International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 9
September 2017

Finite Element Analysis of Design Different Sections and Connectors of Body Load Structure

Harshavardhan Shetty, Balesh Babali, Sachhidananda M H , Ullas M
Mechanical Department PES University Bangalore, Karnataka, India

1. ABSTRACT

Major joints of a typical Automobile play a critical role in the design of automobiles for reduced Noise Vibration and Harshness (NVH) characteristics. These joints after assembly should have a desired strength under bending and torsion loads for the Automobile to be qualified as a safe vehicle. Objective of this work is to optimize load body structure joint designs to improve their strength for different cases of loading. It was observed from crash vehicles that load body structure collapsed at various joints whereas most of the sections remained unaffected. The present work carried out to identify the most stressed joints and improve joints structural strength. Static analysis of complete load body structure was carried out to get exact load cases and boundary conditions for micro level joints optimization. Using these loading conditions critical joints were analyzed independently for getting insights into relatively stressed and unstressed regions. The weld strength of the joints are carried out for the modified and redesigned sections. In order to validate design calculations, linear finite element software was used to carry out virtual simulations. An absolutely contemporary CAE Driven Design approach was implemented to arrive at the best possible designs. Various design modifications were studied in the joint to improve the strength. Few potential designs of joints were finalized and short listed for further implementation. Various design guidelines were formulated for the best design approach. The aim to study the joint strength of major automotive joints of a load body, identify the weak joints and propose design alternatives to improve the performance of such joints under bending load.

Keywords

Load body structure, Redesign, Joint strength, Design Calculations, Structural finite element Analysis.

2. INTRODUCTION

Structural joints vary in ample depending on the various structures and are discussed in this subsection. These bolted, riveted, and pinned joints all come under discrete joints. Also welded and adhesive joints come into continuous joints. To search out the points of interest, however enough of the nuances are ideally given to allure creators in the content. The complexities of the mechanics of joints are basic to their outline when trying to achieve elite and long life. A key ability is to have the capacity to outwardly isolate components and to draw free body graphs keeping in mind the end goal to decide the heaps forced on an association by welds, adhesive, jolts, bolts, or squeeze fit members as with the structure itself. Strength, stiffness or both are necessary for designing of joint. As the joint be going to design for quality There is for the most part less vulnerability since matter of surface contact and flange deformation are not as crucial in the event. It requires a new approach in conventional way, for example, ensuring all bolts stress cones overlap in case designing for strength. Consequently designers of apparatus meant for robot propose competitions know benefit of welding as though it requires near reach a rigid union is usually superior than with the purpose of obligatory near a welded joints. Those parts about joint expense incorporate upon what extent should the joint aggravate, to how much the joint outline require space, also could those joint a chance to be made separated by mistake is produced. Similarly as often likewise space and simplicity might appear with support welded or adhesive joints.

However, the utilization about different materials, secluded assemblies, and the capacity on aggravate transforms every one side of the point on bolted joints utilize. As riveted joints do not entail more parts furthermore operations it is more promptly proven to choose than bolted joints, where in drilling is done and released without much mess. For press-fit it needs expertise to create holes precisely rather than drilling hole can be done easily while outlining a robot for a design challenge. To create a good weld it takes considerably more excellent ability. Over again the students haven't provided enough resources needed for training to weld, also the shop faculty does not take enough time to weld everyone's machine so as to make weld expert. Marking, manufacturing, and assembly of parts must also be carefully prepared. The creation of weakness in the weld and porosity in order not to generate gases is because of dirt, oil, paint, parts to be welded must be cleaned. As to reduce friction the cleaning of bolted joints needed, especially near the thread portion and to efficiently generate clamping forces enable the torque applied. So the surface on steel joints later rusts together resulting wiping with an oil material.

3. JOINING TECHNOLOGY

A very large amount of joining is required insight of a sheet intensive monocoque or unibody structure. Consequently, the overall properties such as strength, global stiffness, NVH (noise, vibration, harshness) and crashworthiness of the whole structure makes considerable effect on the joints properties. The prevailing joining technique is the most vital distinction among steel and aluminium designs. If aluminium alloys are made in comparison to steel exemplifies a high electrical and thermal conductivity respectively low electrical resistance. Traditionally used with steel if in case resistance spot welding technique is applied to aluminium, requires higher the welding current. Conventionally, in consequence resistance spot welding of aluminium proves to be unreliable, costly (frequent electrode cleaning, sheet surface preparation prior to welding, need for special welding equipment, etc) and energy intensive. Yet special effort is required for resistance spot welding of aluminium as proper solutions is developed for the above problems. The low electrode lifetime is a specific problem. The often cleaning of the electrode surface is a possible solution likewise by regular brushing or machining of surface. By fronius delta spot technology, resistance spot welding of aluminium can be achieved effectively. It produces constant quality, reproducible welding points and ensuring high electrode service life due to the constant frontwards movement of the process tape results in a nonstop process.

4. FINITE ELEMENT ANALYSIS

Finite element analysis was used to evaluate the strength of different sections and connectors of load body structure. The study included defining the joint, modelling, determining the loading conditions and evaluating the strength. Analysis is carried out using modelling software such as creo parametric and solver – MSC / NASTRAN. A 3D model of main frame structure is modelled using Creo parametric software. Here as the model is a lumped mass model, where the loading conditions are applied at the centre of gravity of the model. The constraints are given wherever the leaf springs or suspensions are connected to chassis as support to the axles. For the load cases, load is applied by its weight along with the respective factors of g in case of bump loading, braking, acceleration, cornering loading accordingly. The optimization is done by imposing the constraints of keeping torsional, bending stiffness, lateral stiffness and natural frequencies same as that of existing load body.

Specific assumptions made to solve this problem is shown in the table1 below

Material	**Steel**
Young's Modulus of Elasticity (E)	2.1E+05 MPa
Density(ρ)	7.83E-09 Tonne/mm^3
Poisson's ration (ν)	0.3

Table 1 Property Assumptions

(a) Assumptions

Assumptions that are made with respect to the linear static analysis are:

- Material is assumed to be linear, elastic, isotropic and homogenous
- Small displacements
- Small rotations
- Slowly applied load

(b) Boundary Conditions

For static analysis,

- Constraints are given wherever the leaf springs or suspensions are connected to chassis as support to the axles in all six degrees of freedom.
- Centre of mass is a single independent node at the centre of the cross sections which are used for applying the force.
- Unit load (Force or Moment) is applied at the centre of the mass of load body.
- Boundary conditions are interchanged to establish the different cases to calculate the various strength.

Typical loading and constraints are as shown in figure 1.

5. FIGURES/CAPTIONS

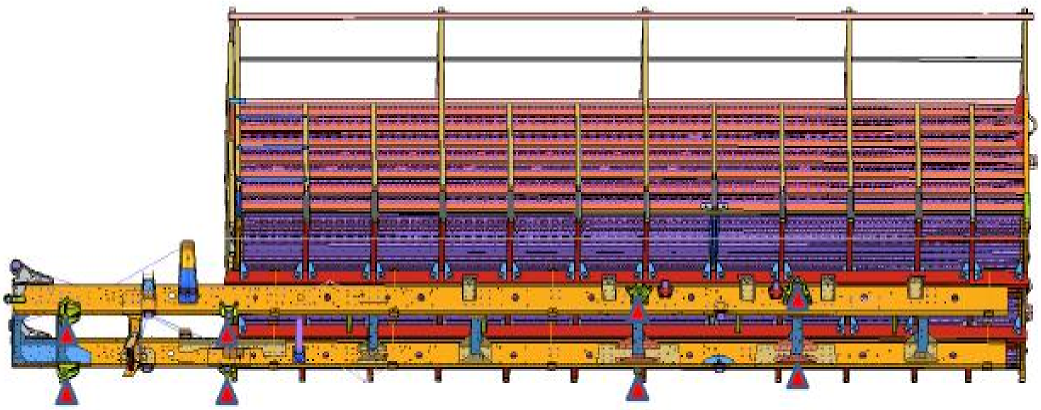


Fig 1 Model of Load body with its boundary condition

A model shown in the above figure, constraints and forces are applied at the centre of the rigid beam elements, so that load is transferred by the joints to the whole finite element numerical model. Front axle tire reaction force is applied on the chassis from suspension mounting point on both LH and RH sides. Rear axle tire reaction force is acting on the rear suspension mounting point and body with pay load weight in terms of force acting on the top of the chassis.

6. STRESS ANALYSIS FOR DIFFERENT LOADING CASE

Further, to observe the maximum stresses, the model subjected to extreme condition and static structural analysis was carried out using MSC Nastran solver. A combined load of 0.8g braking force and 0.8g lateral acceleration were applied to the model considering the longitudinal load transfer during braking and lateral load transfer during cornering. Also, it is analyzed for the following mentioned critical load cases.

Case 1: Von-Mises stress plot under Braking Loading

Figure below shows the loading condition for braking loads. The stress analyses at front and rear vertical pillar is analyzed and are found within the acceptable yield limit. Simulations are as shown in the figures.

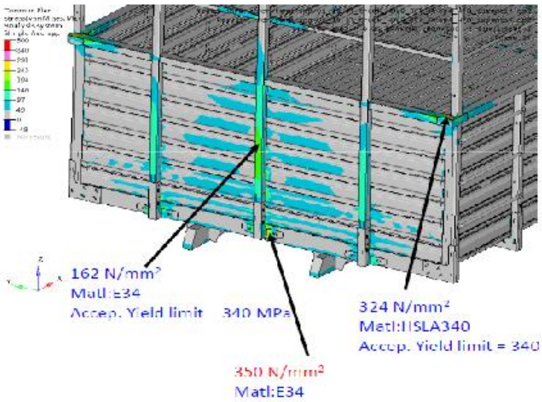


Fig.2 Side pillar for braking condition

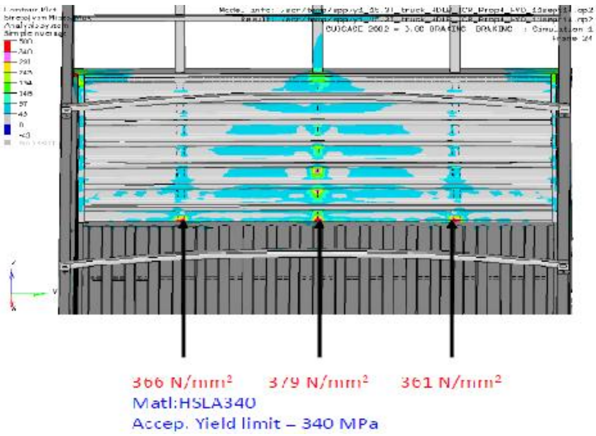


Fig.3 Hinges for braking condition

Case 2: Von Mises stress plot under Cornering Loading

Figure below shows the loading condition for Cornering loads. The stress analyses of all the structural members is analyzed and found within the permissible limit. Simulations are as shown in the figure 4, 5 and 6.

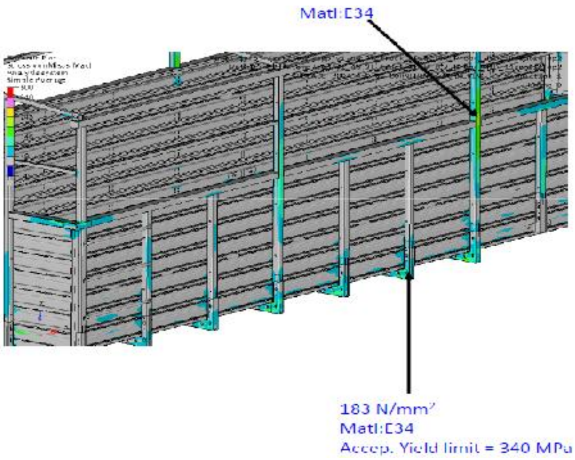


Fig.4 Side pillar for cornering condition

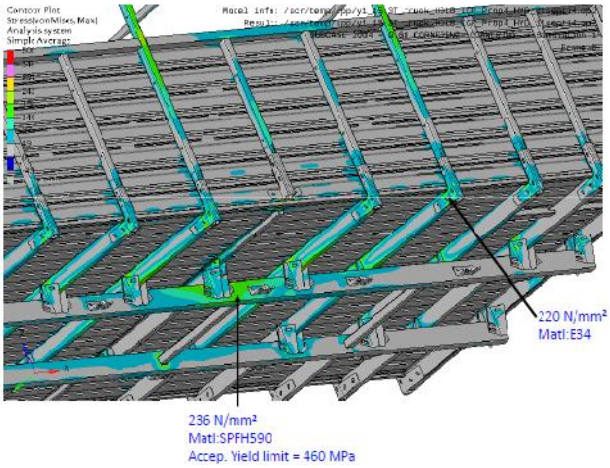


Fig.5 Subframe for cornering condition

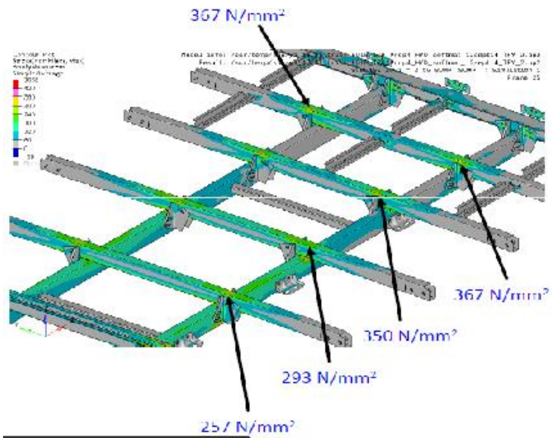


Fig.6 Cross member for cornering condition

Case 3: Von Mises stress plot under Bump Loading

Figure below shows the loading condition for Bump loads. The stress analysis of all the structural members is analyzed and is as shown in the figure 7, 8 and 9.

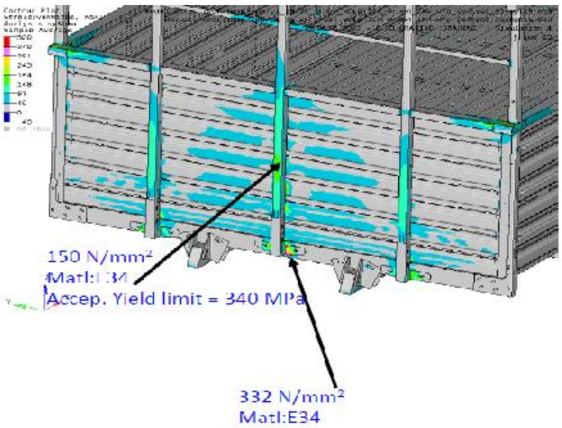


Fig .7 side pillar for bump condition

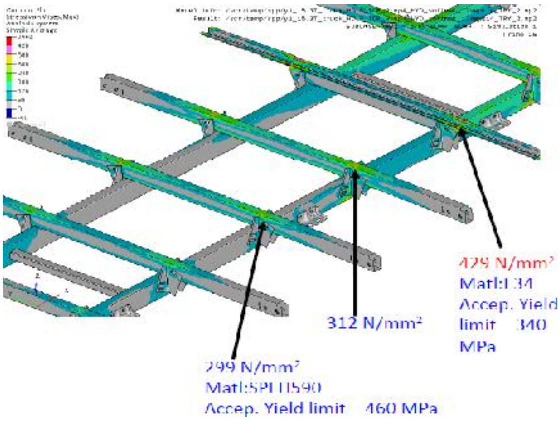


Fig.8 Cross member for bump condition

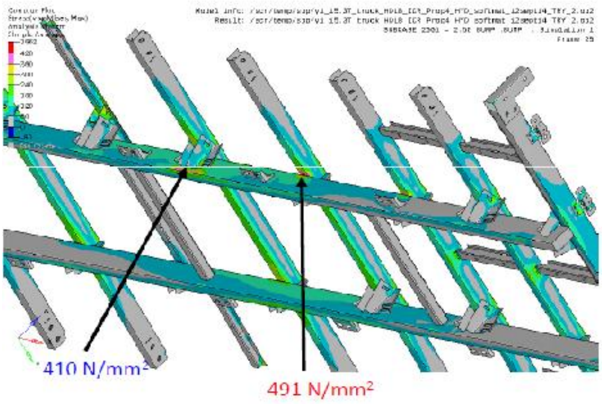
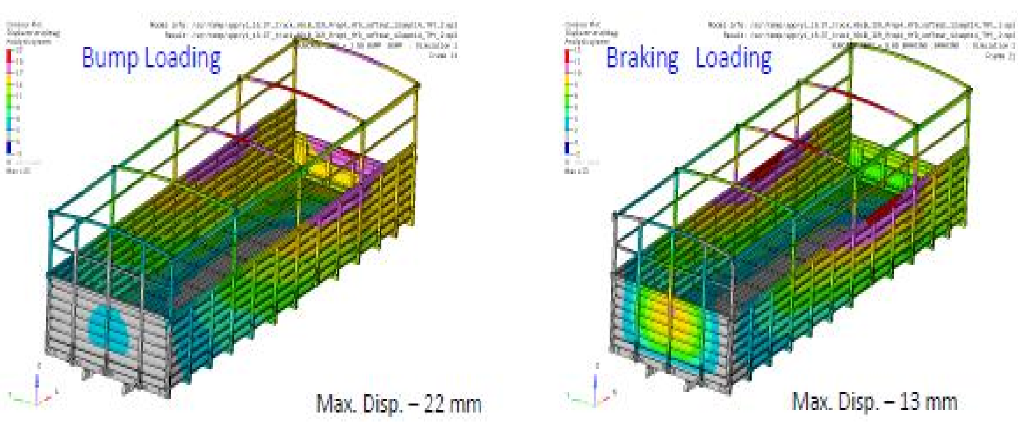


Fig.9 Sub frame for bump condition

7. DISPLACEMENTS

The displacements for various load cases such as Bump, Braking, Cornering and Acceleration loading cases are analysed through FEM analysis. The different cases and its displacements are as shown in the figure 10.



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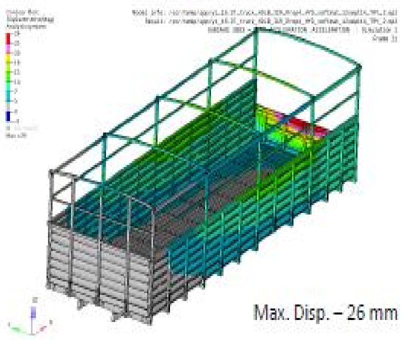
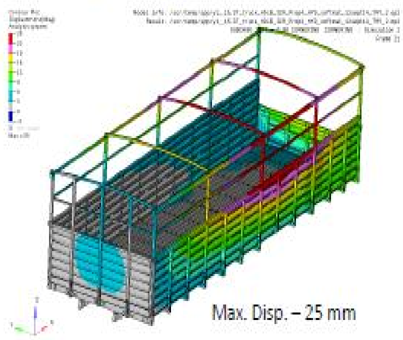
Acceleration Loading



Cornering Loading



Loading Conditions	Members of Load body	Force in KN	Area in mm^2	Classical analysis	FEM analysis
				Stress in N/mm^2	
Braking	Side pillar	75.73	563	134.51	162
	Cross member	75.73	854	88.68	101
	Subframe	75.73	2383	31.78	93
Cornering	Side pillar	56.79	563	100.87	111
	Cross member	56.79	854	199.50	222
	Subframe	56.79	2383	238.31	236
Bump	Side pillar	236.66	563	210.18	212
	Cross member	236.66	854	277.12	299
	Subframe	236.66	2383	397.25	418

Table.2 Table captions should be placed above the table

Correlating of the analysis results through classical and FEM are made. It was found that the stress ranges compared to classical analysis with FEM analysis was found almost equal. The comparison results are calculated and tabulated in the table above in 2.

8. CONCLUSION

From the study, the following results can be drawn:

- The sub frames and cross members distributes the load from floor panel to chassis in a safer manner.
- Cost reduction can be attained by two ways namely, one is in frame to use smaller members and the second way by using profiles thinner sections decreases the cost of the frame. The load body is no longer robust or reliable if surpasses limit. So there should be a thickness bound.
- The load body mass is reduced by 309.11 Kg when compared to existing design, thus making the load body light and economical.
- The stress value are standard and under recommended limit. Wherever the stress values have exceeded the acceptable yield limit, the connectors shall be increased near the maximized stress regions or the pitch of the adjacent members shall be varied to attain the stress values well within the limit.
- The displacements of various sections at different loading cases are determined and found well within permissible limits.

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