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Static Analysis Of Chassis Frame Of Electric Tricycle

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ABSTRACT

Electric tricycle can provide a nonpolluting, point to point and silent transport system for urban and rural areas of India replacing petrol/diesel powered three wheelers .The chassis refers to the lower body of the vehicle including tires, engine, frame, drive line and suspension. Out of these the frame provides the necessary support to the vehicle components placed on it such as payload, batteries etc. This paper presents static analysis of chassis frame of electric tricycle. The model is created using CATIA V5 and imported to ANSYS 12 for static structural analysis. The stress plot includes Von Mises stress and shear stress along with displacement plot. The results are compared with analytical, calculated using bending of beam theory.

Keywords: FEA, Static Analysis, chassis frame.

INTRODUCTION

Most of cities and towns in India are highly polluted. The main reason is the air and noise pollution caused by transport vehicles especially petrol and diesel powered two and three wheelers. Besides being major hazard to people's health, these machines are guzzling huge amount of petrol and diesel for which the country has to pay dearly in foreign exchange outflow. An electric tricycle can provide a nonpolluting, point to point and silent transport system for urban and rural areas of India replacing petrol/diesel powered three wheelers.

An automobile chassis usually refers to the lower body of the vehicle including tires, engine, frame, drive line and suspension. Out of these the frame provides the necessary support to the vehicle components placed on it. The chassis frame consists of side members attached with a series of cross members. Also the members in vertical plane supporting steering system are vital part of chassis frame of electric tricycle. The frame should be strong enough to withstand shock, twist, vibrations and other stresses. The frame should not be overweight as it would directly affect the performance of battery operated electric tricycle.

BASIC CALCULATION FOR CHASSIS REACTION

The bottom chassis frame consists of members of cross section 1 while roof members are of cross section 2 shown in following figure

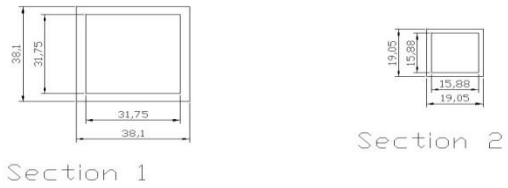

Figure No 1. Different Cross section of Members

The overall dimensions of the chassis frame is given in following table

No.	Description	Dimension(mm)
1	Overall Length of chassis	2108.2
2	Overall Width of chassis	1117.6
3	Overall height of chassis	1435.1

Table No.1 Specification of chassis

The loading on chassis consists of passengers including driver, seats, batteries .The overall weight

distribution overall chassis frame is given in following table

No	Components	Weight(Kg)	Position from origin (mm)
1	Driver	68	628.5
2	Battery	20*4=80	920.75
3	Passenger 1 &2	68*2=146	1949.45
4	Passenger 3 &4	68*2=146	920.75
5	Seats for driver	7	628.65
6	Seats for Passenger 1&2	10	1949.45
7	Seats for Passenger 3&4	10	920.75
8	Chassis Body	250.96	1078.2
Total		697.96	1161.1596

Table No 2. Weight distribution over chassis frame

Material properties of chassis frame is given in following table

Property	SI Units
Modulus of Elasticity	200000 MPa
Density	7800 Kg/m^3
Poisson's Ratio	0.3

Table No3. Material Properties of Chassis Frame

CALCULATION FOR REACTIONS

Chassis is simply clamp with Shock Absorber and Leaf Spring. So Chassis is a Simply Supported Beam with uniformly distributed load. Consider Load acting on long member is 2083.7716 N. Length of the Beam is 2108.2 mm .Uniformly Distributed Load is 2083.77 /2108.2 =0.9884 N/mm. We can assume the uniformly distributed load to be 1N/mm. Now taking the reaction around the Support A.

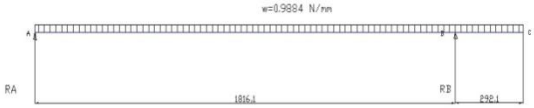

Figure no 2.Simply supported Beam

R_A= W*l*(l-2*c)/(2*b)
=1*2108.2*(2108.2-(2*292.1))/(2*1816.1)
=884.5594 N
R_B= W*l*(l)/(2*b)
=1*2108.2*2108.2/(2*1816.1)
=1223.6405 N

CALCULATION OF SHEAR FORCE & BENDING MOMENT

Shear force at A
V1= R_A
=884.5594 N
Shear force just on left side of B
V2= R_A-W*b
=884.5594 - (1*1816.1)
=-931.5406 N
Shear Force just on right side of B
V3 =V2+ R_B
=-931.5406 + 1223.6405
= 302.099 N
Shear Force at C
V4 = 0
Location D where Shear Force Changes Sign is 884.5594 mm right to A.
CALCULATION OF BENDING MOMENT
Bending moment at A
M1=0 Nmm
Bending Moment at D
M2= R_A*884.5594 –W*(884.5594^2)/2
=391222.666 N.mm
Bending Moment at B
M3= R_B*c
=1223.6405*292.1
=357425.3901 N.mm
Bending Moment at C
M4= 0 Nmm

CALCULATION OF STRESS

Moment of Inertia of Hollow Square cross section of member under study is given by
I = (a^4-a1^4)/12
=(38.1^4-31.75^4)/12
=90915.13235 mm^4
Section Modulus of the section is given as
Z = I/(a/2)
=90915.13235 /(38.1/2)
=4772.447 mm^3
Stress produced on beam is as below
Ϭ= M/Z
=391222.666 /4772.447
=**81.9752 N/mm^2**

FINITE ELEMENT ANALYSIS OF CHASSIS FRAME

For carrying out the FE Analysis of chassis as per standard procedure, first it is required to create merge

part for assembly to achieve the connectivity .Loading and constraining is required to be applied to the structure. Also idealization of parts is done on structure as this will lead to faster analysis since the connected structure will not be physical but it will be a sketch with mechanical properties of mechanical structure. Procedure is followed in this section

CAD MODEL OF CHASSIS FRAME

Simplified CAD model of existing chassis frame is created using CatiaV5 R16 and it is imported in ANSYS as a external geometry file. The model is depicted in Figure below

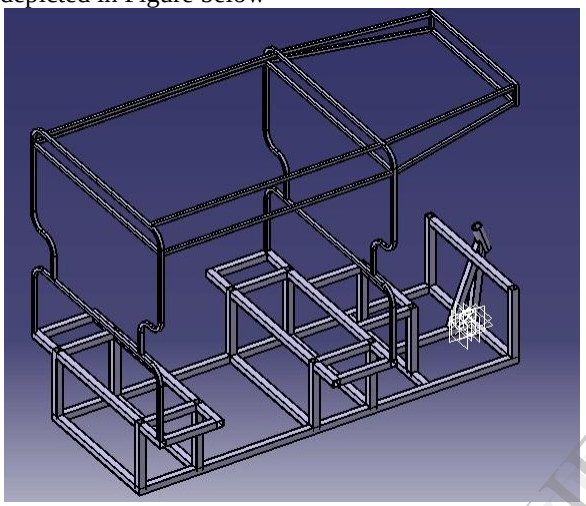

Figure no.3 CATIA V5 model of Chassis Frame

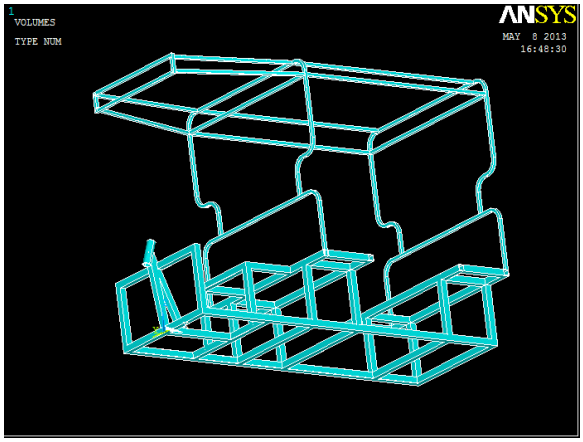

Figure No 4. Imported CAD model to ANSYS

ELEMENT AND NODES

The meshed truck chassis model has 148768 elements and 40127nodes. The element type used is SOLID 285 which is tetrahedral in shape. In order to get a better result, locally finer meshing applied in the region which is suspected to have the highest stress

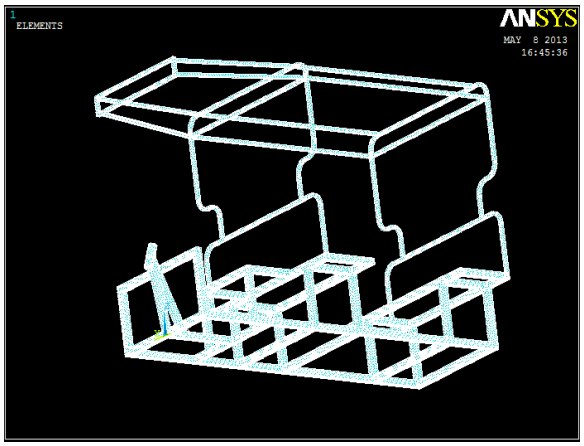

Figure no 5. Meshed Model

LOADING AND BOUNDRY CONDITIONS

The chassis model is loaded by static forces from the body and payloads .Pressure load due to passengers and driver is applied to areas of member forming seating structure in overall model .Earth gravity is also considered for the chassis frame as a part of loading. There are 3 boundary conditions of model; the first two boundary conditions are applied at node representing axle positions over chassis. The third boundary conditions are applied at bottom of suspension bracket at front of chassis. The complete finite element model is shown following

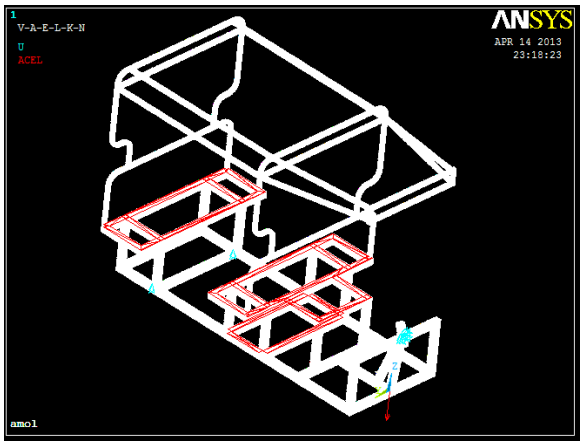

Figure No.6 Complete FEM Model

RESULTS

STRESS

The location of maximum Von Misses stress and maximum shear stress are at bottom of mounting bracket at front of chassis which is showed in Figure.

The Von Misses stress magnitude of critical point is 294.691MPa and the maximum shear stress magnitude is 75.571 MPa.

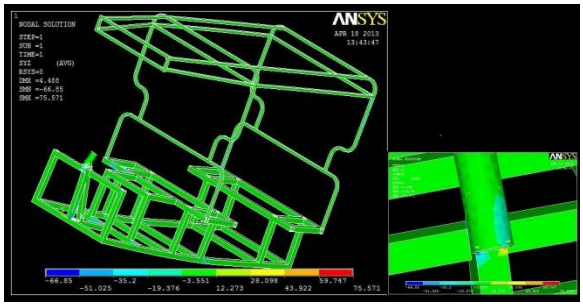

Figure No 7. Shear Stress Plot

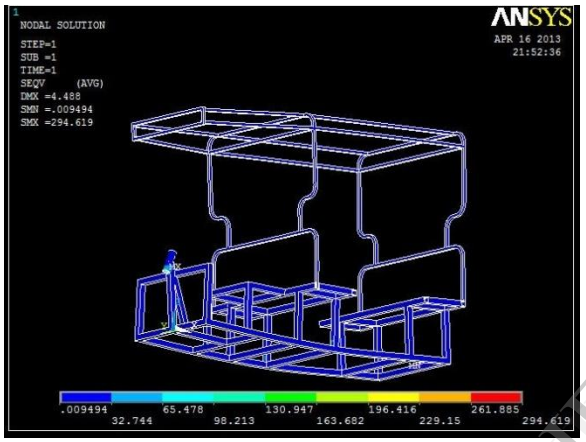

Figure No.8 Von Mises Stress Plot

DISPLACEMENT

The displacement of chassis and location of maximum displacement is shown in Figure. The magnitude of maximum displacement is 4.488mm.

Figure No.9 Displacement Plot

CONCLUSIONS

The analysis is processed in static and structural conditions. The highest shear stress occurred is 75.571 MPa by FE analysis .The calculated maximum shear stress is 81.9752 MPa. The result of FE analysis is 7.81 % lesser than the result of analytical calculation. The difference is caused by simplification of model and uncertainties of numerical calculation .Maximum displacement occurred at roof member as it is free end.

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