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Design and Construction of Potal Frame Apparatus for Practical Training In Civil Engineering

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Abstract
Portal frame are two-dimensional frames connected by rigid joints between their vertical and horizontal members. The purpose of designing such a structure is to minimize the bending moment due to external loading in the beam. It is observed in design process that effects of deflection and deformation on beam and column are often considered in design process while lesser or no consideration are made on what happens to the frame structures when subjected to external forces be it rectangular, square or triangle frames.
This research work will help us to review previous studies on deformation of engineering materials. This study made us to examine existing portal frame apparatus, study their mode of operations and identify parameters required in operating the apparatus. Design and Construct an adequate apparatus for testing deflection and deformation in frame structures when subjected to external forces was made with more economical material. Relevant test were carried out to determine effectiveness of the apparatus compared to other existing apparatus. It was observed that the loads applied on frame structure is the stress that goes to the structure of materials which causes certain disturbance in molecular arrangement of the member called strain. If the stress made the molecular arrangement of the material to return to its normal position after withdrawn, the deformation is elastic. But if otherwise, the deformation is plastic deformation. A critical case may cause the material to break, this is fracture deformation.
Key words: *Deformation, Displacement, Deflection……*

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I. INTRODUCTION

Deformation in engineering refers to the change in size or shape of an object. *Displacements* are the *absolute* change in position of a point on the object. Deflection is the relative change in external displacements on an object. Strain is the *relative* internal change in shape of an infinitesimally small cube of material and can be expressed as a non-dimensional change in length or angle of distortion of the cube. Strains are related to the forces acting on the cube, which are known as stress, by a stress-strain curve. The relationship between stress and strain is generally linear and reversible up until the yield point and the deformation is elastic. The linear relationship for a material is known as Young's modulus. Above the yield point, some degree of permanent distortion remains after unloading and is termed plastic deformation. The determination of the stress and strain throughout a solid object is given by the field of strength of materials and for a structure by structural analysis.

When a material is subjected to increasing in stress it passes through 3 successive stages of deformation. Elastic deformation – wherein the strain is reversible. Ductile Deformation –wherein the strain is irreversible. Fracture – irreversible strain wherein the material breaks.

Engineering stress and engineering strain are approximations to the internal state that may be determined from the external forces and deformations of an object, provided that there is no significant change in size. When there is a significant change in size, the true stress and true strain can be derived from the instantaneous size of the object.

Also, we need to know that compressive loading has causes deformation in the cylinder so that the original shape has changed (deformed) into one with bulging sides. The sides bulge because the material, although strong enough to not crack or otherwise fail, is not strong enough to support the load without change. As a result, the material is forced out laterally. Internal forces (in this case at right angles to the deformation) resist the applied load. The concept of a rigid body can be applied if the deformation is negligible.

Portal frame are two-dimensional frames connected by rigid joints between their vertical and horizontal members. The purpose of designing such a structure is to minimize the bending moment due to external loading in the beam. Due to this effect, a frame can act as a single structural unit. The frames can be fastened with nuts,

bolts, or combinations depending on the building requirements from an Engineering perspective. Such frames are generally made of steel and can be fixed over the concrete slab or footings.

The frames can also be described as two-dimensional rigid frames that have the basic characteristics of a rigid joint between column and beam. A frame usually of steel consist of two uprights and a cross beam at the top: the simplest structural unit in a framed building or a doorway.

Portal frame can be made of any form depending on the structural requirements. Here a few forms of such frames are listed below:

- Crane portal frame with column bracket
- Tied portal frame
- Propped portal frame
- Portal frame with internal mezzanine floor
- Curved rafter portal frame
- Cellular beam portal frame
- Mono-pitch portal frame
- Pitched roof symmetrical portal frames

A portal frame structure consists of many frames which are braced in its axial direction and not braced in its transverse direction. Each frame of the structure consists of many columns and rafters. Bracing in the frames is provided between two consecutive portal frames on its roof.

Portal frames also consist of the steel element which consist of the side rails to support the external wall and roof purlins. These steel elements are needed because it plays an important role in supporting the portal frames against their buckling, which are primary steel structures. The composition of a portal frame includes the following items: Main frame, Haunches, Bracings, Gable frames and Secondary steel work.

Portal frame apparatus is used to examine the horizontal reactions, fixing moments and direction of ways of two rectangular portal frames subjected to vertical loading. It is an experimental apparatus to provide extended investigations into realistic structures including determining the point the points of failure of a loaded portal frame and also identifying the modes of failure.

Several equipment and apparatus had been invented to demonstrate effect of stress over materials used in Civil Engineering construction work in which portal frame apparatus is inclusive. Some apparatus like bending moment, shear force, deflection of beam, continuous beam, struct buckling apparatus and other were designed to examine characteristic of bars used in construction work. Never the less, the deformation and deflection pattern or effect on frame structures made with those bars must equally be evaluated. Hence, portal frame apparatus and others has been designed for Laboratory study of deformation and deflection pattern of frame structures.

This paper will enable us to examine existing portal frame apparatus, study their mode of operations and identify parameters required in operating the apparatus. The knowledge acquired from the study will be used to design and construct an adequate apparatus for testing deflection and deformation in frame structures when subjected to external forces with more economical material.

1.1 Aim and Objectives of the study

This research work was made to design and construct an adequate portal frame apparatus that is more economical using locally available materials after thorough evaluation of similar apparatus. This was guided by the following objectives:

- This study will encourage us to review major causes of deformation of Engineering materials has observed by many researchers.
- Not only that, deformations in portal frames will be specifically studied from previous researchers' papers.
- Critical examination on existing portal frame apparatus will be adopted to evaluated required specifications for a proposed home-made apparatus with same functions.
- A typical portal frame apparatus will be constructed with locally available materials.
- Demonstrations of how deformations occur in portal frame using constructed apparatus.
- Likely suggestions on how to prevent deformation in a portal frame structures will then be suggested.

1.2 Scope of the study

Several studies and research work had been made by many researchers on deformation and deflection of bars. Different analysis and theories have been established. Hence this study was to initiate studies on portal frame. This research work will be limited to:

- Literature review on deformation of engineering materials
- Design and Construction of adequate apparatus for testing deformation of portal frames.
- Experimental test of a typical portal frame to investigate effects of deformation a portal frame structure.

- Suggestion of likely control of deformation in portal frame structure.

II. MATERIALS AND METHODS

2.1 Materials

The materials used for construction of the portal frame apparatus were carefully selected based on knowledge gather after examine similar apparatus of such. The materials specification and required arrangement to make an adequate portal frame apparatus were expressed below; The apparatus is shown in plate 1 below.

Plate 1: The Picture of Portal frame Apparatus

The apparatus comprises of the following materials.

1. Two metric rulers: one-meter rule of one meter long was attached at the base of the frame structure to measure the length of the frame samples to be tested. Another ruler measures the height of the frame to be tested. A wooding ruler was used to reduce the net weight of the machine for it to be potable.
2. Two dial gauge: dial gauges of 10mm reading capacity were used to take deflection readings. A gauge was set for horizontal readings while a gauge was fixed for vertical reading. The gauges were initiated after setting frame before loading for next reading.
3. Different frames: the apparatus was made with different frames of variable diameters. The frames of different rectangular shapes, joints and end support were attached with the apparatus. The frames were made with steel materials of thickness ranging from 2mm to 10mm. the frame comprises of rectangular steel bars.
4. Two mini vice: the apparatus has two mini vices that were mounted on the horizontal testing plain on the apparatus frame. The vice was used as fixed support for the testing frame.
5. Several pulleys: several pulleys were mounted on vertical plain at both sides of the testing frame. Number mounted will be equivalent to numbers of horizontal external point load proposed on the testing frame
6. Apparatus Frame: the frame is 900mm height with a surface of 400mm X 1500mm and was made with a thick rectangular pipe of 25mm X 25mm welded together. The frame was painted and made attractive.
7. Set of Weight: set of weight with relevant hanger was made available for the test. The weight was used to applied load on the bars and varied to demonstrate effect of load on curve bars. The load applied and corresponding deformation of the bar will be recorded for further analysis.

2.2 Method used for the Test

The manufactured apparatus was used to test deformation of portal frame by following the steps mentioned below:

1. Place the apparatus on a rigid floor
2. Take the frame to be used and measured the thickness ‘t’, width ‘b’ and length ‘l’ of the frame. Record the data adequately.
3. fixed the frame on the vice of the machine at both ends, tighten it firmly and set the dial gauge holder.
4. Fixed the dial gauges and ensure that the tip of the gauges touch the bars. Let gauges 1 touches vertical bar and gauge 2 touches the horizontal bar.
5. Locate a point on the vertical bar of the frame that is perpendicular to pulley 1 at the right side and hook the weighting tread to the point.
6. Record initial reading of the gauge, apply additional weight of 50g and record the correspondence gauge difference for more than four times.

7. Repeat step 4 to 6 for pulley 2,3, & 4.
8. Draw the shear force diagram at load 200g.
9. Plot the graph of correspondence weight against deflection.
10. Repeat this procedure for other frames and compare your result

2.3 Precautions

Errors will be afforded from this test if the following precautions were taken to consideration:

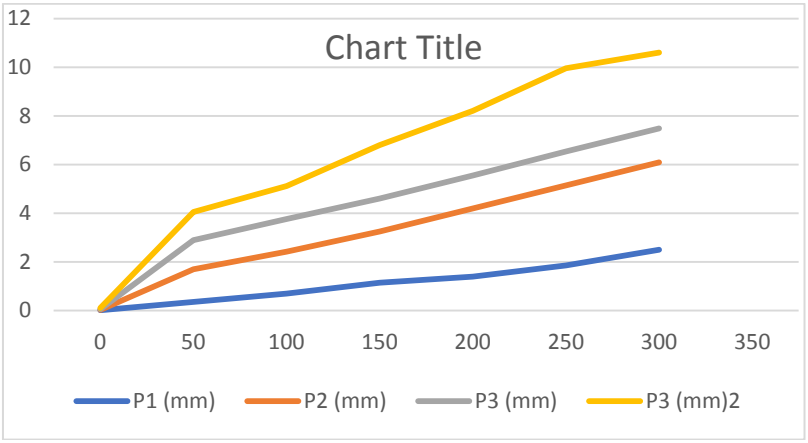
1. The environmental vibration should be avoided.
2. All readings be properly taken.
3. Distraction while working should be avoided.
4. Unnecessary abbreviations of decimal number should not be encouraged.

III. EXPERIMENTAL TEST RESULT

Length of Frame 'l' = 600mm
Hieght of Frame 'h' = 450mm
Thickness't' = 2.0 mm
Wirth 'b' = 25.0 mm
Pulley distance from fixed end 'P' , P1 = 100mm, P2 = 200mm, P3 = 300mm & P4 = 400mm

Table 3.0: Table of Applied Load against Deflection

Load (g)	Pulley 1 (mm)	Pulley 2 (mm)	Pulley 3 (mm)	Pulley 4 (mm)
0	0.01	0.03	0.05	0.10
50	0.35	1.70	2.90	4.05
100	0.70	2.42	3.76	5.12
150	1.15	3.25	4.61	6.80
200	1.40	4.20	5.55	8.21
250	1.85	5.15	6.54	9.96
300	2.50	6.09	7.48	10.60



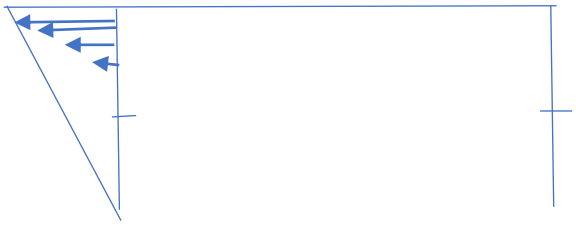


Figure 3.0: The shear force diagram of the reaction at load 200g

IV. CONCLUSIONS AND RECOMMENDATION

4.1 Conclusions

Most engineering-based courses include practical and laboratory experiments to complement the theoretical knowledge acquired by the students, promote their understanding. Practical and experiments in some cases show real situation effects and consequently give in depth knowledge of the course. In engineering education, the focus of laboratories is mostly on integrity theory and practice. However, a lack of coherent learning objectives for laboratory has limited the effectiveness of laboratory instruction and has hampered meaningful research. Both teachers and students see the laboratory as a means to increase the learner's theoretical understanding with practice. In addition, a fundamental component of engineering education is a practical activity conducted in instructional laboratories and the objective can only be achieved through laboratory-based investigations where students have to demonstrate understanding of and ability to apply a systems approach to engineering problems. However, where there are no or insufficient equipment, tools, apparatus etc. to achieve the mentioned objectives, then the trainer who knows that practical and experiments play a vital role in engineering education would have to improvise a working alternative where the research, experiments, tests etc. would be carried so as to complement whatever had been taught in the classroom. Hence, in such a situation, design and construction with engineering principles become inevitable and the reason for the choice of this project which in actual fact, had enhanced the learning of engineering courses by the students.

4.2 Recommendations

I hereby recommend that Engineers should take cognate note of deformation effects of frame structures and materials before recommended for construction works. Also, adequate reinforcement against such failures needed to be introduced where necessary. Finally, more research work on comparison of experimental and theoretical values of different materials were required.

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