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# ANALYSIS AND DESIGN OF HEAVY-VEHICLE CHASSIS FOR THE EFFECTS OF DIFFERENT STRESS DISTRIBUTIONS ON THEIR PERFORMANCE

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## ABSTRACT

A dump truck chassis is an off-road vehicle system component. This study models, designs, and analyses heavy vehicle chassis. The main goal is to calculate the linear static stress distribution in the crucial section of the chassis and anticipate its fatigue life. Pro-E, HYPER MESH, and ANSYS are commercial finite element analysis software packages used to analysis a truck chassis model. An off-highway higher tone dump truck with a load carrying capacity of 50-60 tones was studied. The linear static and fatigue analysis was used to assess the chassis' stress distribution and longevity. The complete fabricated structure is welded to BS 5400 welding standard. It is used to weld the entire chassis. Chassis are made of high strength structural steel (IS 1030) plates and ASTM A148 Gr.150-125 castings to sustain enormous loads and prevent fatigue failure. Using Pro-E software, a complete feature-based chassis model was created, resulting in 146 pieces. Hyper mesh 9.0 software is used for meshing. There are nodes and elements in the FE mesh model. a connection The FE mesh model features a 3D tetrahedral solid element shape, which gives a close result. To examine an element's aspect ratio, warpage, Jacobian, and skew. Local finer meshing on the front and rear rail structure of the chassis was done to acquire accurate results of the vital area. Refine mesh applied to the chassis's vital area. The bending and torsional left and right ramp loads were manually calculated and added to the FE model. According to the FE results, the largest stress concentration is on the rear side of the rail structure. Following the FE analyses, the chassis' safety factor and fatigue life were determined. An investigation of field failure of the chassis indicated highest stress and deflection at the rear rail structure of the chassis. The tyre reaction forces and torsional resistance are calculated for FE analysis. The box type variable section chassis rear rail structure width and plate thickness are calculated by hand and FE iterations. Redesign the present chassis construction with fatigue calculations and a Pro-E model of the chassis. The FE study was repeated to establish the improved chassis' stress distribution and fatigue life. Stress distribution at front and rear rails of chassis, fatigue life beyond 30,000 Hrs. This includes stress and displacement charts with numerical values, primary load types like bending and torsional, as well as frame left and right ramping calculations. To validate the FE analysis, the chassis was fatigue tested. The stresses and displacement levels at important points on the chassis were determined using 500 strain gauges and fatigue testing. To impart load to the chassis, hydraulic actuators are installed on the front and rear suspension.

**Keywords:** Design, Truck Frame Structure, Stress Analysis, Modelling, Pro-E, HYPER MESH, Finite Element Analysis.

## I. INTRODUCTION

The dump truck used in mining and construction. A standard dump truck includes hydraulic suspension and a closed box frame with a body mounted on top. The chassis supporting the truck's front and rear suspension. The body lifts the vehicle's back side to dump materials on the ground. The chassis is the main load bearing element of a back dump truck. The chassis supports the power train and allows the dump body to carry the whole payload. In terms of vehicle longevity, the chassis is neither serviced nor interchangeable. A chassis must have a life expectancy of 30,000 hours or greater under normal driving conditions.

### 1.1 Truck Chassis for A Dump Truck with A Higher Ton Maximum

Dump truck chassis are mostly used for coal. The dump truck's chassis holds coal weighing from 1200 to 1800 N/mm3. The vehicle's body is made up of two parts: chassis and bodywork. The truck chassis structure the consequences of alterations to the frame and cross-members on vehicle reaction, especially in rough and off-road conditions, are unknown. For example, reducing a suspension cross-torsion member's stiffness affects roll stability, handling, ride, and durability. So the major goal is to understand truck chassis behaviour. To upgrade the current design for greater ride quality and longer fatigue life. This is the industry's most intensive product transition in years. To create a moderate car, the structural engineer must employ creative ideas. Automobile designers had to adapt quickly to new safety criteria and then reduce weight to fulfil fuel economy needs. No new vehicle sizes could be tested, and no performance data could be obtained.

### 1.2 Important issues in chassis design

The truck manufacturers' key task is to improve design and optimise it to fulfil client needs while improving performance. the truck chassis is a vital part of the vehicle. So it's typically highlighted for modification to increase comfort, and chassis life.

### 1.3 Significance of Fe Analysis of Chassis Design

It is essential to have extensive understanding of chassis design and analysis. The chassis had not vanished, but had been relocated between the body and the road surface. Modern chassis systems include suspension member mounting on the chassis, engine and transmission mounting brackets on the chassis. The chassis design is also constrained by cost and weight. The consumer expects improved refinement, material quality, and riding comfort. The chassis design determines several aspects of vehicle behaviour, including ride comfort, material quality, handling, and road holding. The chassis design is one of the most effective ways to determine a vehicle's "character." Every aspect of a chassis was scrutinised and improved, and only the best survived.

## II. REVIEW OF LITERATURE

The fatigue damage described by Miner (1945). Dislocations, slide bands, micro fractures, etc. might occur during the start phase. Because these events can only be quantified in a controlled laboratory setting, most damage summing procedures are empirical. These approaches link harm to a tiny laboratory specimen's life. For this reason, a specimen's separation is analogous to a little break forming in a major component or structure. Tanaka et al. (1981) used FEM to analyse the stress on a vehicle chassis with riveted joints. The issue was solved using ANSYS 5.3, a commercial finite element programme. Prior to construction, a truck chassis' stresses must be determined to enhance design. To minimise stress around the chassis frame's riveted union. If changing the thickness isn't practicable, extending the connecting plate length may be. Conle et al (1991) studied the fatigue life of vehicle chassis components. Conclusion: Combining vehicle dynamics modelling, finite element analysis, and fatigue analysis is a suitable approach for auto component design. Our durability technique has to be improved before it can be used in applied engineering work. Thompson and Vissert (1991) provide an overview of mine haulage road structural design. They advocate the mechanistic design approach, a redesigned structural design, and related limiting design criteria based on current pavement structural performance investigation and quantification. Using the mechanistic technique in a design project may minimise building expenses as well as operating and maintenance costs. 2086 kN load The authorised maximum dual-wheel axle payload on public roads is 80 kN, which is comparable to a 25 t vehicle with tandem rear axles. These trucks force axle weights of 110 to 170 t on haul roads that are at best developed experimentally on the concept of adequate. Wannenburg (1993) describes an overarching concept for generating information from car warranty data, including instances of how studying warranty data helped identify organisational risk and drive early action. Fung, Smart, et al. (1994) studied joints using finite elements. The findings for the stress concentration factor for a single lap joint are in acceptable accord with existing data. However, this joint's stress concentration happened distant from the point of failure for a riveted joint.

Ibrahim et al. (1994) investigated the impact of structural flexibility on truck ride vibration. The study's goal was to examine how vehicles react to environmental stimuli. The approach was spectral analysis. According to the author, excessive vibration in commercial cars was caused by road abnormalities, causing ride and comfort issues. The author created a truck frame model using finite element method (FEM) and estimated its modal characteristics. The findings were in excellent agreement with the experimental data, and the modelling approach was quite effective. Wannenburg (1993) describes an overarching concept for generating information from car warranty data, including instances of how studying warranty data helped identify organisational risk and drive early action. Fung, Smart, et al. (1994) studied joints using finite elements. The findings for the stress

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concentration factor for a single lap joint are in acceptable accord with existing data. However, this joint's stress concentration happened distant from the point of failure for a riveted joint. Elbeheiry and Karnopp (1996) presented active vehicle suspensions with inherent limitations to manage a vehicle's reaction on a road. A linear quadratic regulatory architecture with full-state feedback was first proposed. Then, in the lack of comprehensive state knowledge, optimum output feedback and minimal norm criterion techniques are described. We established a generic equation for the optimum control force based on readily quantifiable feedback values. Conle and Chu (1998) examined publications and books produced in the last 10–15 years on fatigue analysis of welded joints. Following a brief introduction, the various fatigue analysis methodologies are discussed such fatigue testing and assessment, fatigue loading, variable amplitude effects, environmental impacts, etc. Zhongzhe and Ping (2006) addressed fatigue life analyses and enhancements of an SUV autobody. The FE approach was used to get the stress distribution for unit displacement excitation. To derive load spectra for the vehicle reliability test, a bilateral track model was used. The crucial areas were established using the nominal stress approach and a uniaxial stress condition. Components with important areas have longer life.

## III. MODELING AND ANALYSIS

The basic goal is to compute the reaction forces indicated in payload and vehicle weight. A second heavy load scenario will look for fatigue fractures caused by the fundamental stresses of running. They include jogging on a 12 percent incline uneven track, navigating bends, rolling and bouncing, and track twisting. Bending and torsion are load combinations.

### 3.1 Chassis Linear Statistics

Because the chassis is so important, reducing frame members is not an option. The second technique to reduce frame costs is to use smaller profile parts. There should be a thickness restriction. If the limit is surpassed, the truck chassis becomes fragile. Figure 1 shows the first CAD model of the vehicle chassis with boundary conditions imposed. The top and lower cover plates are 24 mm thick. 12 mm interior and exterior plates, 6 mm horizontal backup plates REAR AXLE CASTINGS AND PLATES It is used to weld the whole chassis.

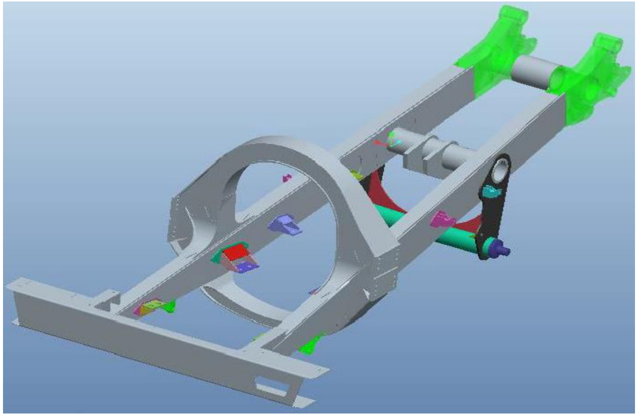


**Figure 1:** CAD Model of chassis

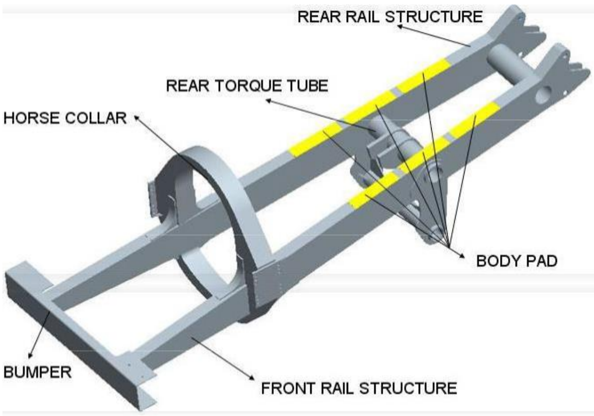



**Figure 2:** Main frame chassis pro-E model

### 3.2 Load Cases

To analyse a vehicle's chassis, a thorough model of the structure is required. It is considerably more important when the vehicle's centre of gravity is off-center. Before establishing the boundary conditions and load situations, a lot of testing was done.The finite element model demonstrates the ability to meet both model description and efficiency criteria. In certain circumstances, the finite element model has an experimental outcome. As long as enough data is given on load repetitions, the same finite element model may be used to analyse chassis fatigue. The similar model may be used to study lateral vibrations. The aforementioned boundary conditions may be utilised as a starting point for assessing stresses in the chassis.

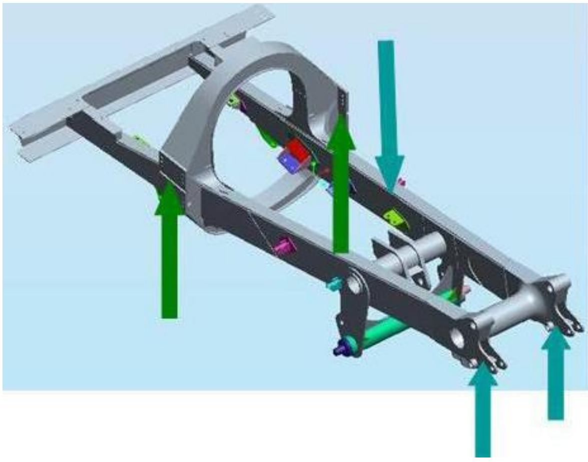
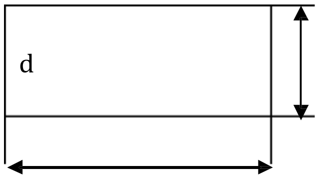


**Figure 3:** Loading free body diagrams

## IV. DESIGN CALCULATION

**Rail width and thickness calculation**

Depth of rail b/t < 63.2




b/t = 21(ratio)

b = 21×t (t=2mm)

b

b =21×2

b = 42 in

b - Width of the chassis

= 42 × 25.4

t - Thickness of the chassis

d - Height of the chassis

Assume b/t ~ 1067/20 and b/t~1067/25

Therefore, the thickness of the plate t = 20 mm and t1 = 25 mm.

| Tensile Yield Strength | b/a =1 | b/a = ½ | b/a =0 |
|---|---|---|---|
| 40,000 PSI | 76.7 | 63.2 | 58 |

## V. RESULTS AND DISCUSSION

**FATIGUE LIFE ANALYSIS OF CHASSIS**

It is the front bumper of the vehicle. The front rail structure is near the bumper. The engine and suspension are located in the horse collar of the chassis. The rear torque tube structure connects the left and right rail structures and supports the load during torsion and cornering. a chassis pad for the body and cargo. Finally, the rear rail supports the chassis's rear axle and suspension.

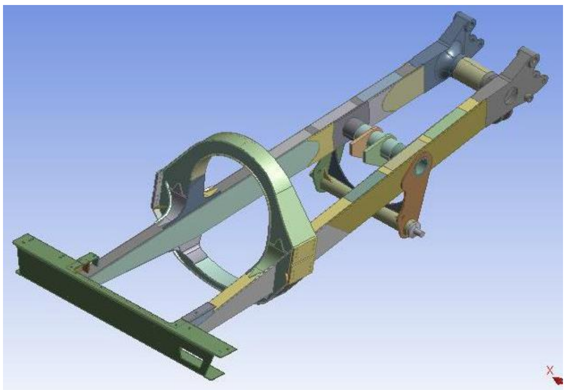


**Figure 4:** Chassis model for Fatigue life analysis

### Chassis meshed Model

The chassis solid model was created in Pro-E Version5. The FE model necessary for the analysis was built from the CAD model of the whole chassis. A stress and fatigue model is illustrated in Figure 5.5. The finite element model was built using SOLID 45, a higher order three-dimensional solid tetra element that is ideally suited to modelling irregular meshes. The element has ten nodes, each with three translational DOF.

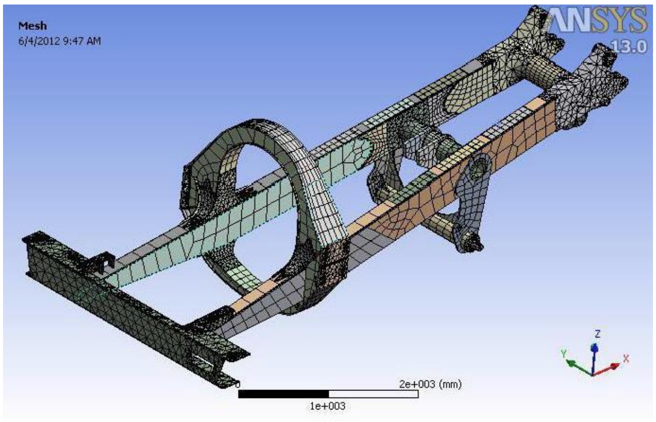



**Figure 5:** Chassis meshed Model

### Fatigue Boundary Condition

The maximum load instances, four fatigue load scenarios were analysed. The most severe vertical fatigue load instance was discovered in the same region of interest as previously, with loading circumstances as illustrated in Figure 5.6. The fatigue life range is perpendicular to the weld and positioned in the horse collar part. It's about 307 Mpa. This is the most essential location for all fatigue load scenarios. The FE model's load was set to match the vertical fatigue test's loading range. To satisfy the equation of equilibrium circumstances, apply body weight and payload to the body pad and tyre response load to the suspension mounting points.

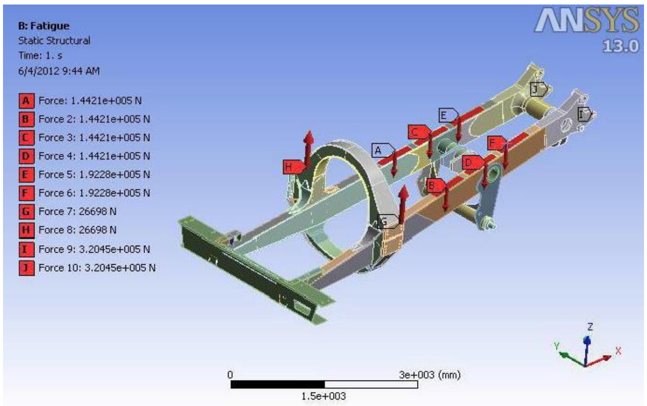



**Figure 6:** Bending load condition

### Total Deformation of the Chassis

The complete deformation of the chassis, with the highest deformation occurring at the chassis's rear end. The chassis is 18 mm long. The plot's colour dispersion dropped from rear rail to front, maximum level to lowest level, across the chassis. axial and lateral gradient distribution.

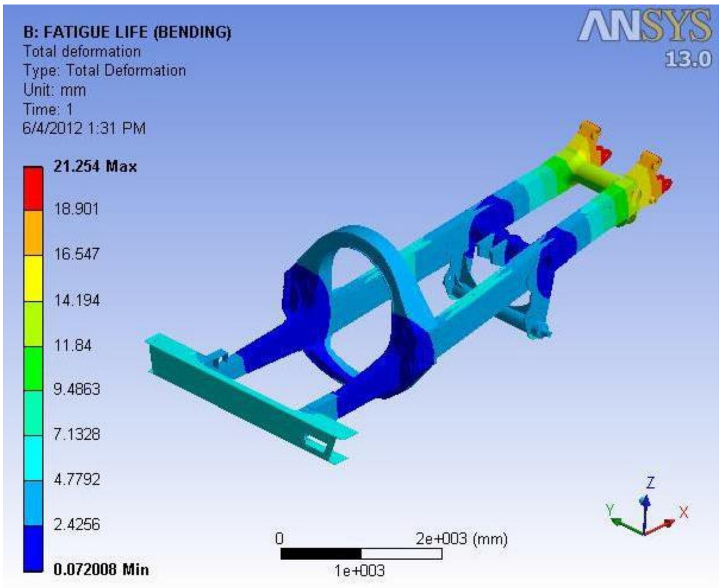



**Figure 7:** Total deformation of bending

## VI. CONCLUSION

The limitations utilised in this analysis, the chassis torsional stiffness is adequate to guarantee that the suspension determines the chassis strength and stiffness. Conclusion: the method of strain life has accomplished the fundamental purpose of fatigue life and safety factor. Overall bending and torsion strength enhanced. The overall deflection was also 10% less. The chassis fatigue test required 3.5 million cycles. Extending the chassis fatigue life, deflection and strength by increasing plate thickness, box section width and centre cross member was proven to be optimal. Work on torsional rigidity of the chassis and suspension includes simulating infinite springs and differential loading via the wheel hubs instead of the chassis spring mounts. At the point of contact with the ground, measuring camber and toe response is also important. This chassis construction should be further studied and refined in terms of overall performance, structural dynamic behaviour, and quality auditing. Based on these criteria, the general advise is to study structural analysis first, then concentrate on particular areas like chassis. As a result, this analysis may aid increase entire body refinement and progress.

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