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BUCKLING ANALYSIS OF TRACTOR TIE ROD SUBJECTED TO COMPRESSIVE LOAD

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Abstract: **A tie rod is a slender structural rod that is used as a tie and capable of carrying tensile and compressive loads. As the ratio of its length to the radius of gyration of its cross section is normally quite large, it would likely buckle under the action of compressive forces. When it becomes worn out, steering will become more difficult there by producing clunking noise. The vehicle will also typically be pulling or (dragging) to either side (left or right). Thus the aim of the project is to analyze tie rod for active to improve the mass and buckling load of tie rod. The objectives of this study are to carry out the theoretical, experimental and modal analysis of tractor Tie rod to find different modes shapes by analysis FE software.**

Keywords: **Tie rod, buckling analysis, Compressive load, buckling load, Abaqus, Hyper mesh.**

I. INTRODUCTION

For the past century a great deal of research has been invested to help predict the critical buckling loads of cylindrical columns. Research (both theory and experimental) has indicated that geometrical imperfections and modified boundary conditions greatly impact the critical buckling load magnitudes and scatter of cylindrical columns. A tie rod contains such geometrical imperfections and modified boundary conditions from a perfect cylindrical shell, since a tie rod typically consists of two outer rod ends threaded into a cylindrical rod body, with varying end conditions. It is very important to accurately predict the buckling loads of structural tie rods, especially ones that are compression critical in automobile industries and aerospace applications.

There are several applications where a tie rod is utilized to help secure and support equipment on an automobile and aircraft, such as on the fuselage of an airplane. These are purely structural members, so a robust knowledge of the design loads is required to ensure the part will satisfy its function on the automobile and aircraft. In certain cases, these tie rods need to be designed to buckle at a specific load to avoid puncturing or damaging nearby components. Based on the design criteria of minimizing compression margin safety coupled with the degree of difficulty to predict buckling behavior, accurately calculating the critical buckling load is of high importance. This report is an analytical study that gives a designer a systematic approach to accurately predict the buckling load of a structural tie rod. To accomplish this level of accuracy, a nonlinear finite element analysis is conducted. The goal of the report is to establish an acceptable method of predicting the buckling load of a structural tie rod due to axial compression.

II. EXPERIEMENTAL SET UP

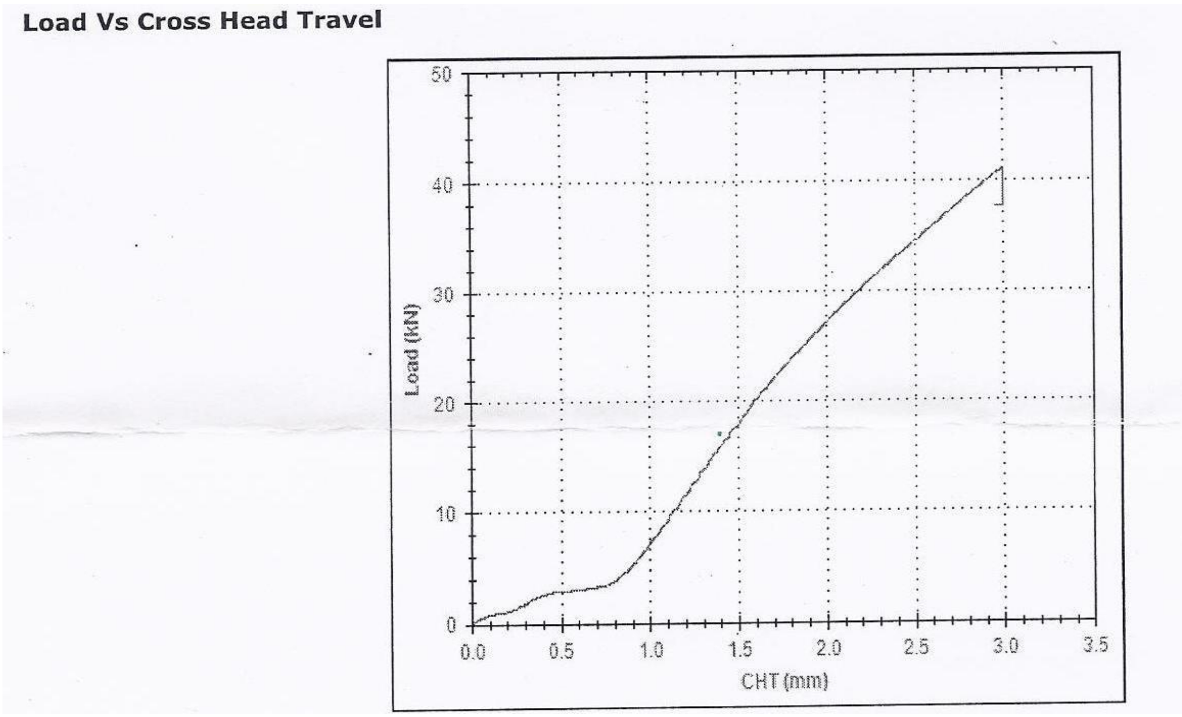
A. Compression Test

Operation of the machine is by hydraulic transmission of load from the test specimen to a separately housed load indicator. The hydraulic system is ideal since it replaces transmission of load through levers and knife-edges, which are prone to wear out and damage due to shock on rupture of test pieces.

Load is applied by a hydrostatically lubricated ram. Main cylinder pressure is transmitted to the cylinder of the pendulum dynamometer system housed in the control panel. The cylinder of the dynamometer is also of self-lubricating system. The load transmitted to the cylinder of the dynamometer is transferred through a lever system to a pendulum. Displacement of the pendulum actuates the rack and pinion mechanism which operates the load indicator pointer and the autographic recorder. The deflection of the pendulum represents the absolute load applied on the test specimen. Return movement of the pendulum is effectively damped to absorb energy in the event of sudden breakage of specimen. Experimental setup is shown in figure 1 and Experimental graph load versus CHT is shown in graph 1.

B. Figures, Graphs and Tables

Fig.1: Experimental setup



Graph 1: Experimental graph load vs CHT

Fig.2: Displacement at 5.619mm

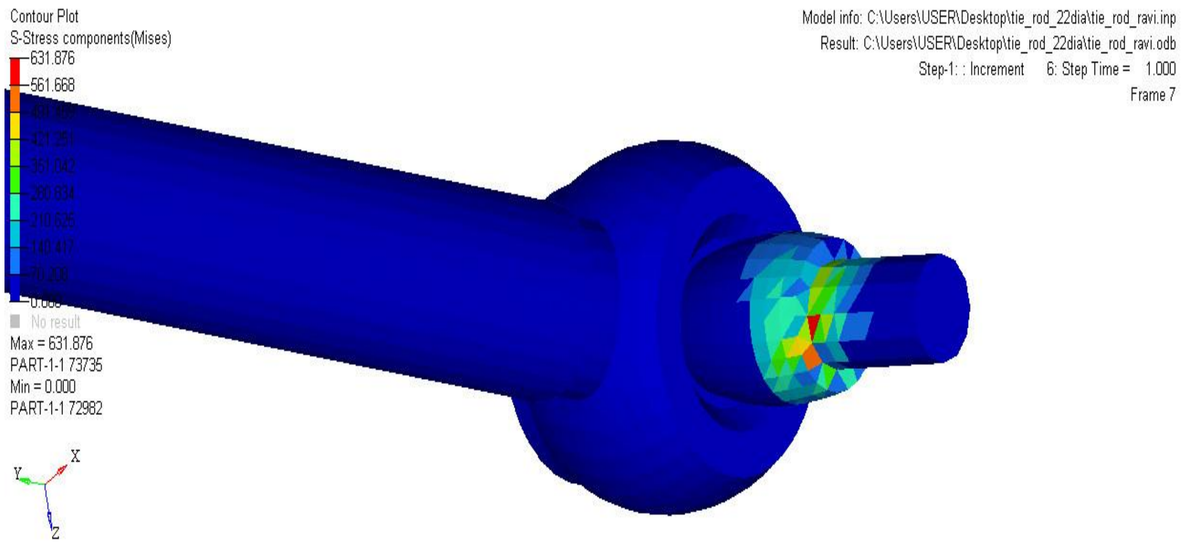


Fig.3: Stress at 631.876N/mm^2

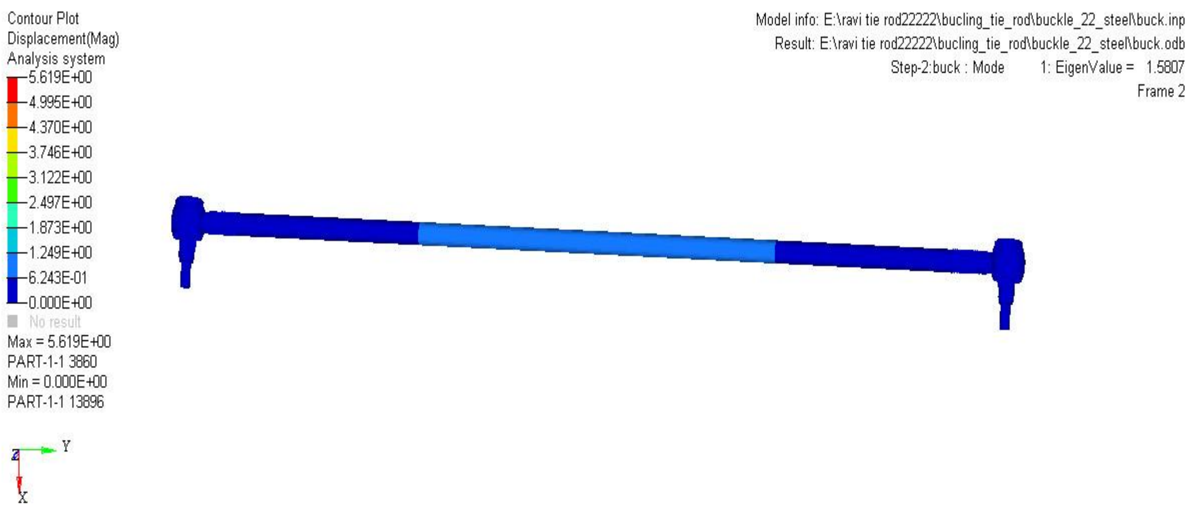


Fig.4: Buckling eigen value at 1.5807

Table 1: Comparison of Design iteration like different materials, shape, and size with Stress and Displacement

Different materials	**Different iterations**	**Displacements in mm**	**Stress in N/mm^2**	**Yield strength in N/mm^2**	**Ultimate strength in N/mm^2**
Aluminum A6016	ITR-1	29.88	2078.650	35	90
	Actual tie rod	23.137	1874.060	35	90
	ITR-2	20.619	1688.973	35	90
Cast iron C1540	ITR-1	12.034	1050.84	85	220
	Actual tie rod	9.838	876.871	85	220
	ITR-2	8.574	857.814	85	220
Mild steel SAE 1020	ITR-1	10.094	900.019	250 -785	380-1570
	Actual tie rod	5.619	633.875	250 -785	380-1570
	ITR-2	2.837	466.199	250 -785	380-1570

Table2: Comparison of Design iteration like different materials, shape, size and buckling load factor

Different materials	**Different iterations**	**Eigen value or load factor**	**Buckling load in N**
Aluminum A6016	ITR-1	-0.0212	-869.2
	Actual tie rod	-0.017983	-737
	ITR-2	0.0531	217.71
Cast iron C1540	ITR-1	0.3541	14518.1
	Actual tie rod	0.47491	19471.31
	ITR-2	0.86841	35604.81
Mild steel SAE 1020	ITR-1	0.65838	26993.58
	Actual tie rod	1.5807	64780.0
	ITR-2	2.259	92619.0

Table3: Mass count

Different iterations	**Mass ton/mm^3**
ITR-1	3.466 E^{-3}
Actual tie rod	3.533E^{-3}
ITR-2	3.039 E^{-3}

III. RESULTS AND DISCUSSIONS

Static analysis is performed to know the maximum stress developed on the tie rod and also the displacement and reaction forces at the contact location. The name Static indicates that the load on the tie rod is constant, that is load not varying with respect to time. Static analysis is performed with 41000 N loading applied as compressive force in Y directions. The boundary conditions are applied and all DOF in the Hanger location are constrained. As the actual tie rod can be analyzed then results like displacement, stress and buckling eigen value as shown in figures 2,3 and 4 respectively. Results will be decreased displacement, stress and increased buckling eigen value then buckling load will be increasing. To analyze the different materials, shape and size like itr-1, actual tie rod, itr-2.In table 1 mild steel SAE 1020 (itr-2) will be better results like stress and displacement compared to other iterations. To analyze the different materials, shape and size like itr-1, actual tie rod, itr-2.In this table mild steel SAE 1020 (itr-2) will be better results like buckling load factor and buckling load compared to other iterations.

IV. CONCLUSION

Mesh model of tie rod satisfied all quality criteria's hence the results are accurate. The displacement, stress, buckling eigen value and mass count as shown tables 2, 3 and 4 respectively. Results will be decreases displacement, stress, mass count and increases buckling eigen value then buckling load will be increases compare to actual tie rod. Loads and boundary conditions are accurately simulated to obtain the realistic loading conditions. Mild steel SAE 1020 ITR 2 gives better results like stress, displacement, mass of the model and buckling load when compare to remaining Iterations (ITR_01, actual tie rod, ITR_02). Finally concluded in future days to use the tractor tie rod for modify design (itr-2).

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