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Analysis on Typical T- Structural Frame Subjected to Varied Loading Angle using MATLAB

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ABSTRACT

A structure refers to a body or system of connected parts used to support a load. Important examples related to Civil Engineering include buildings, bridges, and towers; and in other branches of engineering, ship and aircraft frames, tanks, pressure vessels, mechanical systems, and electrical supporting structures are important. To design a structure, an engineer must account for its safety, aesthetics, and serviceability, while considering economic and environmental constraints.

Once the dimensional requirement for a structure have been defined, it becomes necessary to determine loads the structure must support. Structural design therefore begins with specifying loads that on the structure. This current paper work is the analysis on typical T- structural frame s ed to a load of 5kN at one end and other two ends are fixed. The load applied is at any angle etween -90° to +90°. Analysis is been carried out using MATLAB and the obtained results sh the variation of force with respect to applied load angle, which helps the designer to design the frame to support the maximum force transmitted to them.

Keywords: Structure, Structural frame, MATLAB

I. INTRODUCTION

To perform an accurate analysis a structural engineer must determine information such as structural loads, geometry, support conditions, and material properties. The results of such an analysis typically include support reactions, stresses and displacements. This information is then compared to criteria that indicate the conditions of failure. Advanced structural analysis may examine dynamic response, stability and non-linear behavior. There are three approaches to the analysis: the mechanics of materials approach (also known as strength of materials), the elasticity theory approach (which is actually a special case of the more general field of continuum mechanics), and the finite element approach. The first two make use of analytical formulations which apply mostly simple linear elastic models, leading to closed-form solutions, and can often be solved by hand. The finite element approach is actually a numerical method for solving differential equations generated by theories of mechanics such as elasticity theory and strength of materials. However, the finite-element method depends heavily on the processing power of computers and is more applicable to structures of arbitrary size and complexity.

Each method has noteworthy limitations. The method of mechanics of materials is limited to very simple structural elements under relatively simple loading conditions. The structural elements and loading conditions allowed, however, are sufficient to solve many useful engineering problems. The theory of elasticity allows the solution of structural elements of general geometry under general loading conditions, in principle. Analytical solution, however, is limited to relatively simple cases. The solution of elasticity problems also requires the solution of a system of partial differential equations, which is considerably more mathematically demanding than the solution of mechanics of materials problems, which require at most the solution of an ordinary differential equation. The finite element method is perhaps the most restrictive and most useful at the same time. This method itself relies upon other structural theories (such as the other two discussed here) for equations to solve. It does, however, make it generally possible to solve these equations, even with highly complex geometry and loading conditions, with the restriction that there is always some numerical error. Effective and reliable use of this method requires a solid understanding of its limitations.

MATLAB is powerful computing software which is presently utilized in a number of educational institutions around the country to solve mathematics and engineering-related problems. The name of the software MATLAB stands for “Matrix Laboratory” since the built-in capabilities of this package are specifically designed for efficient handling of matrix and array operations. The effective and easy to-use computing environment of MATLAB along with availability of a large number of helpful MATLAB built-in functions has rendered it the popular tool of choice for many educators in various engineering fields. Using the MATLAB interactive environment, programs placed in script files can easily be created and edited to perform the desired computations and to generate the needed output. The capabilities of MATLAB can further be enhanced by additional “toolbox” modules that can separately be purchased through The Math Works, Inc., the company that produces the MATLAB software. These modules are designed to perform a variety of specialized tasks. The solutions presented in this paper are obtained using the basic features of MATLAB without utilizing any specialized MATLAB toolboxes.

In the submitted paper the procedure for solving structural analysis problems using MATLAB software is discussed. The goal of this paper is not to replace or alter the traditional techniques and procedures used in the subject, but as a means to complement and to make it more meaningful. The procedure is described in the paper through formulating and discussing the MATLAB solutions for simple structural frame problem applied to varying load.

II. OBLEM STATEMENT

The dimension of the frame in which ctural members support the 5kN load is as shown in Fig.1. The load is applied at any angle etween -90° to +90°.

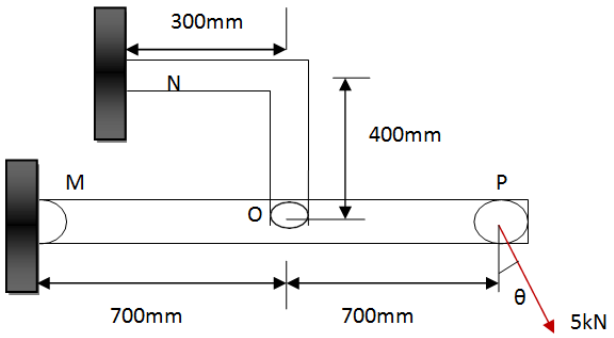
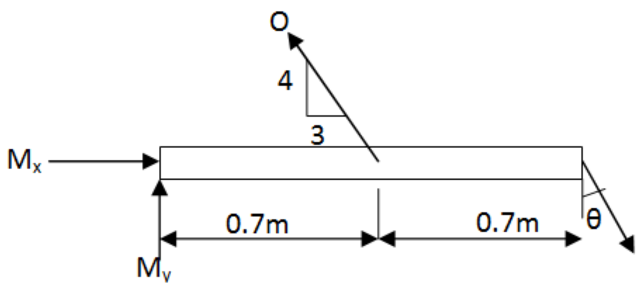


Fig. 1 T- sha structural frame

The pins at M and O need to be designed to support maximum force transmitted to them. Writing a MATL program to plot the forces at M and O as a function of d find their maximum values and corresponding angles

III. Analytical formulation

Free-body diagram of MOP of Fig. 1 is shown in Fig. 2. Note that member ON is a two-force member, thus the direction of the force O is from O to N. The equilibrium equations are,



$\Sigma M_m = \frac{4}{5}O\,(0.6) - 5\cos\theta(1.4) = 0$

$\Sigma F_x = M_x - \frac{3}{5}O + 5\sin\theta = 0$

$\Sigma F_y = M_y + \frac{4}{5}O - 5\cos\theta = 0$

Solving these equations yields,

$O = 12.5\cos\theta$, $M_x = 0.6\,O - 5\cos\theta$ and $M_y = 5\cos\theta - 0.8O$

$M = \sqrt{(M_X^2 + M_Y^2)}$

Substitution and simplification yields

$M = \sqrt{81.25\cos2\theta + 25\sin2\theta - 75\cos\theta\sin\theta}$

Maximum value of M is obtained from MATLAB program while maximum value of O is 12.5 N at $\theta = 0$.

The maximum value of M and the corresponding angle θ will be found in the MATLAB program.

IV. MATLAB Solution

```
>> al= -pi/2:0.01:pi/2; O=12.5*cos(al); Mx=0.6*O-5*sin(al); My=5*cos(al)-0.8*O; M=sqrt(Mx.^2+My.^2);
[Mmax,K]=max(M);
plot(al,O,al,M)
legend('M','O')
xlabel('Teta (rad)')
ylabel('Force (kN)')
fprintf('Maximum value of M=%f and corresponding angle =%f\n',Mmax,al(K)*180/pi);
```

MATLAB Result:

The result is as shown in Fig. 3. The Maximum value of M=9.999962 and corresponding angle =-26.401685

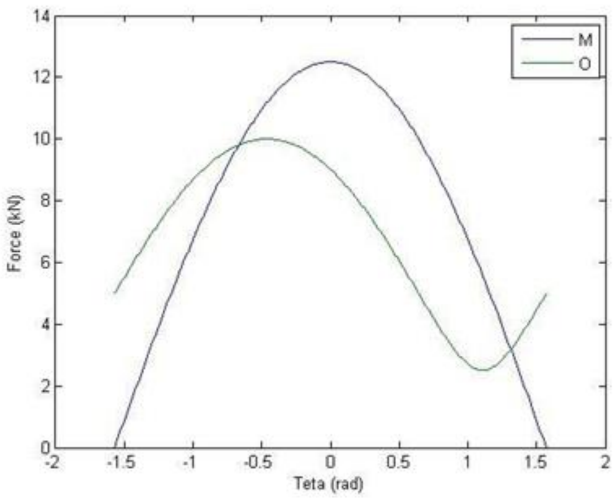


Fig. 3 Output Force(kN) vs. Teta(rad)

V. CONCLUSION

The work is analysis on typical T- structural frame subject to a load of 6kN at one end and other two ends are fixed. The load applied is at any angle etween -90° to +90°. Analysis is been carried out using MATLAB and the obtained result ows the variation of force with respect to applied load angle.

The following conclusions can be drawn from the analysis are:

1. MATLAB is a powerful tool in the analysis of simple to complex problems and most effective in the analysis in structures subjected to varying loads and angles.
2. The result shows that The Maximum value of M=9.999962 and corresponding angle =-26.401685. This or These results help the designer to design the frame to support the maximum force transmitted to them.

The work is no more exhaustive, structure can be analyzed for varying loads brought and highlighted in future scope of paper work.

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