Dynamic Analysis of 3 Cubic meter Tractor Trailer

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Abstract

In the present market scenario, cost reduction technique is most important role to meet the competition in the market. Weight reduction and simplicity in design are also application of industrial engineering etc. are used as sources of technique. Various components or products used in rural areas are mostly manufactured in small scale industries such as farming machinery, thrashers, tractor trolleys etc. It has been observed that these rural products are not properly designed. Tractor trolleys are manufactured in small to moderate scale industries. Though tractor trolleys are manufactured of various capacities by various industries, still there is a large variation in manufacturing methods, component design etc. In this paper focus on first we design & then dynamic analysis of tractor trailer which is more import component in rear axle gear drive.

Keywords-*3 Cubic meter Tractor Trailer, CAD, Dynamic Analysis*

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1. INTRODUCTION

To During service, any trailer is subjected to loads that cause stresses, vibrations and noise in the different components of its structure. This requires appropriate strength, stiffness and fatigue properties of the components to be able to stand these loads. On top of that, quality of a trailer, as a system, which include efficient energy consumption, safety, and provision of comfort to the user are highly desired.

Vehicle dynamics, a discipline of broader significance, is an area where the basics of analyses on vehicles are dealt with. Forces/loads acting on vehicles can be categorized as road, aerodynamic, and gravity loads. Of all these, forces and moments generated by tires at the ground are significant in controlling motion of the vehicle. The response of the vehicle structures to these loads are dealt with in vehicle dynamics.

The responses of a trailer are defined in terms of deflections, stresses, and strains, natural frequencies, random response functions, and fatigue life and so on. Evaluation of the above is what puts the basis on which robustness of a vehicle system or design is ascertained in terms of its mechanical behavior. Simulation of vehicle responses largely concentrates on determination of the above.

Different researches have been carried out regarding the performance, the response of components to static and dynamic loads, crashworthiness, safety and others by different institutions and automotive companies. Particularly, with the growing simulation capability using computers, researches are facilitated that are aimed at achieving better quality products.

2. TECHANICAL SPECIFIACTION OF 3 CUBIC METER TRACTOR TRAILER

Table I

Technical Specification of 3 Cubic Meter Tractor Trailer

Item No	Item	Specification	Justification and remarks
1	Capacity	The trailer shall be of 3 cubic meter capacity.	A 3 m^3 capacity gives a payload of approximately 5 tonnes. This is within the haulage capacity of a 55 to 65 hp tractor. Given a small hauler, this size maintains a balance between Loading /offloading time, and travel time. It also maintains a balance between the weight of the load and the strength of the trailer. Its relatively small size enables greater maneuverability on narrow roads.
2	Size	The trailer shall have the following dimensions: Height to top of body1300 mm Overall length 4800 mm Overall width 2550 mm Drawbar length 1130 mm Inside dimensions of bucket: Top width 2000 mm Bottom width 1500 mm Length 3150 mm Depth 555 mm	The relatively low sides make for easy hand loading. The long drawbar prevents the rear tractor wheels fouling the bucket during sharp turning. The overall width is governed by the narrowness of the roads, and by highway regulations. The depth of the bucket is limited at the bottom end by hitch height and on top by the size of the human frame. Front and rear gussets could be added for additional strength.
3	Shape	The bucket shall have sloping sides, sloping front, and an angled back.	The sloping front and sides contribute to the ease of unloading. Sloping front and sides make for a stronger design than a rectangular shape. A rectangular box shape was tried but found to be weaker. The sloping back allows for the natural repose angle of the spoil.
4	Body	The body of the trailer (the bucket) shall be all steel plate of 3 mm thickness reinforced by cold pressed steel channel of 40 x 80 x 3 mm at intervals as shown on the attached drawings. Two drainage holes shall be made at the front.	The thickness of the steel body copes with the rough loading of heavy material. In areas of high corrosion, e.g.at the coast, the use of 4mm plate could be considered. **NB** This is an integral design. Arbitrary modifications, such as cutting doors in the bucket, may weaken the trailer.
5	Chassis	The chassis shall comprise an A-frame, side members and crossbars, and shall be of U-shaped channels of 160 x 65 x 8 mm welded together as per the attached drawings. Continuous welds shall be used throughout. The middle member of the chassis shall be of two U-shaped channels of 160 x 65 x 8 mm welded together to form the draw bar of 1130 mm in length as per the attached drawings.	The A-frame design gives three-point support to the front of the bucket and prevents failure of the drawbar. The side members and crossbars support the bucket throughout its length and prevent structural failure of the bucket as a whole. Suitable breathing holes should be provided.
6	Axle	The axle shall be made of two U-shaped hot rolled steel channels of 100 x 50 x 6 mm. These shall be welded together with the stub axle welded between them. The axle shall be located 1100mm from	This design of axle will bear a rated load of 9000 kg. For rougher conditions, the axle rating could be increased to 10000kg. In this case, you may want to consider tyre sizes of 1100 x 20, 16 ply. A spare tyre could be fitted to the front of the bucket.

		the back of the chassis. Total length of the channels 1860 mm. Total length of the stub axle 500 mm (minimum). Tyre size 900 x 20 14 ply. There will be a distance of 100 mm between the top of the wheel and the sloping sides of the body.	
7	Towbar	1 Towing eye: To be cut from 32 mm steel plate. Inside hole diameter 50 mm. 2 Towing socket: Internal diameter 80 mm. To be made from cast steel with additives. To fit inside the drawbar.	Over time the towing eye will wear out. This design allows for cheap and simple replacement of the towing eye. This item can be produced by the manufacturer.
8	Painting	One primer coat. Two coats industrial grade paint.	
9	Hitch	The pickup hitch shall be of the hydraulic weight transfer type. It shall have a four-position mounting as indicated in the attached drawings. It shall incorporate a fail-safe locking mechanism. The mountings shall be arranged such that the hitch will accommodate a wide range of tractors and models. The pickup hitch must be of heavy duty commercial grade. Ordinary agricultural hitches are too light and will break. Drawings of a suitable heavy duty hitch, designed to be adapted to fit any make and model of tractor, are appended. This design does not involve any complex processes and can be made by a local manufacturer.	Weight transfer increases traction and provides for more positive steering. This kind of hitch has a longer life compared with other types, and there is less down time due to hitch failure. The four-position mounting distributes the forces, provides a robust fixing, and results in less maintenance. It also helps to maintain the structural integrity of the tractor. The locking mechanism prevents the trailer from parting from the tractor and possibly causing an accident. The universal design ensures that it can be adapted to a wide range of tractor types and models. There are two options for attaching the trailer: pin and eye, or ball and socket. The towing eye fits over the pin; or the towing socket fits over the ball. Either a pin or ball is mounted onto the hitch assembly at the rear of the tractor. This pin or ball is raised and lowered by the tractor's internal hydraulics. The whole arrangement is referred to as an hydraulic pickup hitch.
10	Tractor	1. Power: between 60 and 65 hp (note that effective power declines with altitude, e.g.at 1500m (5000ft) a tractor will have lost 20% of its power). 2. Drive: two-wheel drive. 3. Wheel rims: heavy duty. 4 .Tyres: industrial grade. 5Supplier: to have a significant market share in the country. 6.Make and model: see Annexure	Tractors of 60 to 65 horsepower are readily available, and their cost is relatively modest. For mountainous terrain, the power needs to be increased to between 65 and 80 horsepower. Four-wheel drive is unnecessary; two-wheel drive is cheaper. Heavy duty wheel rims are necessary to support sustained heavy working conditions. Industrial grade tyres have a longer working life and are therefore more cost effective. A supplier with a significant market share is more likely to have an adequate supply of spare parts, and to be able to carry out effective servicing and repairs. To improve traction and stability, weights can be added to the front of the tractor. If a PTO shaft is fitted to the tractor, it is better to remove it.

3. FE ANALYSIS OF 3 CUBIC TRACTOR TRAILER IN ANSYS WORK BENCH

3.1 Introduction

The finite element method (FEM), sometimes referred to as finite element analysis (FEA), is a computational technique used to obtain approximate solutions of boundary value problems in engineering. Simply stated, a boundary value problem is a mathematical problem in which one or more dependent variables must satisfy a differential equation everywhere within a known domain of independent variables and satisfy specific conditions on the boundary of the domain. Boundary value problems are also sometimes called field problems. The field is the domain of interest and most often represents a physical structure.

The field variables are the dependent variables of interest governed by the differential equation. The boundary conditions are the specified values of the field variables (or related variables such as derivatives) on the boundaries of the field. Depending on the type of physical problem being analyzed, the field variables may include physical displacement, temperature, heat flux, and fluid velocity to name only a few.

3.2 Basic Steps of FEA Analysis

3.2.1Preprocessing: Defining the problem

The major steps in preprocessing are

(i)Define key points/lines/areas/volumes,

(ii)Define element type and material/geometric properties,

(iii)Mesh lines/areas/ volumes as required. The amount of detail required will depend on the dimensionality of the analysis, i.e., 1D, 2D, ax symmetric, and 3D.

3.2.2 Solution: assigning loads, constraints, and solving

Here, it is necessary to specify the loads (point or pressure), constraints (translational and rotational), and finally solve the resulting set of equations.

3.2.3Post processing: further processing and viewing of the results

In this stage one may wish to see

(i)lists of nodal displacements,

(ii)element forces and moments,

(iii)deflection plots, and

(iv)Stress contour diagrams or temperature maps.

3.3.Step-1 Pre-processing

1)First Prepare Assembly in Solidworks 2011 and Save as this assembly as .IGES for Exporting into Ansys Workbench Environment. Import .IGES Model in ANSYS Workbench Simulation Module .

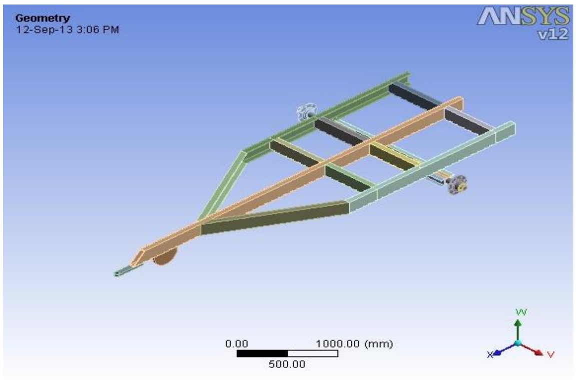
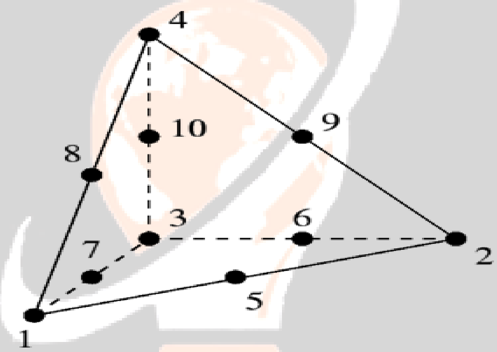


Fig. 1 Geometry of Trailer using static analysis

2) Check the Geometry for Meshing.

3) Apply Material for Each Component.

4) Create mesh.



No. of Nodes:- 28200

No. of Elements:- 15737

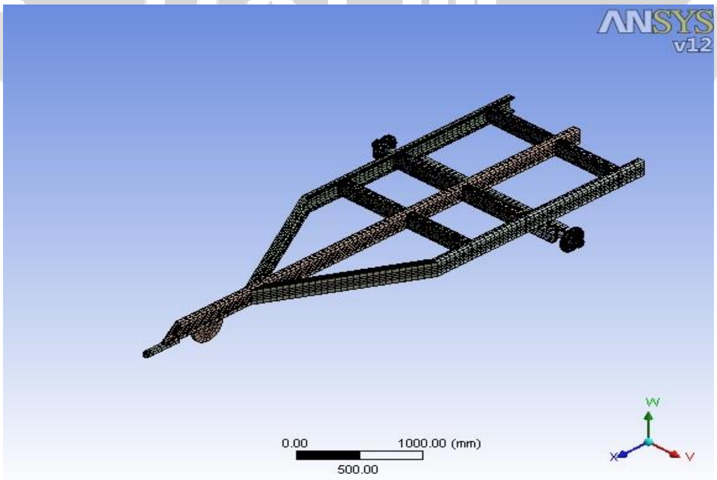


Fig. 2 Meshing of trailer using static analysis

5) Define Boundry condition

3.4.Apply Fixed Support

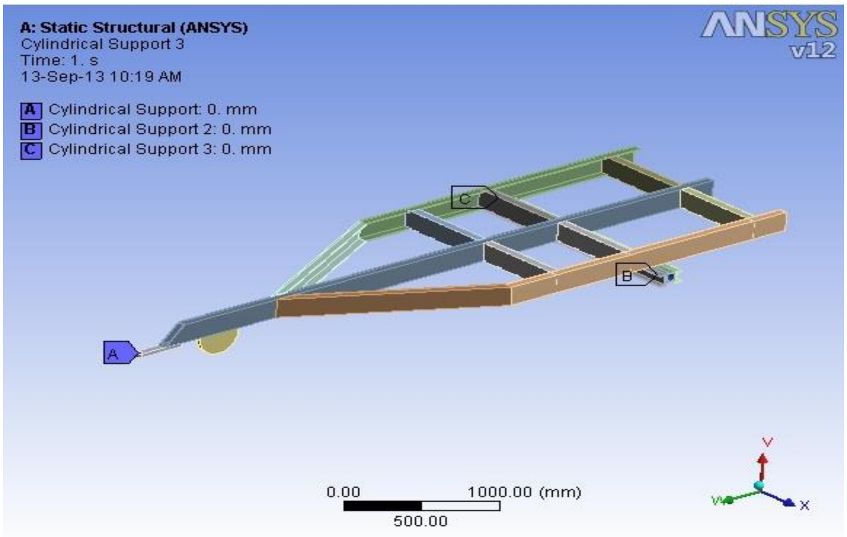


Fig.3 **B**oundary condition of trailer using static analysis

3.5 Apply Force

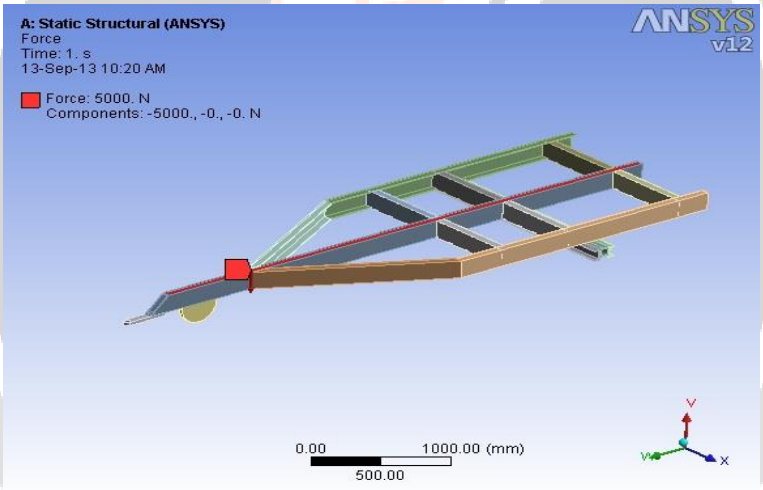


Fig.4 Force analysis of trailer

4.. Dynamic Analysis of 3 Meter Cubic Trailer

4.1 Dynamic Analysis of 3 Meter Cubic Trailer

An approximation for the component deformation was introduced by means of a weighted sum of constant shape functions. When dealing with the task of deriving these functions the finite element method can be very effective. Here, a well-known and widely used concept known as component mode synthesis (CMS) can be used. One of the most common approaches (Craig and Brampton 1968) is based on the idea of using normal mode analysis techniques to calculate eigenvectors for use as shape functions, or shape vectors, respectively. While employing eigenvectors for approximation was already very widespread, Craig and Brampton among others (Hurty 1965) enhanced the method by taking into account additional types of vectors. In the following, Craig and Brampton's method is dealt with in more detail since it is also implemented in MSC.ADAMS/Flex. Here, the following types of vectors or modes are utilized:

1. Fixed boundary normal modes

2. Static correction modes

Fixed boundary normal modes are eigenvectors that result from a finite element normal mode analysis. They are connected with the boundary condition implying that all nodes of the finite element model are fixed at which forces and joints that is applied within the multi body system. In the following sections, these nodes are referred to as interface nodes. Static correction modes are deformation vectors that result from static load cases with which loads are applied to interface points. Typically, a unit load is applied to every nodal coordinate, whereas all other interface nodes are fixed. This leads to six static correction modes for each interface node. Figure 2 illustrates some mode shapes for a one-dimensional bar. The shapes (a) and (b) are fixed-boundary normal modes, shapes (c) and (d) are static correction modes resulting from a unit displacement (c) and a unit rotation (d), respectively. The use of static correction modes ensures a good approximation of the deformation when forces and moments are applied to interface points. The fixed boundary normal modes are important as soon as high frequency excitation is expected, i.e., if the loading may not be considered “quasi-static”. Note: In the following, the flexible component is always assumed to be represented by a finite element model.

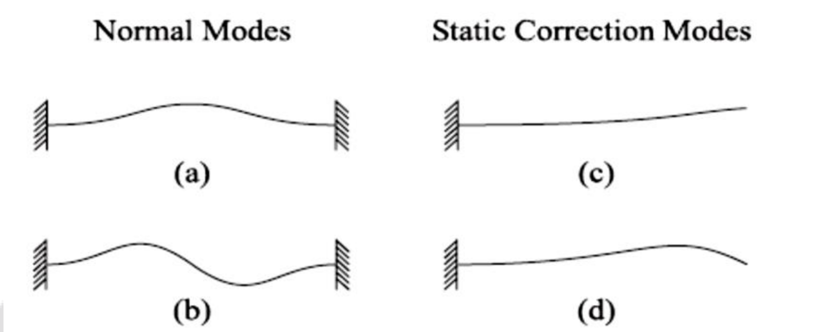


Figure 4.1 Mode shapes of one-dimensional bar

4.2 Benefits of Modal Analysis:-

- Allows the design to avoid resonant vibrations or to vibrate at a specified frequency (speaker box, for example).
- Gives engineers an idea of how the design will respond to different types of dynamic loads.

.3 Steps of Dynamic Analysis

- Helps in calculating solution controls (time steps, etc.) for other dynamic analyses.

MODEL ANALYSIS

4.3.1 Geometry

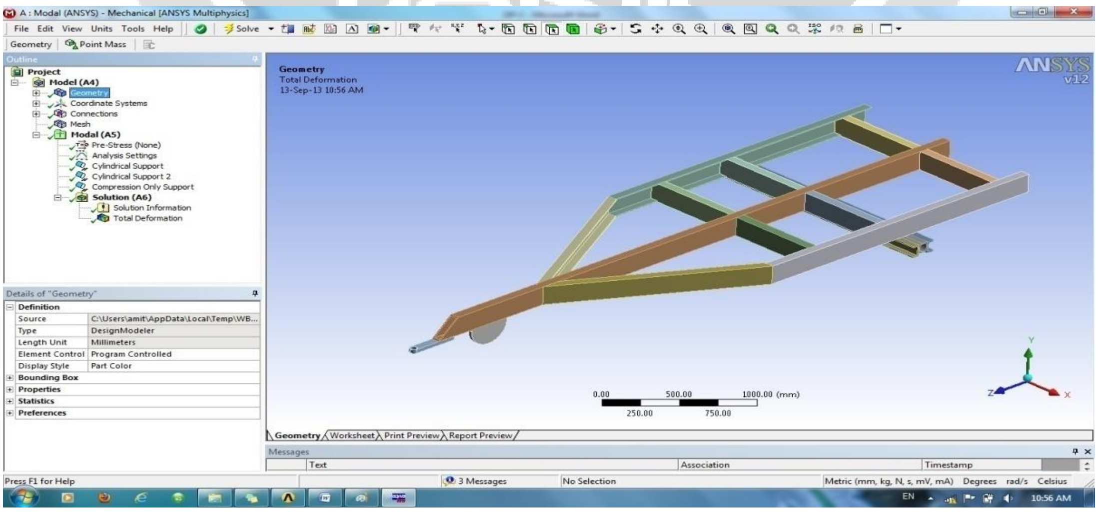


Figure 4.2 Geometry of trailer using dynamic analysis

4.3.2 To Find Natural Frequency at Connection Region

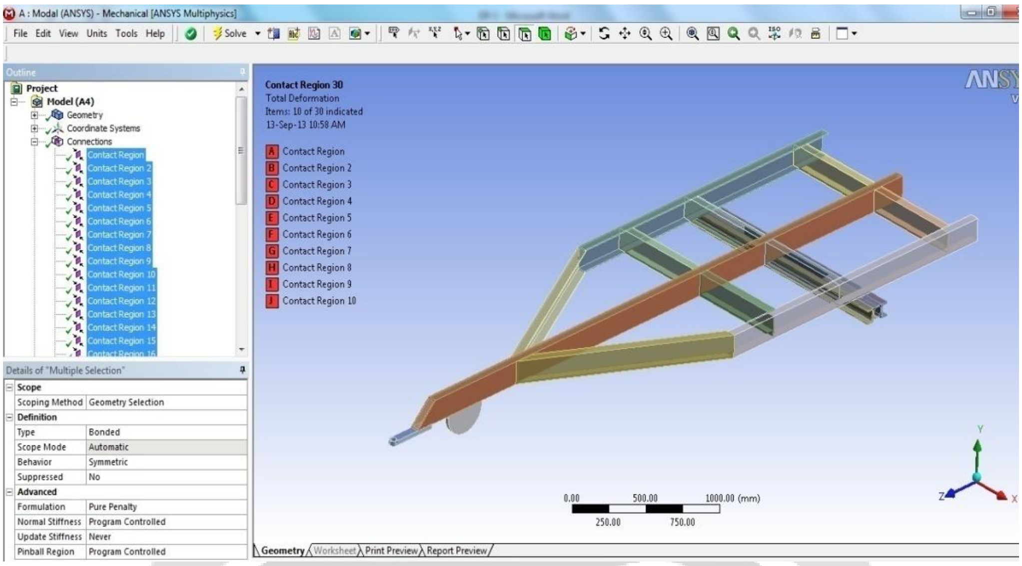


Figure 4.3 Connection between parts

4.3.3 Meshing

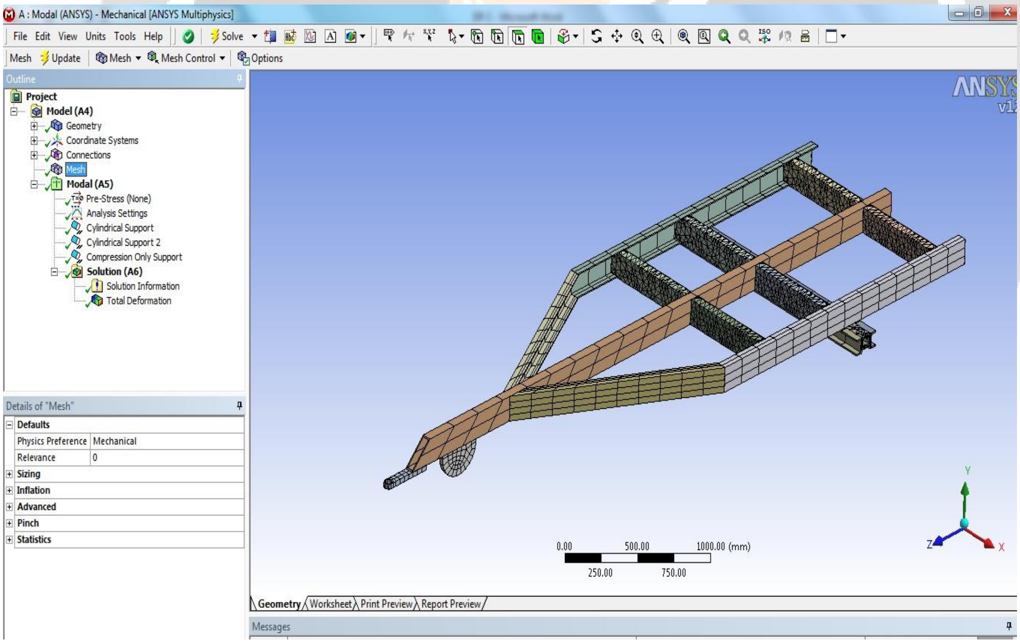


Figure 4.4 Mesh Model of Trailer Structure

4.3.4 Apply Fixed Support

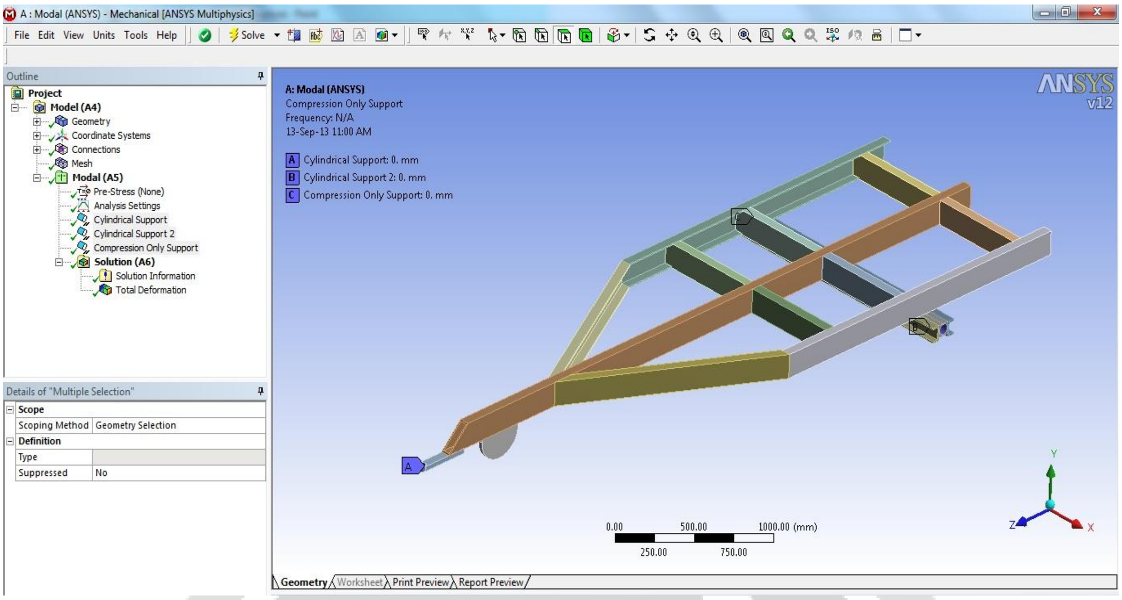


Figure 4.5 Application of Fixed Support

4.3.5 Results of Analysis

Mode - 1

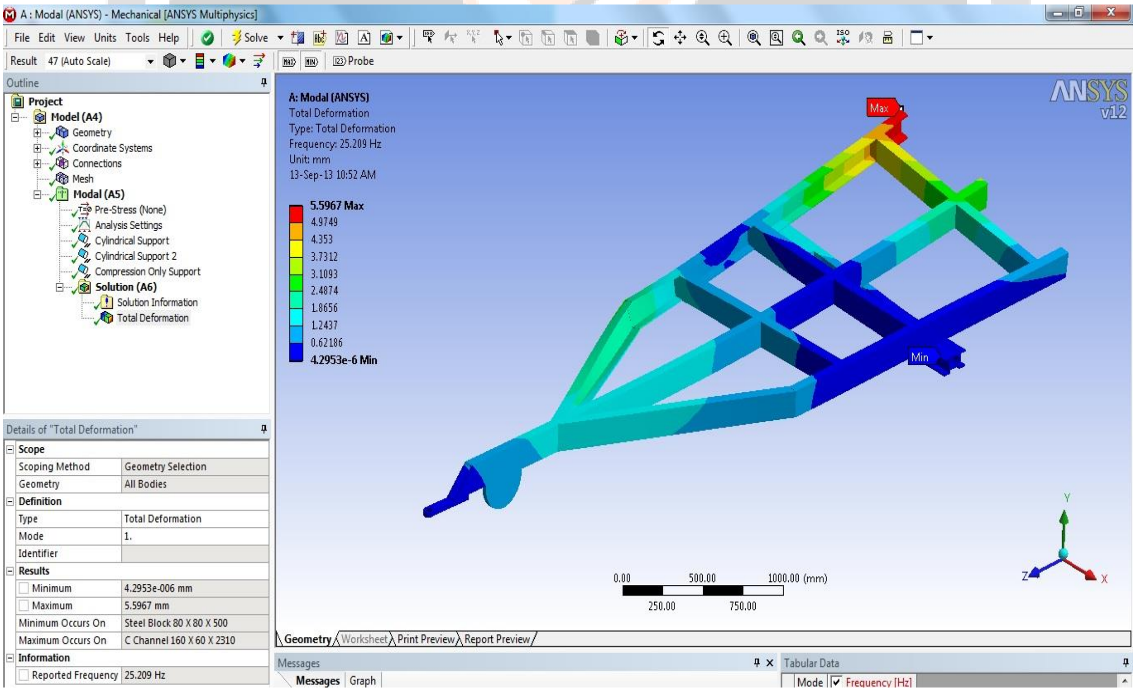


Figure 4.6 Total deformation of mode 1

Mode-2

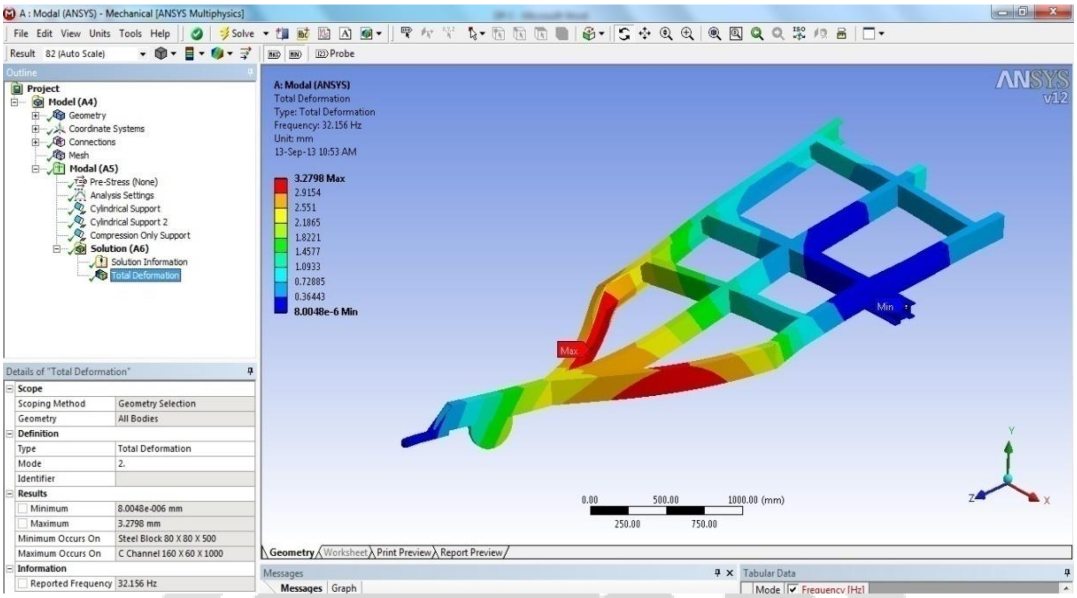


Figure 4.7 Total deformation of mode 2

Mode-3

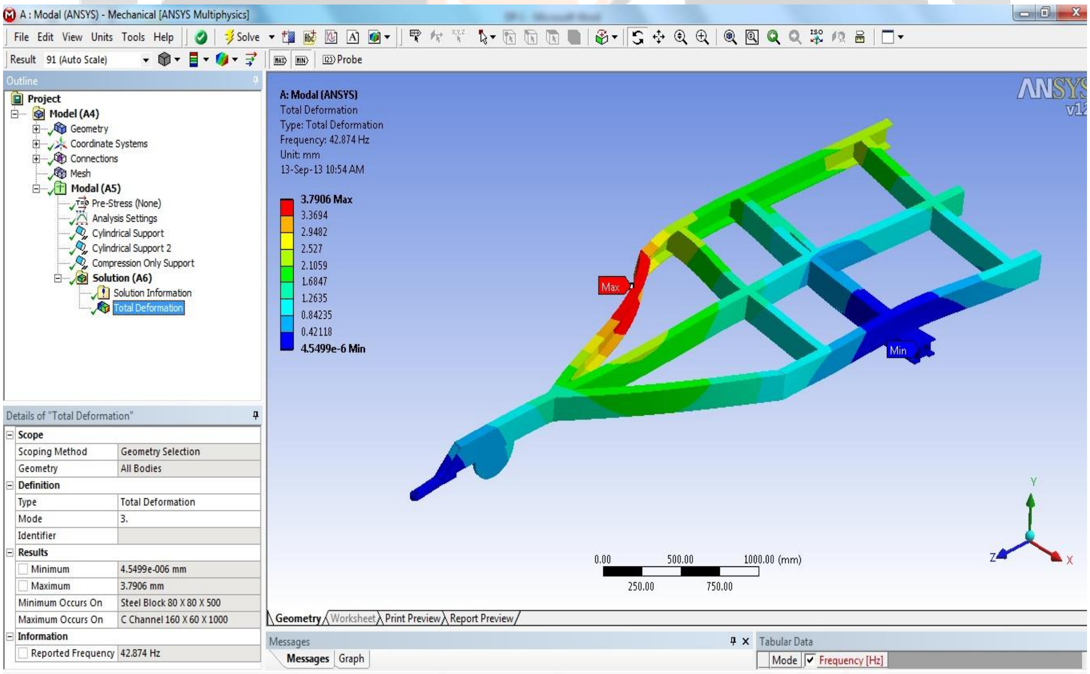


Figure 4.8 Total deformation of mode 3

Mode-4

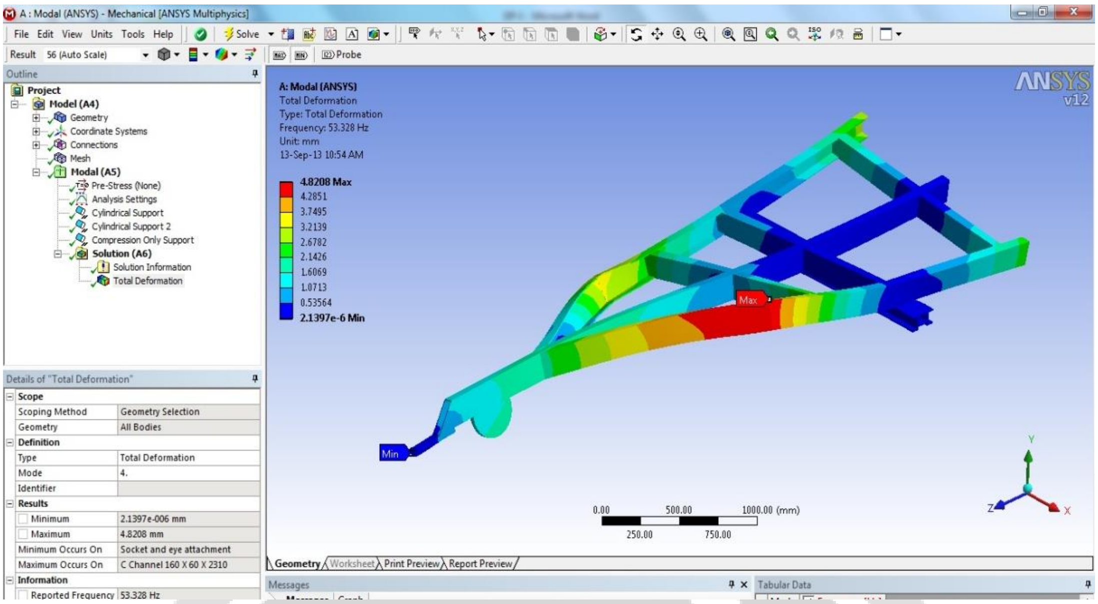


Figure 4.9 Total deformation of mode 4

Mode-5

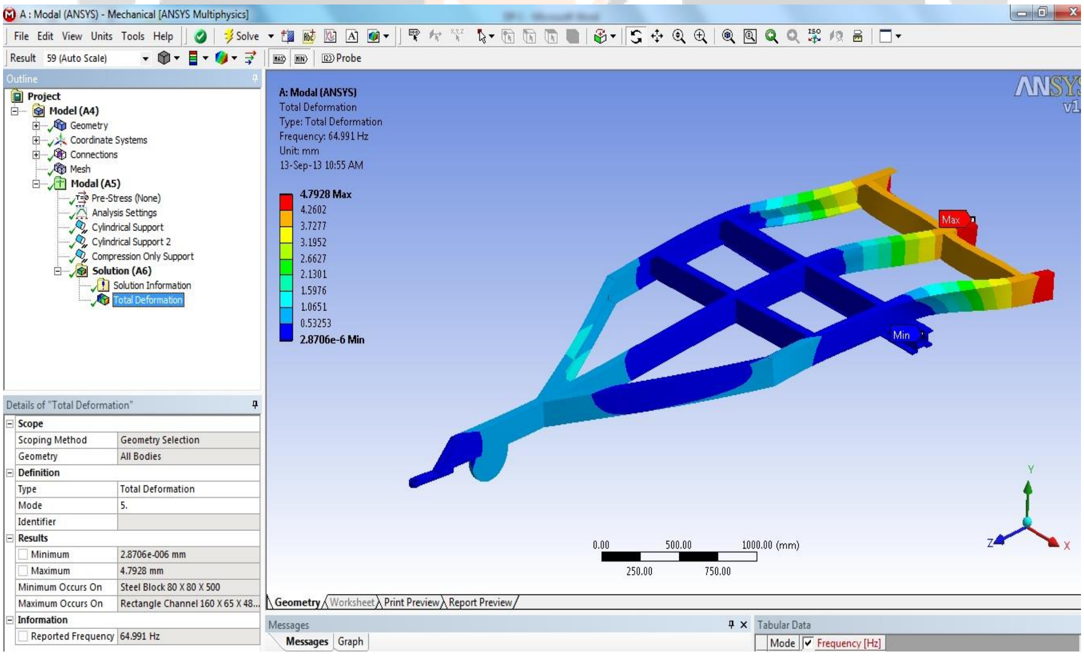


Figure 4.10 Total deformation of mode 5

Mode-6

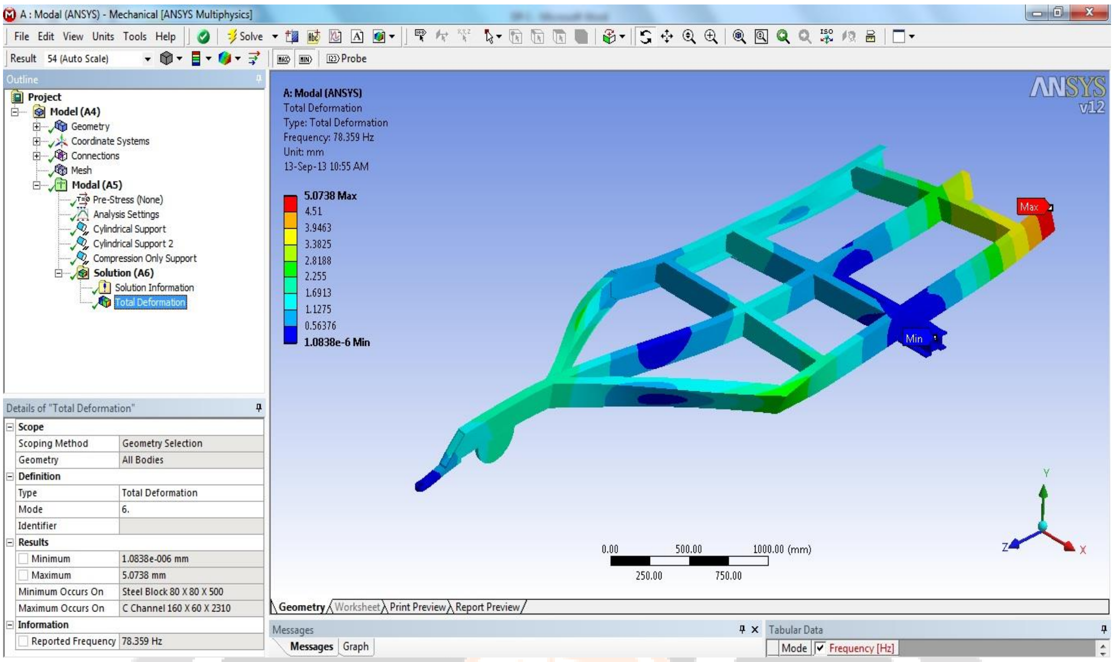


Figure 4.11 Total deformation of mode 6

5. Comparison between Two Material Result Base on Static and Fatigue Analysis

Sr. No.	Material	Max. Von-mises Stress in MPa		Max. Shear Stress in MPa		Total Deformation in mm	
		Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
1	Structural Steel	2.04×10^{-9}	18.69	1.17×10^{-9}	9.58	0	0.289
2	Grey Cast Iron	2.3×10^{-9}	19.31	1.37×10^{-9}	9.8	0	0.525

Table 5.1 Comparison of Static Analysis Result

Table 5.2 Comparison of Fatigue Analysis Result

Sr. No.	Material	Life	Damage Life 1×10^9	Safety Factor	Fatigue Sensitivity
1	Structural Steel	1×10^6 Cycle	1000	4.611	50-150%
2	Grey Cast Iron	-	-	-	-

5. CONCLUSION

In this study, the responses of a commercial vehicle with Trailer are determined under static and dynamic loads, the results of which are believed to be significant. The analysis includes stress and displacement/deflection responses of the vehicle to the loads. The dynamic analysis is carried out taking into account different road roughness conditions.

From the results obtained in the analysis, the following can be concluded:

- The structure particularly part of the structure where there is change in cross-section is affected the most by static loads.
- The bucket structure experiences the highest deflections and stresses due to random excitations caused by road roughness.
- Part of the structure which is affected the most by static loads is also affected by dynamic loads, comparable to highly loaded points on the bucket structure.

- The trailer structure, in any of the cases considered has comparable displacement/deflection with the Trailer. However, the level of stress, in any of the cases, is very low and in comparable to highly stressed points in the end joint and structure.

- The analysis performed in this research is based on some assumptions and restrictions. However, complete structural analysis and thus, understanding of behavior of the vehicle is attained taking every possible detail into account. Therefore, the following are recommended for future work as extensions and elaborations of this research.

The effects of wind shield, and trailer structures on the overall stiffness characteristics of the structure.

1. **NVH Analysis on Tractor trailer**
2. **Test on Different road Conditions..**
3. **Feasibility check for the commercialization.**

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