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Determination of Strength Analysis of Bus Body Carline through FEA

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Abstract: ***Buses are the foremost mode of road transportation. The design of the bus body depends mainly leading the performance constraint under various types of loading and operating circumstances besides those of the road conditions. In India the majority of the buses are designed and fabricated on the basis ancient time experience. The bus body design parameter essentially consists of shape, stability purpose and strength is carried out at different operating circumstance such as quasi static load and braking loads. Here we analyse two different carline, state transport utility passenger vehicle is compared with new developed prototype carline. Applied quasi static loading & different loading conditions using yield strength of materials 240 Mpa and 380 Mpa respectively, Test procedures followed were as per AIS-052 (Revision 1) and AIS-031 results analyzed by FE model for strength analysis .***

Keywords – ***Carline – Bus Body Structure – Quasi static loading – AIS-052 – AIS-031 — FE Analysis***

I. INTRODUCTION

In India the majority of the buses are designed and fabricated based on the ancient times experience not on any adequate scientific considerations. Their structural strength and stability are barely evaluated resulting in reduced passenger safety, fuel efficiency, with increased possibility of maintenance damages etc. Hence there is a need to design and evaluate bus body structure by using scientific technique. The conventional prototype testing is a versatile technique for evaluation of performance but it is time consuming, very costly and reproduction of test results and optimization of design is very difficult. Finite Element Analysis (FEA) is widely used in automobile sector for this purpose due to its versatility in scientific evaluation, reproducibility of the results and ease of optimization etc with very low levels of cost implications.

The bus body can be divided into three parts; the chassis and engine, structural body, interior and exterior parts. The chassis and engine are quite important. They must pass the standard test by domestic and international organization. The chassis consists of frame, which is a box type section and varies longitudinally as per the load and strength required for Body. Numerous Stiffeners are also added at the locations where the effect of Bending is Maximum. [1]

The second part is the bus body structure. The body comprises of six main components; the left frame side, the right frame side, the front frame side, the back frame side, the top frame side and the bottom frame side. The top frame side is sometime called “the roof frame side”. The bottom frame side is also called “the floor frame side”. The left and the right side are similar but the left side is normally composed of passenger door(s). On the other hand, the right side has two doors; the driver door and the emergency door. The sides are concerned to be critical parts and they must be strong. [2]

The third part, top frame or roof frame is considered as the critical part. It should be strong part in order to ensure safety of passengers. This part must support different loads such as interior components, air conditioners; luggage loads and aerodynamic load. The back frame and front frame are mostly supported and joined with the left and right sides as well as the roof frame and the floor (bottom side) frame. These two parts need to be both aesthetically good and strong. Therefore the shape is quite become curvature, slop and good aerodynamic. The last part is bottom frame side, also called the floor, which is welded or joined with the chassis and the other five parts. Each part is further combined by a lot of pieces which is here called gussets. After this, the outer body paneling is done that gives the aesthetics. [3]

A. *Bus body design parameters:*

The bus body design parameters consist of strength, light weight, manufacturability, adaptability, weld ability. Technical contradictions, the possible contradiction among the parameters have been identified. To accomplish this, the fact that improvement of one parameter can worsen another one has been taken into account.

- Weight of the moving object,
- Length of the moving object,
- Area of the moving object,
- Column of the moving object,
- Durability of the moving object
- Shape,
- Stability object,
- Strength [6]

II. PROBLEM DESCRIPTION

Now days there is demand on buses, not only on the cost, weight and shape aspects but also on the improved entire vehicle features and overall work performance. In addition to this number of variants that are possible due to different types of designs and modularization, call for several design iterations to arrive at appropriate combination. For optimized bus body design, newly developed models are chosen whose specifications are taken from the local industry.

A. *Objective:*

The main objectives of the work is

- The Project work concerned about the Strength analysis of bus carline
- Here we analyse the carline of bus, existing state transport utility passenger vehicle is compared with newly developed carline.
- Applied quasi static loading & different loading conditions using yield strength of the materials 240 Mpa and 380 Mpa respectively, results analyzed by FE model for strength and stability analysis.

B. *Methodology:*

The procedure is as follows,

- CAD model were prepared by using SOLIDWORKS 2012.
- Pre-processing will be performed by using CAE software ANSYS 13.0.
- Solver and Post-Processor also will be performed by using CAE software ANSYS 13.0.
- Results were compared with analytic results and analyzed as per ARAI standards.

C. *Design Parameter Details:*

The parameters which considered are the dimensions of actual bus given below.

Specification parameter	**Dimension (mm)**
Wheel base	5330
Front over-hang	1775
Rear over-hang	3200
Width of the bus structure	2580

TABLE 1: Specification parameters of bus are in mm

Specification parameter	**Kilo Gram (Kg)**	**Newton (N)**
Weight of the Roof Structure	176.54	1731.86
Weight of the LH side Structure	241.81	2372.16

Weight of the RH side Structure	239.49	2349.40
Weight of the Floor Structure	176.54	1731.86
Passenger Wt.+ luggage Wt (as per AIS052 Std) (68+7) x 40	3000	29430
No. of standees weight	750	7358
Seat weight	1000	9810
Wt. of the Structure without floor	980	9610

TABLE 2: Specification parameters are in [Kg] and [N]

For the ease of modeling and analysis bus structure model is reduced in its size, keeping width of the structure same, length of the bus is reduced to 2m.

STU Vehicle Specification	Kilo Gram (Kg)	Newton (N)
Weight of the Roof Structure	34.87	342
Weight of the LH side Structure	58.36	572.5
Weight of the RH side Structure	62.04	608.67
Weight of the Floor Structure	139.37	1367.3
Weight of the Total Structure	294.83	2892.3

TABLE 3: Specification parameters For STU Vehicle in [Kg] and [N]

New developed Vehicle Specification	Kilo Gram (Kg)	Newton (N)
Weight of the Roof Structure	55.6	545.57
Weight of the LH side Structure	54.5	534.64
Weight of the RH side Structure	55	539.55
Weight of the Floor Structure	126.5	1240.96
Weight of the Total Structure	291.6	2860.72

TABLE 4: Specification parameters For New Developed Vehicle in [Kg] and [N]

D. Factors influence the bus body carline:

The Shape optimization is generally based on shape of carline.

The major aspects for consideration of Carline are:

- Categorization of buses based on the seating capacity and on minimum comfort levels and the type of operation.
- Standardization of the floor level height, gangways
- Stability and strength evaluations of the bus body structure & seating.
- No part of the residual space projects outside the deformed structure. [12]

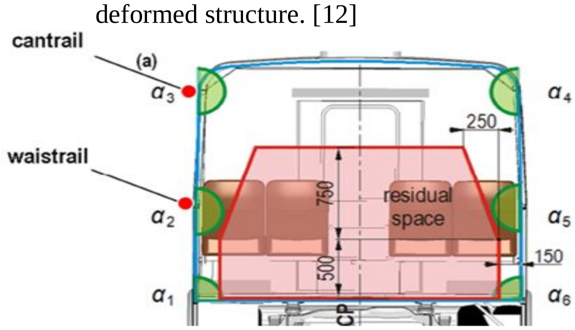

Fig. 1 Carline Model with Residual Space & dimension are in mm [13]

III. MODELING AND SIMULATION OF BUS BODY

Bus body structure modeling process was carried out in Solidworks 2012. This chapter discusses the detailed three dimensional modeling of a bus carline and simulation of the model. Before measuring of the structure, drawing of the bus structure is made. This helps for easy placement of the measured length on the corresponding members on the drawing. The bus structure is made with steel beams of rectangular hollow section with different size.

A. *Modeling:* The geometries under consideration are generated in the SOLIDWORKS2012 Modeling package. It is an authoritative program used to create complex designs with great precision. It has properties like Feature-based nature, Bidirectional associative property and parametric in nature. When designing a model using Solid Works, you can visualize it in three dimensions, the way the model exists once it is manufactured.

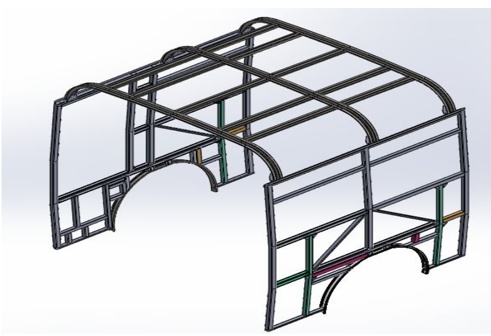

Fig. 2 Cad Model of Bus Body Carline

B. *Meshing:* Finite element meshing is made with ANSYS 13 workbench. The mesh influences the accuracy, convergence and speed of the solution. Furthermore, the time it takes to create mesh model is often a significant portion of the time it takes to acquire results from a CAE solution. Tetrahedral and quadrilateral mesh elements are used while meshing of the bus structure. In ANSYS 13 Workbench, Tetra/quad mesh method provides:

- ❖ Support for 3D inflation
- ❖ Built-in growth and smoothness control. The mesh will attempt to create a smooth size variation based on the specified growth factor. [4]

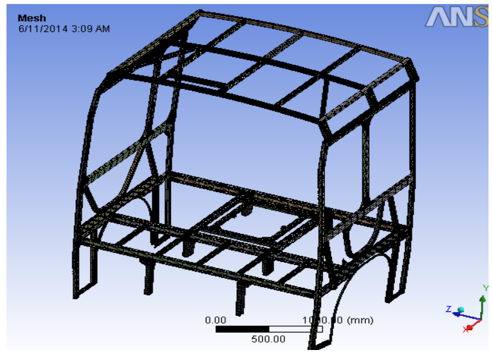

Fig. 3 Mesh Model for Newly developed Bus Structure

<u>Mesh Detail of New Bus Structure:</u>

Bus structure type	Newly developed bus structure
Mesh method	Tetrahedron / quad type
No. of nodes	237742
No. of elements	87172

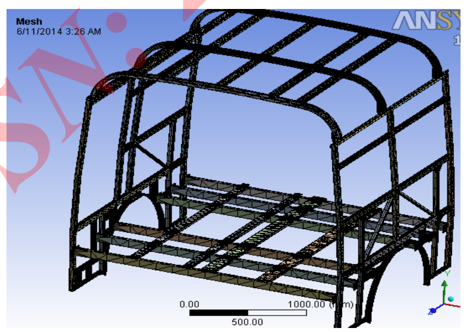

Fig. 4 Mesh Model for STU vehicle Bus Structure

<u>Mesh Detail for STU Vehicle:</u>

Bus structure type	Newly developed bus structure
Mesh method	Tetrahedron / quadrilateral type
No. of nodes	391795
No. of elements	158964

C. *Boundary and loading condition:*

The boundary condition used in the analysis is different according to the operating circumstances of the bus. During the static loading case the main loads that are considered are passenger weight, seat weight, luggage weight and self weight of the bus which is taken into consideration. [5]

Fixed end conditions used, only the bending moment and deflection occurs in these conditions. Fig. 5 shows that, load applied to roof arch member, fixed at both ends 10475 N Load applied to each arch member. In Fig. 6 shows that, load applied to STU window-rail, which is fixed at both ends 840 N Load applied to window-rail. Similarly in Fig. 7 shows that, load applied to New Carline cant-rail at angle 75°, which is fixed at both ends 1212.8 N Load applied to cant-rail. [7]

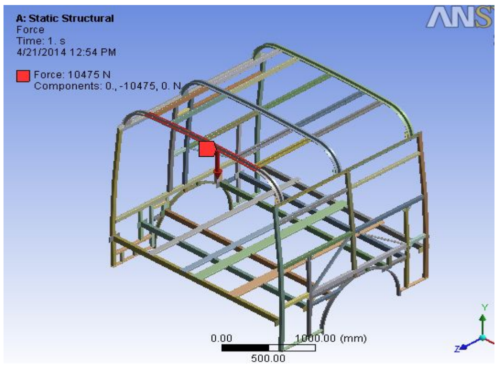

Fig. 5 load applied to roof arch member

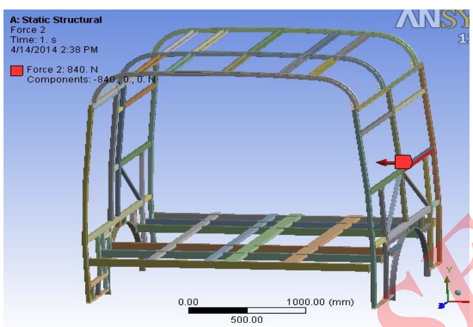

Fig. 6 load applied to window-rail

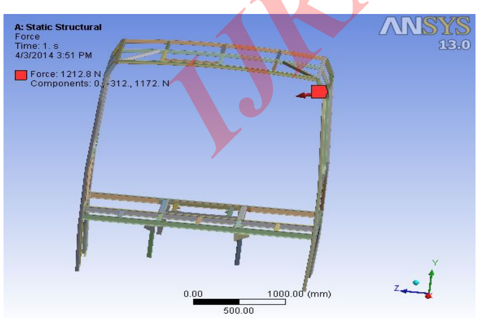

Fig. 7 load applied to cant-rail

D. *Post-processing:*

Post-processor contains sophisticated routines used for sorting, printing, and plotting selected results from a finite element solution.

Material : YST240					
Density Kg/m3	**Youngs Modulus E (Mpa)**	**Poissons Ratio**	**Yield Strength (Mpa)**	**Ultimate Strength (Mpa)**	**% Elongation**
7860	**210**	**0.3**	**240**	**410**	**15**

TABLE 5: Material Properties for YST240

Result Analysis of Roof Arch Member (Case I):

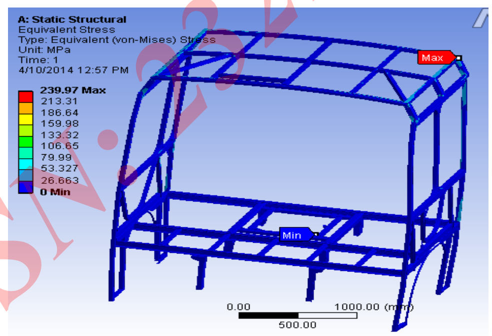

Fig. 8.1 von-mises stress distubution for New Carline

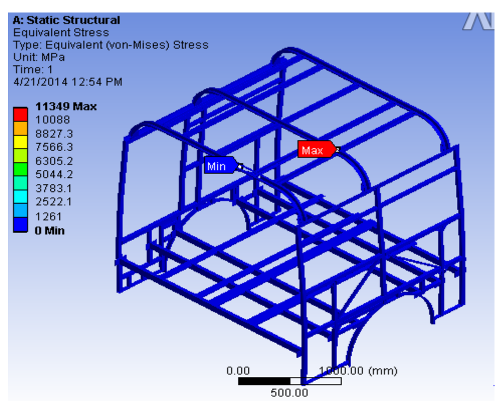

Fig. 8.2 von-mises stress distubution for STU Carline

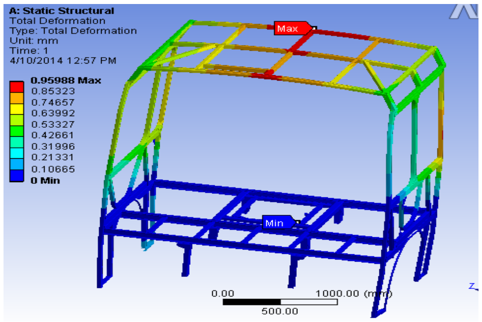

Fig. 8.3 Deflection for the New Carline roof arch member

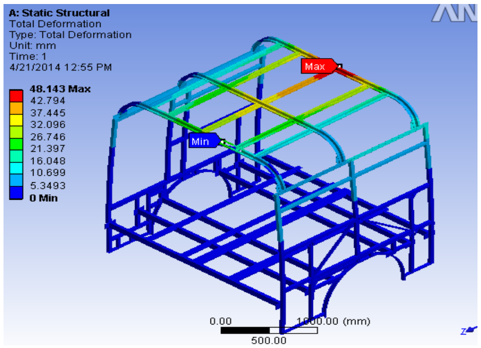

Fig. 8.4 Deflection for the STU Carline roof arch member

Results for Case I:

After taking iterations 10475N load applied to each roof arch member of New Carline and also Same load (10475N) applied to for STU Vehicle Carline. From fig. 8.1 and fig. 8.2 shows that the equivalent stresses developed are 239.97 Mpa for New Carline and 11349 Mpa for STU Vehicle respectively.

For Same Load Carrying Capacity, Deflection of roof arch member are shown in fig. 8.3 and fig. 8.4 and the deformations are 0.96 mm for New Carline and 48.14 mm for STU Vehicle Carline respectively.

In fig. 8.4 deformation developed is Maximum at roof arch member and through-out the roof deformation occurred is 48.14 mm. and comparing with the fig. 8.3 deflection is 40 times more. Due to change in structure, the deflection varies accordingly. Where in STU vehicle hat sections were used, which has less weighted structure but deforms too early.

Result Analysis of Waist-Rail (Case II):

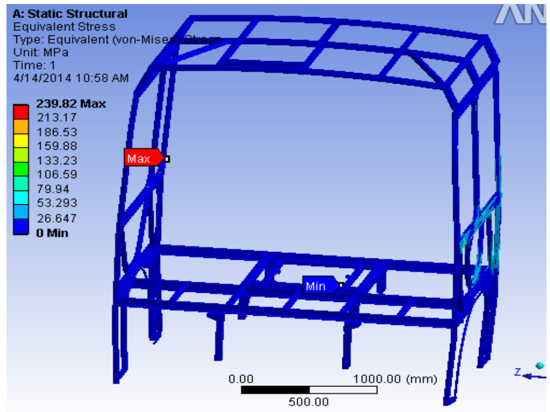

Fig. 9.1 von-mises stress distubution for New Carline

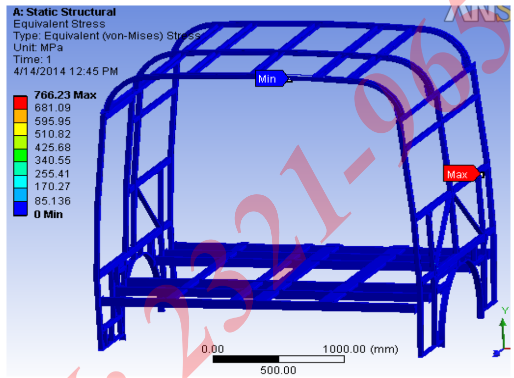

Fig. 9.2 von-mises stress distubution for STU Carline

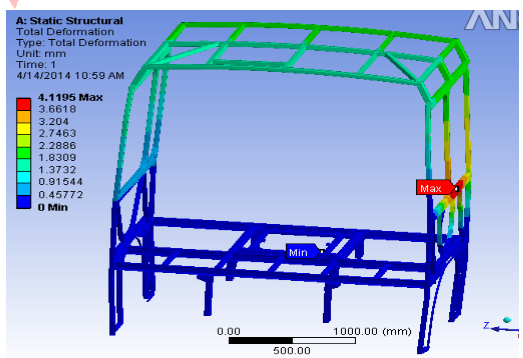

Fig. 9.3 Deflection of New Carline at waist-rail

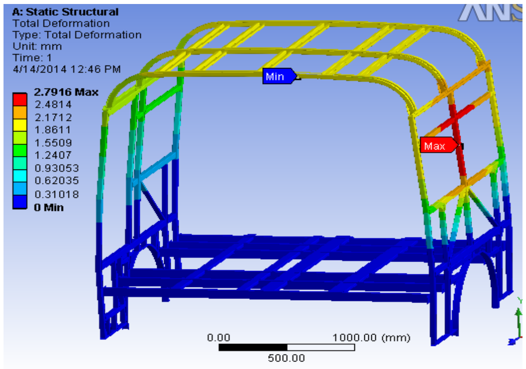

Fig. 9.4 Deflection of STU Carline at waist-rail

Results for Case II:

After taking iterations 5370 N load applied to window rail of New Carline and also Same load (5370 N) applied to for STU Vehicle. From fig. 9.1 and fig. 9.2 shows that the equivalent stresses developed are 239.82 Mpa for New Structure Carline and 766.23 Mpa for STU Vehicle respectively.

For Same (5370 N) Load Carying Capacity, Deflection of the window rail are shown in fig. 9.3 and fig. 9.4 and the deformations are 4.12 mm for New Carline and 2.79mm for STU Vehicle respectively.

Result Analysis of Cant-Rail at angle of 75° (Case III):

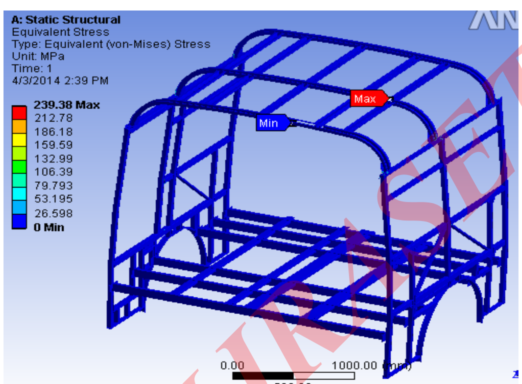

Fig. 10.1 von-mises stress for the STU cant- rail at angle 75°

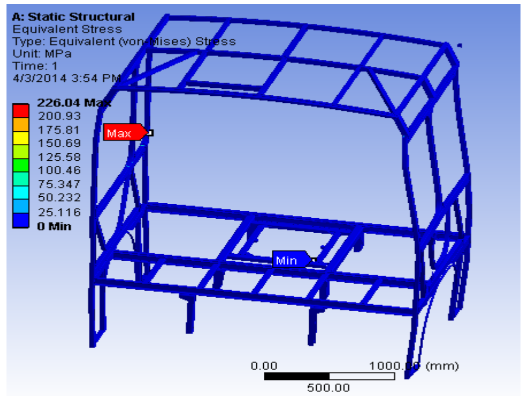

Fig. 10.2 von-mises stress for the New Carline cant- rail at angle 75°

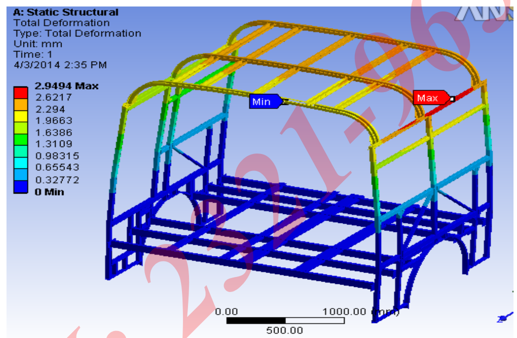

Fig. 10.3 Deflection of STU Carline at cant-rail at angle 75°

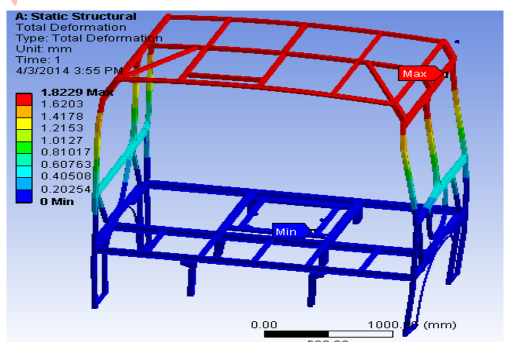

Fig. 10.4 Deflection of New Carline at cant-rail at angle 75°

Results for Case III:

After taking iterations 1212.8 N load applied to STU Carline cant-rail at angle of 75°.and also Same load (1212.8 N) applied for New Carline. From fig. 10.1 and fig. 10.2 shows that the equivalent stresses developed are 239.38 Mpa for STU Carline and 226.04 Mpa for New Carline respectively.

New Carline cant-rail can withstand upto1285.9 N load for this case.

For Same (1212.8 N) Load Carying Capacity, Deflection of the cant-rail are shown in fig. 10.3 and fig. 10.4 and the deformations are 2.94 mm for STU Vehicle and 1.82 mm for New Carline respectively.

IV. RESULTS AND VALIDATION

Since the problem given is a complex structure. The theoretical method used to determine the stress and deformation is very complex and difficult. Hence, in order to validate the results obtained for the given complex structure some standard problems are solved using ANSYS 13.0 and the results obtained are compared with the theoretical values.

A frame fixed at both ends. We opted to solve this problem for finding the stress variation and displacement in the frame subjected to a uniformly distributed load (UDL) because the result for this could be easily verified analytically. The load applied to specimen based on load carrying capacity, as material properties are same as material YST240.The cross section used for specimen is rectangular tubular section. [8]

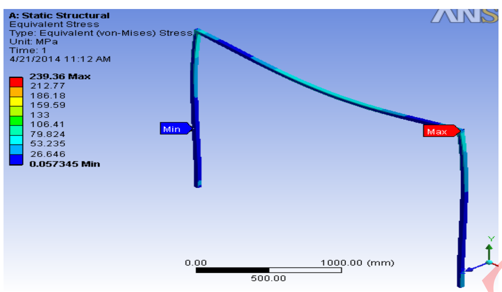

Fig. 11.1 von-mises stress for the speciman

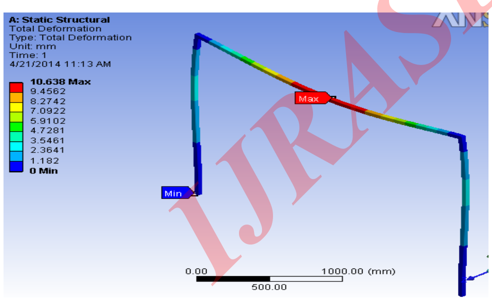

Fig. 11.2 Deflection for the speciman

By using equations, stresses and deflections are calculated and compared with ANSYS results below table. [9]

Load applied (P) in 'N'	Stresses in (Mpa) ANSYS	Stresses in (Mpa) HAND CALC'N
1000	155.93	154.50
1500	233.89	231.76
1535	239.36	237.16
1540	240.14	237.93

TABLE 6: Stress Distributions for the Specimen with Varying Load

Load applied (P) in 'N'	Deflection in (MM) ANSYS RESULTS	Deflection in (MM) HAND CALC'N
1000	6.93	6.22
1500	10.39	9.34
1535	10.638	9.56
1540	10.67	9.59

TABLE 7: Deformations for the Specimen with Varying Load [10]

Since both the FEM result and the analytical result tally each other, deflections vary with 10% and stresses vary with less than 1%. It is clear indication that the procedure adopted is valid and accurate. Further, on these lines, as we have adopted similar approach for YST380 material the entire course of the work, we can say that the results obtained in all further analysis are valid and accurate. [11]

V. CONCLUSION

This paper focuses on improving of the strength of bus structure. The strength of bus structure is the most significant thing to be considered in the design process. The bus model used in this paper for simulation was developed with the same dimensions of a real bus, with local bus manufacturer .The strength of the bus structure is analyzed various major load cases.

From case I to case III results show that, most cases the equivalent stresses developed and deflection occurred are seems to be similar but when it comes to roof strength rectangular tubular section has more strength than hat section.

And the Newly developed Carline has simple geometry, fewer elements used also reduced in weight.

VI. SCOPE OF FUTURE WORK

- The behavior of the structure throughout rollover of the bus need to be analyzed.
- Further redesign of the bus structure taking into account individual members.
- Vehicle Weight Reduction to improve the overall performance of the Bus and Frontal Crash of Bus for Driver /Passenger Safety.

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