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Static Structural Analysis of Frame of an Commercial Autorickshaw to Reduce Accidental Damage Using Ansys

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Abstract—This research deals with the reduction of crash injuries occurred in the motorised autorickshaw. One of the easiest means of transportation is travelling in an autorickshaw in India. It is cheap, affordable, and can carry up to 3-6 passengers depending on manufacturer. The focuses of crash analysis in the present research are material properties, frame or superstructure and area of impact. Instead of cast iron if carbon steel is used, the strength characteristics of frame increases. The strength to weight ratio of carbon steel is higher.
The frame is designed in such a way that the members experience minimum stress and have minimum deformation. Members are kept in the roof so that the members can withstand side impact and the rear impact that will cause minimum damage to the passenger compartment. For frontal impact, a horizontal member is provided to absorb frontal impact force. The main focus of this project is passengers' and driver's safety.

Keywords- *Autorickshaw, Front Impact Analysis, Material Selection, Strength to weight ratio*

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I. INTRODUCTION

Motorized three wheeler auto-rickshaw is popular for transportation in India. An auto-rickshaw generally has sitting capacity of three passengers and one driver. They are lighter in weight, affordable to drivers and available inhybrid and gas powered versions. In India gas powered auto-rickshaw i.e. CNG auto-rickshaw is preferred mostly, since it has higher efficiency. A CNG auto rickshaw emits lesser CO, NC pollutants, and is more efficient than petrol powered rickshaws. An auto rickshaw is a common form of urban transport, both as a vehicle for hire and for private use for transportation.

There are two types of layouts used in India. In older versions the engines were mounted below the driver's seat, while in latest versions engines are mounted behind passenger compartment in rear.There are many different auto rickshaw designs, applications, and variations. The most commonly used type is sheet-metal body or open frame resting on three wheels, a canvas roof with drop and down side curtains, a small cabin at the front for the driver with handlebar controls, and a cargo, passenger, or dual purpose space at the rear. Three wheelers are an integral part of the country's automobile sector as they are one of the most preferred means of transportation in rural as well as urban India.

The rising population and increasing need for affordable and convenient transportation is fuelling the market for passenger three wheelers. An auto-rickshaw can be easily afforded by any driver and requires lesser maintenance.

But the number of accidents occurred due to auto rickshaws are the most. The number of Deaths and Injury Rate are higher as compared to other passenger vehicles. This is because a light weight auto-rickshaw will have higher speed and Centre of Gravity is near to roof. There are no triangulated members, cross members that can absorb the stresses induced during collision with any other object or vehicle.

Hence aim of this work is to add members in the frame such that there is not much increase in overall weight of the vehicle and the Centre of gravity is lower. The frame absorbs the impact and transmits lesser impact to driver and passenger compartment.

II. STATISTICAL DATA

According to National Crime Records Bureau of India approximately 1,05,000 people killed and 4,53,000 injured in road traffic crashes (RTCs) in India in 2006. In addition, rickshaw drivers are known for hazardous driving practices and are major violators of traffic laws.

Table 1 Details of Vehicle Population as on for the years 1999-2000 to 2011-2012 [1]

Sr. No	Year	Transport Vehicles	Non Transport Vehicles	Total
1	2000-2001	8,26,046	47,49,994	55,76,040
2	2001-2002	8,58,113	51,49,856	60,07,969
3	2002-2003	8,99,284	56,09,086	65,08,370
4	2003-2004	9,51,943	61,35,597	70,87,540
5	2004-2005	10,16,149	68,01,123	78,17,272
6	2005-2006	11,12,590	75,09,700	86,22,290
7	2006-2007	12,20,632	82,76,705	94,97,337
8	2007-2008	13,13,997	89,75,059	10,289,056
9	2008-2009	13,98,189	96,00,462	1,09,98,651
10	2009-2010	14,97,890	1,03,74,683	1,18,72,573
11	2010-2011	16,21,857	1,13,71,278	1,29,93,135
12	2011-2012	17,77,974	1,26,35,743	1,44,13,717

As per data collected by RTO Gujarat the vehicle population detail as on years 1999-00 to 2011-12 are shown in Table 1. There has been a huge increment in number of transport vehicle.

The data of vehicles based on type and number of registered vehicles are shown in Table 2. In the Passenger vehicle the highest number of vehicles registered is Auto-rickshaw. Hence the number of deaths has been increased due to accident caused by autorickshaw. Generally type of accidents occurred are: rickshaw and two wheeled vehicles i.e. bike, active, bicycle, rickshaw and car, rickshaw and heavy vehicles such as dumpers, trucks, buses etc.

Table 2 Details of Vehicle Population types of vehicle wises as on for the years 1999-00 to 2011-12

Types of Vehicle		No. of Vehicles Registered
Non-Transport Vehicle		17,77,974
Two Wheeler	Motor Cycle/ Scooters	86,33,560
	Mopeds	18,78,744
	Motor Cars & Station	14,11,898
	Jeep	1,67,991
	Police Van	2,350
	Tractor	4,95,136
	Others	46,064
Transport Vehicle		**17,77,974**
GOODS VEHICLES	Truck/ Lorries	2,72,375
	Tanker	29,158
	Three Wheeler LGVs	2,63,632
	Tanker	1,85,326
PASSENGER	School Buses	3,581
VEHICLES	Private Service Vehicles	5,495
	Taxi	52,826
	Auto Rickshaw	5,61,740
	Ambulance	5,705
	Trailers	3,17,509
Total		**1,44,13,717**

The limited crashworthiness and serious injury risk prevails even at a low crash speed for motorised rickshaw occupants and the pedestrians gets hit by motorised rickshaws. Also, extra passengers are seated to gain more money by drivers which cause overloading, and hence rollover occurs.

In recent years, the auto industry has experienced the greatest demand from customers, regulators, and media to provide safer vehicles.

III. MATERIAL SELECTION

The material selected must be lighter in weight and high strength to weight ratio. Carbon steel has higher strength to weight ratio and its price is relatively low.Carbon steels are steels with carbon content up to 2.1% by weight. As the carbon percentage content rises, steel has the ability to become harder and stronger through heat treating; however, it becomes less ductile. AISI SAE 1552 is selected because it is easily available and its properties are shown in Table 3

Table 3 Properties of AISI SAE 1552

Properties	Metric
Elastic modulus, GPa	210
Poisson's ratio	0.29
Tensile Strength: Ultimate, MPa	780
Tensile Strength: Yield, MPa	470
Strength to Weight Ratio, kN-m/kg	110
Density, kg/m^3	7800

IV. NUMERICAL SIMULATION

A. *Static Structural Analysis*

A static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects.Steady loading and response conditions are assumed; that is, the loads and structure's response are assumed to vary slowly with respect to time. Commercially available FEA package ANSYS-Workbench 16.0 is used for stress analysis. Top down approach has beenused for the analysis for which CAD model is generated using Creo 3.0 as shown in Fig. 1.

Outer diameter is kept 1inch and thickness of 3mm.

Weight of Frame is 58 kg.

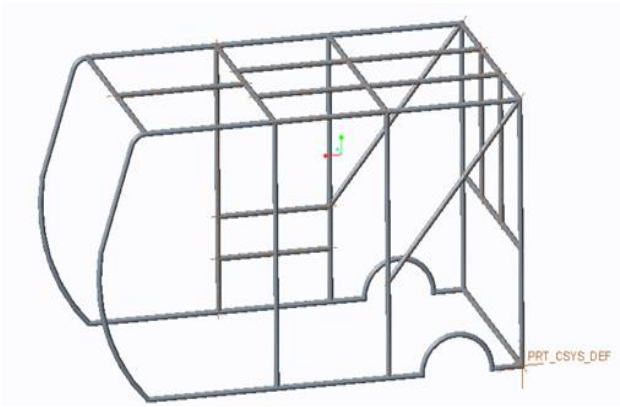

Figure 1. CAD model of Frame of autorickshaw

Ten node Tetrahedral element is been used for mesh generation. It is better suited for and more accurate in modelling problems with curved boundaries. Mesh is controlled with advanced sizing with the curvature and proximity size function method.

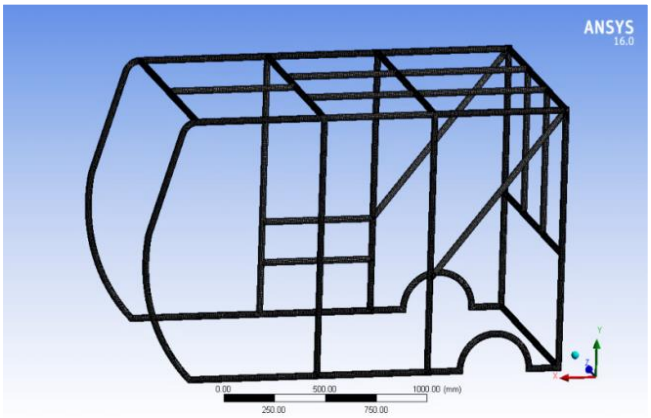

Figure 2.Mesh Model of frame of autorickshaw

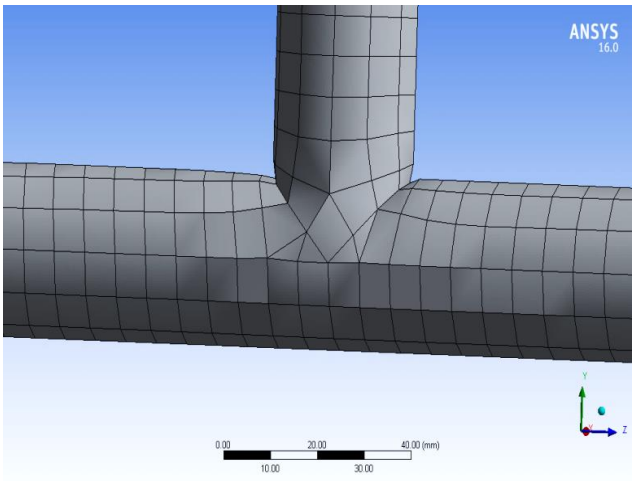

Figure 3. Fine Mesh generated due to Proximity and Curvature at joints

As shown in figure 3, fine meshing is generated because of proximity and curvature. If automatic mesh is used, the mesh generated will be coarse and mesh will be uneven. The results of analysis will be inaccurate and false. This feature provides fine meshing at each joint. .

The mesh details are shown in Table 4.

Table 4 Mesh Details

Parameter	Value
No of Nodes	0.5 Million
No. of Elements	0.3 Million
Jacobian Ratio	< 1
Proximity Minimum Size, mm	3.05

B. Boundary Conditions - LOADS APPLIED

Inertia loads are basically used in structural analysis and they attribute to the inertia of the body such as gravitational acceleration, angular velocity and angular acceleration.
In static structural based on impact conditions 1G, 1.5G, and 2G loading cases are considered based on speed of the vehicle, which here considered is 50 kmph.

At this stage, the desired crush sequence and mode will need to be selected and crush zones identified to assure that the structural pulse parameter can be realized, that is, the force amplitude and the maximum crush distance, as determined in model studies.

V. RESULTS AND DISCUSSION

A. Front Impact Analysis

A frontal crash is the most common type of crash resulting in fatalities. Major strides have been made in frontal protection. A frontal crash is a two-impact event. In the first impact, the vehicle strikes a barrier, causing the front-end to crush. Kinetic energy of the vehicle is expended in deforming the vehicle's front structure.

The second impact occurs when the occupant continues to move forward as a free-flight mass and strikes the vehicle interior or interacts with or loads the restraint system.

Some of the kinetic energy is expended in deforming the vehicle interior or the frame. The remaining kinetic energy is dissipated as the occupant decelerates with the vehicle.

In Ansys dynamic load is converted to static load by providing momentum of autorickshaw frame to other vehicle/object during crash. This structure will have a peak load capacity to support the energy absorbing members in front of it, without exhibiting excessive deformation.

The result of front impact deformation is shown in fig. 4, which shows that this structure induces deformation up to 21.90mm.

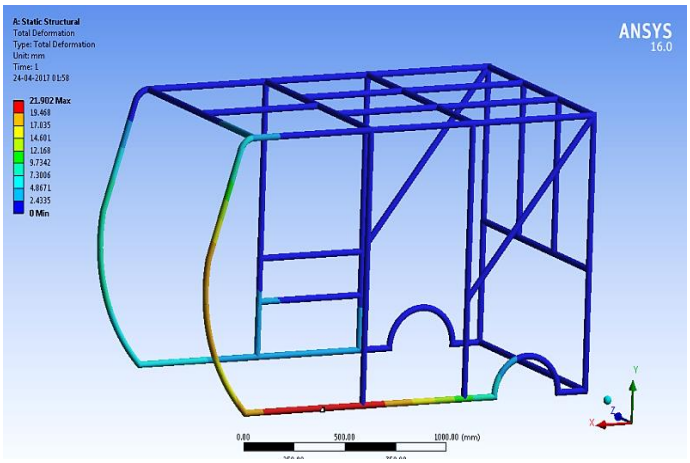

Figure 4.Total Deformation for Front Impact

The maximum stress induced is shown in fig. 5

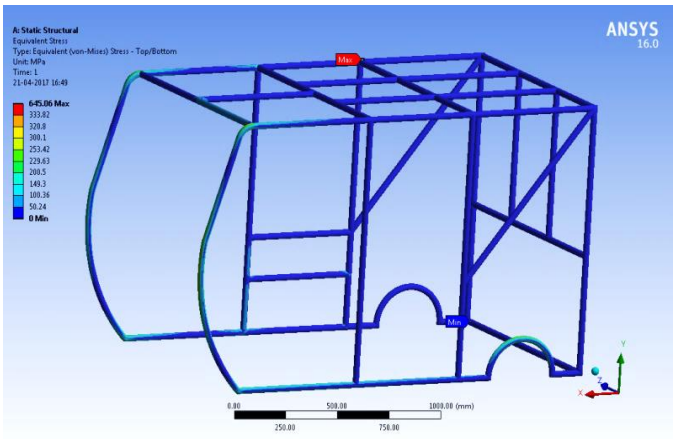

Figure 5.Maximum Stress for Front Impact

Table 5 Data of Analysis

Impact Force, N	14000
Total Deformation, mm	21.90
Von Mises Stress, MPa	320.8
Factor of Safety	1.47

$$\text{Factor of Safety} = \frac{Yield\ Stress}{Working\ Stress}$$

$$= \frac{470}{320.8}$$

$$= 1.47$$

VI. CONCLUSION

The results of Front Impact of the frame using Numerical Simulation shows that the Maximum Stress and Total Deformation occurs is 320.8MPa and 21.90 mm respectively. The FOS of the frame obtained is near 1.47 which is acceptable and can be improved further by modifying the geometrical parameters of the highly stressed skin of the frame.

Further analysis of the frame including the Sheetmetal, Roof material, Engine, Transmission, Seats, Tyres and Braking System may results into better withstanding of loads by Frames. Proper use of Sheetmetal would results into increase in safety of the Driver and the Passengers inside. Sheetmetal has dual advantage: Increases strength to weight ratio and absorbs front impact loads (avoids Penetration of Impact Loads inside the frame).

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