 18$ mm, $D_{fi} = 12$ mm
Final Area (A_f) = $\pi/4 * (D_{fo}^2 - D_{fi}^2) = \pi/4 * (18^2 - 12^2) = 141.30\ mm^2$

RESULT: - The following results are obtained from the test data for Mild steel
Modulus of Elasticity (E) = Stress/Strain = 0.39670/0.011764 = 33.721 kN/mm^2

6. M-C-L_3-HS:-

CONSTANT VALUE FOR BEAMS:-

Length of beam (L) = 85 mm
Width of beam (b) = 70 mm
Thickness of beam (t) = 32 mm
$I = b*t^3/12 = 70*32^3/12 = 191146.666\ mm^4$
$L_1 = L_i = 100$ mm, $D_i = 14$ mm, $D_0 = 20$ mm
Initial Area (A_i) = $\pi/4 * (D_{ino}^2 - D_{ini}^2) = \pi/4 * (20^2 - 14^2) = 160.242\ mm^2$

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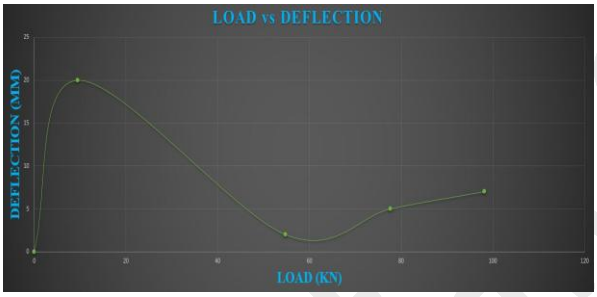
SL.	LOAD (W) (kN)	DEFLECTION (∇)mm	STRESS(σ) = $p/Ai(\frac{kN}{mm^2})$	STRAIN (ε) = $\frac{\nabla L}{Li}$
1.	0	0	0	0
2.	9.456	20	0.234001	0.07
3.	54.738	2	0.34181	0.01
4.	77.692	5	0.48515	0.01
5.	98.0969	7	0.612569	0



L_f = 77 mm, D_{fo} = 21 mm, D_{fi} = 8.7 mm
Final Area (A_f) = $\pi/4 * (D_{fo}^2 - D_{fi}^2) = \pi/4 * (21^2 - 8.7^2)$ = 365.31 mm^2

RESULT: - The following results are obtained from the test data for Mild steel
Modulus of Elasticity (E) = Stress/Strain = 0.234001/0.07 = 3.3428714 kN/mm^2

8. CONCLUSION

Our project is one of the effective way to determine the actual strength of mild steel in pure bending condition. The bending test is the simplest mechanical test used in evaluating the properties of metals. Because most of the rotating parts in a machine or members of a structure bends because of loading conditions. As shaft are the essential parts of machines, it is important to know the various failure points in bending for various shapes of materials for safer use of machine for long duration of time. In this project a parametric study is carried out in order to predict the important parameters such as the material dimension, deflection behavior such as stress & strain under the application of load, based on material properties & cross section. As this test is carried out for parametric study only the parameters that are affected by bending are studied.

9. SCOPE FOR FUTURE WORK

➢

1. The dimensions of specimen such as thickness of the specimen, diameter of specimen, and length of specimen can be varied for different results.
2. In this research work the material used is Mild Steel. The experimentation can also be done for other materials like Aluminium, Stainless Steel, and different composites Materials.

3. In our experiment we studied the failure of material under pure bending subjected to central concentrated load. But this experiment can also be carried out by using different loading conditions like uniformly distributed load (U.D.L.), uniformly varying load (U.V.L.), and point load at free end with different dimensions.
4. In our experiment the bending of beam is carried out using a simple support. But this experiment can be carried out by using different support conditions.
5. In our experiment we studied the failure of material subjected to pure bending. The Experimentation can be also be studied for Tensile and Compressive Strength for different specimens.
6. These tests can be conducted at different temperature of specimen and effects can be studied.
7. With this advance technology software analysis can also be made to compare the results based on theoretical & experimental analysis.

10 . REFERENCES

i. Manual of Steel Construction, 8th Edition, 2nd revised printing, American Institute of Steel Construction, Gotluruet al. (2000)

ii. Gere and Timoshenko, 1997, Mechanics of Materials, PWS Publishing Company

iii. Timoshenko, S. P. (1940). Strength of materials, Part I, D. Van Nostrand Company, Inc., New York, NY.

iv. Young, W.C., and Budynas, R.G. (2002). Formulas for Stress and Strain, 7th ed., McGraw Hill, New York, NY.

v. Higdon, A., Ohlsen, E. H., Stiles, William B., Weese, John A., and Riley, William F. (1985). Mechanics of materials, John Wiley and Sons, New York, NY.

vi. Boresi, A. P. and Schmidt, R. J. and Sidebottom, O. M., 1993, Advanced mechanics of materials, John Wiley and Sons, New York.