Design and Analysis of Bus Body Frame

K. R. Padmavathi[1], E. K. S. Hariharan[2], M. V. Muthu Kumar[3], S. Pranesh[4], R. Raghul Raj[5]
[1]*Associate Professor, Department of Mechanical Engineering, Panimalar Engineering College, Chennai, India*
[2,3,4,5]*Student, Department of Mechanical Engineering, Panimalar Engineering College, Chennai, India*

***Abstract*: Buses are the foremost mode of road transportation. In India, largely ancient style designs are used. The design of the bus body, mainly depends upon the assorted varieties of loading and operational circumstances, eliminating the road conditions. The design model of the bus body is generated in CATIA and later foreign to ANSYS for analysis. The design model of the bus body is subjected to model analysis, linear static analysis and impact analysis through Finite Element Analysis Method. The main objective of this work is to perform the above analysis and forecast the results in terms of stress and strain under several loading conditions. We tend to obtain the results for Structural Steel (Existing material), that is getting used widely in bus body frames. We tend to obtain the results via the identical analysis for two different materials: Aluminium Alloy 6061 and Kevlar; that gave us better results compared to structural steel, whereas, the density of the steel is additional compared to the composite materials.**

***Keywords*: Bus body Frame, Model Analysis, Linear Static Analysis, Impact Analysis.**

1. Introduction

A bus is a road vehicle that is intended to old several passengers. Buses will have a traveller capacity as maximum as three hundred individuals. The foremost common style of bus is that the single-deck rigid bus, omni-bus, articulated bus and also the minibus. Buses could also be used for regular bus transport, regular school or college transport, personal rent, tourism, political campaigns and other different purposes. Buses were initially designed with an engine within the front and an entrance at the rear. By the transition to one-person operation, several makers moved to middle or rear engine styles, with one door at the front or multiple doors. Usually, the chassis is mixed with the engine. Normally, the chassis consists of 2 main types: a single piece & the three joint combination parts. The medium size buses with one floor uses a single part and also the buses with long size or with 2 floors uses the 3 joint combination elements. These elements are subjected to simulation or physical test; torsion and bending tests are used widely. The top frame or the roof frame is taken into account as the important elements that has to have high factor of safety so as to confirm safety for the passengers. The rear and also the front frames are principally supported and joined with the left and right sides. Thus the form becomes quite curvature, slop and better aero dynamic. The prevailing half is more combined by plenty of items that is here referred to as trusts.

The bus body design parameters are 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 and stability of the object.

2. Survey

Prasannapriya Chinta, L. V. Venugopal Rao [1], Optimization of mechanical response of automotive and body designs are increasingly relies on new models. Generally, in international market for passenger's buses design processes can rely on supercomputing facilities. Nowadays for the passenger buses have many local producers which construct vehicles based on local needs. In the competitive to stay these producers comply with the same requirements and weight reduction of their international counterparts without access to latest computation facilities. This paper proposes a new method for designing a bus body structure is designed and modelled in 3D modelling software Pro/Engineer. The original body is redesigned by changing the thickness and reducing the number of elements so that the total weight of the bus is reduced. The present used material for structure is steel. It is replaced with composite materials Kevlar and S 2 Glass Epoxy. The density of steel is more than that of composite materials, so by replacing with composites, the weight of the structure is reduced. Structural and Dynamic analysis is done on both the structures using three materials to determine the strength of the structure. Analysis is done in Ansys. In this project, a bus body structure is designed and modelled in 3D modelling software Pro/Engineer. The dimensions of the body structure are taken from the journal specified in literature survey. The original body is redesigned by changing the thickness and reducing the number of elements so that the total weight of the bus is reduced. The present used material for structure is steel. It is replaced with composite materials Kevlar and S 2 Glass Epoxy. The density of steel is more than that of composite materials, so by replacing with composites, the weight of the structure is reduced. Structural and Dynamics analysis is done on both the structures using three materials to determine the strength of the structure. Analysis is done in Ansys. By observing the analysis results, the displacement and stress values are within the limits, and the strength of the composite materials is more. So it can be concluded that by reducing the thickness and also using composite materials yields better results than original model and conventional steel.

Rajesh S. Rayakar, D. S. Bhat [2] 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 analysed by FE model for strength analysis. 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 analysed various major load cases. From case I to Case III results show that, most cases the equivalent stresses developed and deflection 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 simply geometry, fewer elements used also reduced in weight.

3. Problem description

There is demand for 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 modulation, all for several design iterations to arrive at appropriate combination. For optimized bus body design, newly developed models are chosen whose specifications and dimensions are taken from the local industry.

A. Objective

The main objective of the work is to analyse different materials of the bus body frame by model analysis, linear static analysis and impact load analysis.

B. Methodology

- *Geometric Modelling:* The three-dimensional model is created using CATIA.
- *Finite Element Analysis:* The three-dimensional model created using CATIA is imported to ANSYS software and it is meshed. The meshed model is called as the Finite Elemental Model.
- *Suitable Boundary Conditions:* The meshed model is subjected to certain bound condition and analysis is completed using ANSYS software.

C. Design parameter details

The parameters which considered are the dimensions of actual bus represented in Table 1 and Figure 1.

Table 1
Specification Parameters of Bus

Specification Parameter	Dimension (m)
Length	10.767
Width	2.55
Height	3.32

Specification Parameter Dimension (m)
Length 10.767
Width 2.55
Height 3.32
TABLE 1: Specification Parameters of Bus

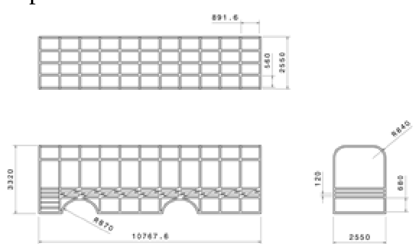

Fig. 1. Two-dimensional representation of bus body

4. Modelling and simulation of bus body

Bus body structure modelling process was carried out using CATIA. In this chapter, the three dimensional modelling and also the simulation of the model is distributed in an elaborate manner. The bus structure is created with steel beams of rectangular hollow section with different size.

A. Modelling

The geometric three dimensional model are generated using CATIA as shown in Figure 2. It is an authoritative program used to create complex designs with great precision. It has features like Feature-based nature, Bidirectional associative property and parametric in nature.

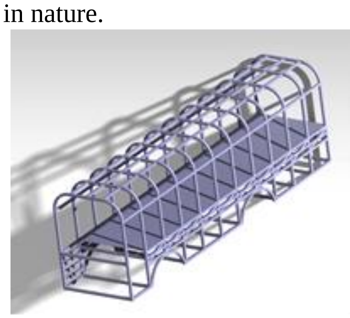

Fig. 2. CATIA model of bus body frame

B. Meshing

Finite element meshing is made with ANSYS workbench. The mesh influences the accuracy, convergence and speed of the result. Moreover, the time it takes to make mesh model is usually a big portion of the time it takes to accumulate results from a CAE solution. Tetrahedral and quadrilateral mesh components are used whereas meshing of the bus structure.

C. Boundary and Loading Condition

The boundary condition used in the analysis is totally different according to the operative circumstances of the bus. Throughout the static loading case the most loads that are considered are acceleration 27778 mm/s^2, breaking load and impact load.

5. Existing system

A. Structural steel (S275)

Table 2
Material Properties of Structural Steel

Density	7.85e-006 kg mm^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Young's Modulus	2.e+005 MPa
Poisson's Ratio	0.3
Bulk Modulus	1.6667e+005 MPa

B. Break load analysis

1) Total deformation

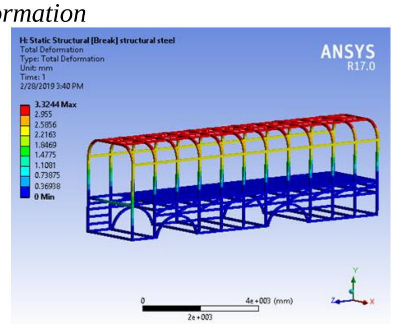

Fig. 3. Equivalent elastic strain

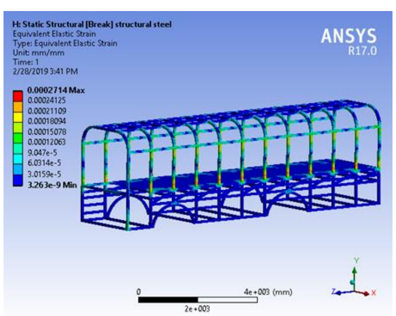

Fig. 4. Equivalent elastic strain

2) Equivalent stress

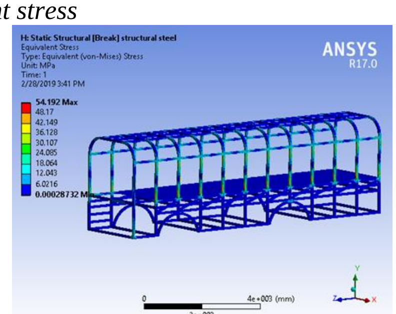

Fig. 5. Equivalent stress

Figures 3, 4 and 5 represents the Total Deformation, Equivalent Elastic Strain and Equivalent Stress of the Bus Body (Structural Steel) during Break Load Analysis.

C. Impact load analysis

1) Total deformation

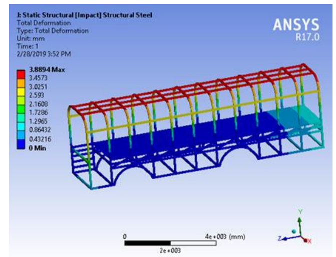

Fig. 6. Total deformation

2) Equivalent elastic strain

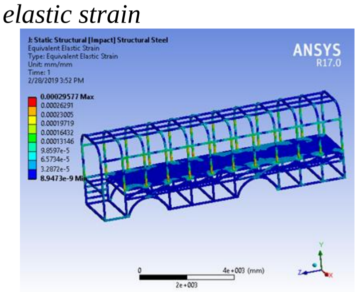

Fig. 7. Equivalent elastic strain

3) Equivalent stress

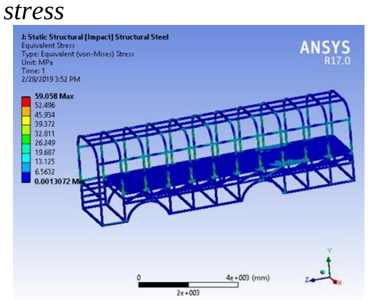

Fig. 8. Equivalent stress

Figures 6, 7 and 8 represents the Equivalent Deformation, Equivalent Elastic Strain and Equivalent Stress of the Bus Body (Structural Steel) during Impact Load Analysis.

D. Velocity load analysis

1) Total deformation

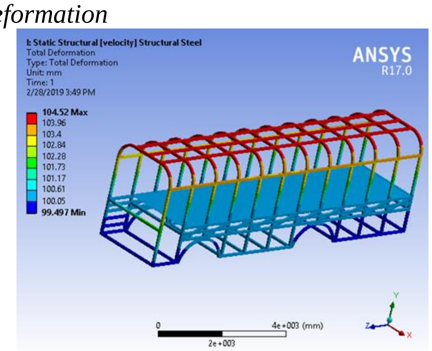

Fig. 9. Total deformation

2) Equivalent elastic strain

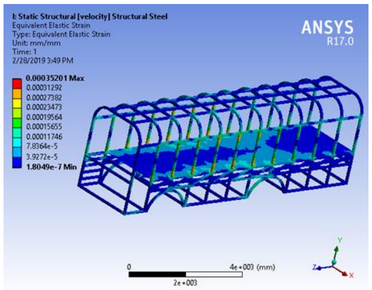

Fig. 10. Equivalent elastic strain

3) Equivalent stress

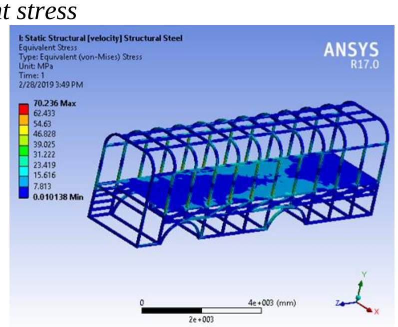

Fig. 11. Equivalent stress

Figures 9, 10 and 11 shows the Total Deformation, Equivalent Elastic Strain and Equivalent Stress of the Bus Body (Structural Steel) during Velocity Load Analysis.

6. Proposed system

A. Aluminium alloy 6061 (A6061)

We have chosen Aluminium 6061 Alloy,

- since it is highly versatile and so it can be used for any structural component.
- It is used in Boats, watercrafts and also in bicycle frames.

The material properties of Aluminium Alloy 6061 are,

Table 3
Material Properties of Aluminium Alloy 6061 6061

Density	2.77e-006 kg mm^-3
Tensile Strength	124–290 MPa
Young's Modulus	68.9 GPa
Thermal Conductivity	151–202 W/(m·K)

B. Break load analysis

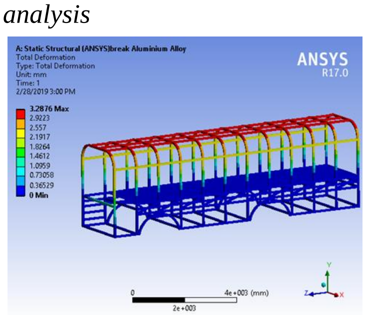

Fig. 12. Total deformation

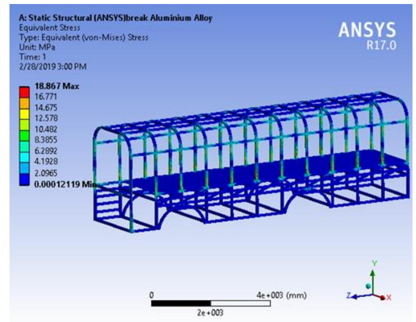

Fig. 13. Equivalent stress

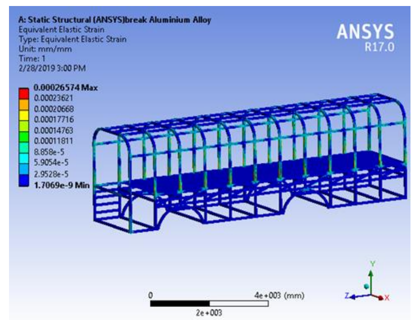

Fig. 14. Equivalent elastic strain

Figures 12, 13 and 14 shows the Total Deformation, Equivalent Stress and Equivalent Elastic Strain of the Bus Body (Aluminium Alloy 6061) during Break Load Analysis.

C. Impact load analysis

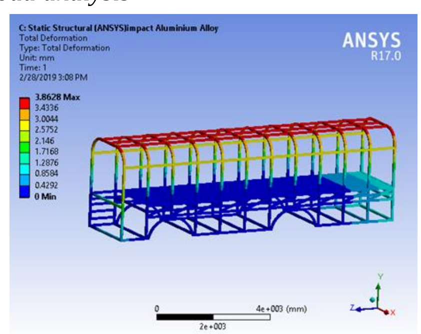

Fig. 15. Total deformation

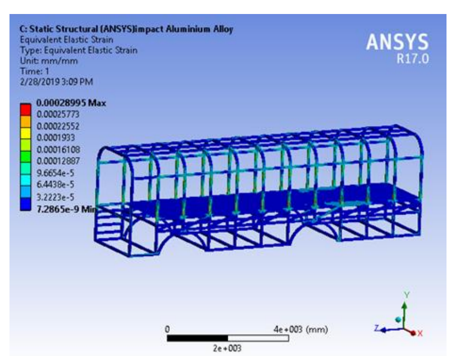

Fig. 16. Equivalent elastic strain

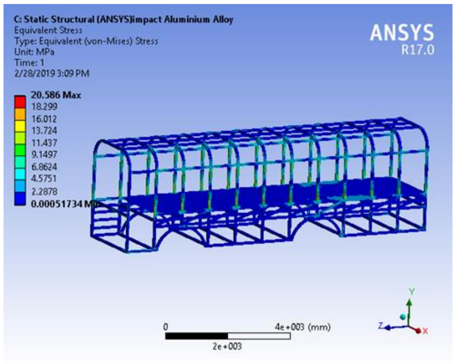

Fig. 17. Equivalent stress

Figures 15, 16, and 17 shows the Total Deformation, Equivalent Elastic Strain and the Equivalent Stress of the Bus Body (Aluminium Alloy 6061) during Impact Load Analysis.

D. *Velocity load analysis*

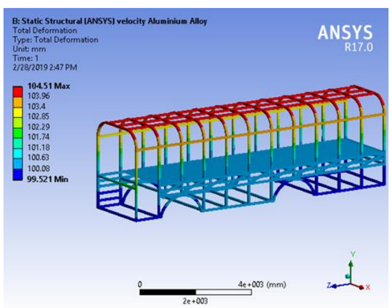

Fig. 18. Total deformation

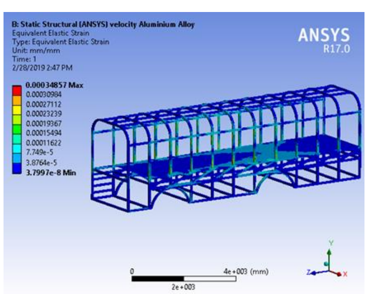

Fig. 19. Equivalent elastic strain

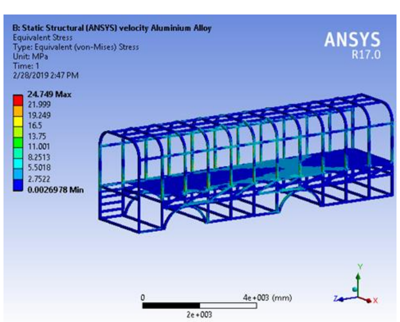

Fig. 20. Equivalent stress

Figures 18, 19 and 20 represents the Total Deformation, Equivalent Elastic Strain and Equivalent Stress of the Bus Body (Aluminium Alloy 6061) during Velocity Load Analysis.

1) *Kevlar*

Kevlar consists of closely packed polymer chains. Kevlar is as tough a steel. It has high tensile fatigue and good flex resistance.

The material properties of Kevlar are,

Table 4
Material Properties of Kevlar

Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa	Density
1.12e+005	0.36	1.3333e+005	41176	1.44e-006 kg mm^{-3}

E. *Break load analysis*

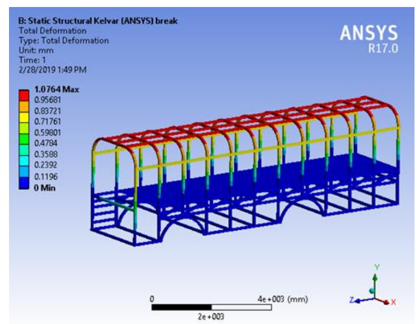

Fig. 21. Total Deformation

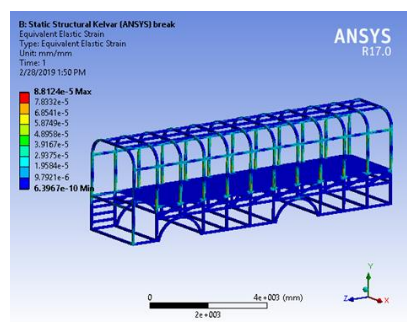

Fig: 22. Equivalent elastic strain

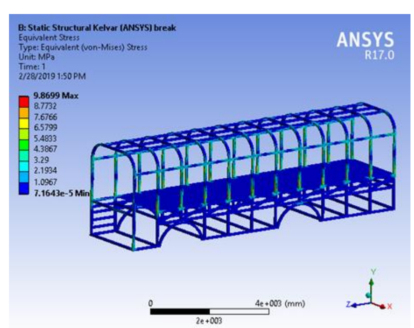

Fig. 23. Equivalent stress

Figures 21, 22 and 23 shows the Total Deformation, Equivalent Elastic Strain and Equivalent Stress of the Bus Body (Kevlar) during Break Load Analysis.

International Journal of Research in Engineering, Science and Management
Volume-2, Issue-3, March-2019
www.ijresm.com | ISSN (Online): 2581-5792

F. Impact Load Analysis

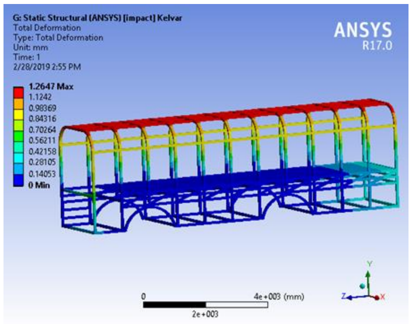

Fig. 24. Total deformation

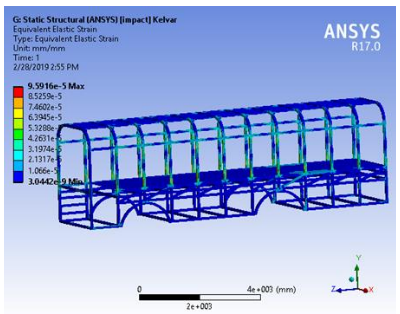

Fig. 25. Equivalent elastic strain

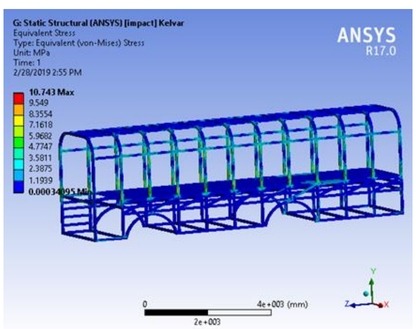

Fig: 26. Equivalent stress

Figures 24, 25 and 26 represents the Total Deformation, Equivalent Linear Stress and Equivalent Stress of the Bus Body (Kevlar) during Impact Load Analysis.

G. Velocity load analysis

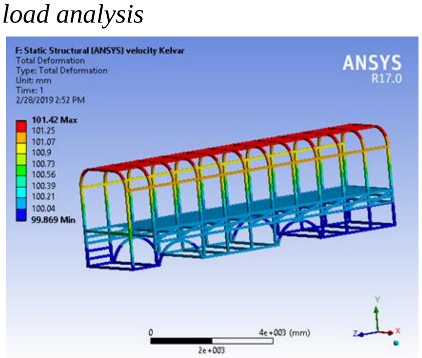

Fig. 27. Total deformation

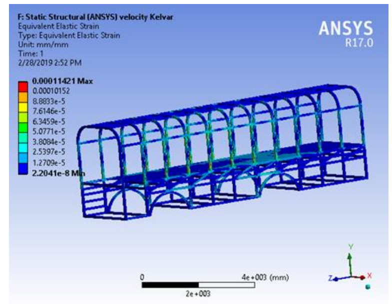

Fig. 28: Equivalent elastic strain

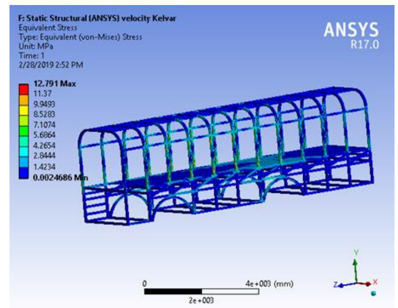

Fig. 29. Equivalent stress

Figures 27, 28 and 29 represents the Total Deformation, Equivalent Linear Strain and Equivalent Stress of the Bus Body (Kevlar) during Velocity Load Analysis.

7. Results and discussions

A. Break load analysis

Table 5
Comparison of Total Deformation

Material	Time [s]	Minimum [mm]	Maximum [mm]
Structural Steel	1.	0.	3.3244
Aluminium Alloy 6061	1.	0.	3.2876
Kevlar	1.	0.	1.0764

Table 6
Comparison of Equivalent Elastic Strain

Material	Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
Structural Steel	1.	3.263e-009	2.714e-004
Aluminium Alloy 6061	1.	1.7069e-009	2.6574e-004
Kevlar	1.	6.3967e-010	8.8124e-005

Table 7
Comparison of Equivalent Stress

Material	Time [s]	Minimum [MPa]	Maximum [Mpa]
Structural Steel	1.	2.8732e-004	54.192
Aluminium Alloy 6061	1.	1.2119e-004	18.867
Kevlar	1.	7.1643e-005	9.8699

B. Impact Load Analysis

Table 8
Comparison of Total Deformation

Material	Time [s]	Minimum [mm]	Maximum [mm]
Structural Steel	1.	0.	3.8894
Aluminium Alloy 6061	1.	0.	3.8628
Kevlar	1.	0.	1.2647

Table 9
Comparison of Equivalent Elastic Strain

Material	Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
Structural Steel	1.	8.9473e-009	2.9577e-004
Aluminium Alloy 6061	1.	7.2865e-009	2.8995e-004
Kevlar	1.	3.0442e-009	9.5916e-005

Table 10
Comparison of Equivalent Stress

Material	Time [s]	Minimum [MPa]	Maximum [Mpa]
Structural Steel	1.	1.3072e-003	59.058
Aluminium Alloy 6061	1.	5.1734e-004	20.586
Kevlar	1.	3.4095e-004	10.743

C. Velocity load analysis

Table 11
Comparison of Total Deformation

Material	Time [s]	Minimum [mm]	Maximum [mm]
Structural Steel	1.	99.497	104.52
Aluminium Alloy 6061	1.	99.521	104.51
Kevlar	1.	3.4095e-004	10.743

Table 12
Comparison of Equivalent Elastic Strain

Material	Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
Structural Steel	1.	1.8049e-007	3.5201e-004
Aluminium Alloy 6061	1.	3.7997e-008	3.4857e-004
Kevlar	1.	2.2041e-008	1.1421e-004

Table 13
Comparison of Equivalent Stress

Material	Time [s]	Minimum [MPa]	Maximum [MPa]
Structural Steel	1.	1.0138e-002	70.236
Aluminium Alloy 6061	1.	2.6978e-003	24.749
Kevlar	1.	2.4686e-003	12.791

8. Conclusion

The model analysis, the linear static analysis and the impact analysis has been done for the existing and the proposed systems and the results are tabulated. According to the result, we concur that the material Kevlar has the capacity to withstand higher load capacity and it gives minimum deformation when subjected to acceleration and impact, which increases the factor of safety of the bus model. In modern times, though Kevlar costs higher compared to Structural Steel and Aluminium Alloy 6061, it is better to opt for Kevlar due to its load withstanding capacity and its factor of safety.

References

[1] Rajesh. S. Rayakar, D.D. Bhat, “Determination of Strength Analysis of Bus Body Carline through FEA”, at International Journal for Research in Applied Science and Engineering Technology, Vol.2 Issue VII, July 2014
[2] Prasanna Priya. Chinta, L.V. Venugopal Rao, “A new Design and Analysis of Bus Body Structure” at IOSR Journal of Mechanical and Civil Engineering, Volume 11, Issue 5 Ver.1, Sep-Oct 2014
[3] Guruprasad T, Satish Babu, Maruthi B H, Pramod K N, Manjunatha H G, “Bus Body Structural Strength Analysis Through FEA”, at International Journal for Technological Research in Engineering, Volume 2, Issue 11, July 2015.
[4] Li Zhaokai, Shen Fulin, Xiao Yuan, Xie Xuliang, Wang Gaoqing and Zhou Wenguang, "Finite element analysis of body framework for large size bus," *2011 International Conference on Electric Information and Control Engineering*, Wuhan, 2011, pp. 5039-5042.
[5] Madhav G. Badami, Murtaza Haider, “An analysis of Public Bus Transit Performance in Indian Cities”, in Transportation Research Part A Policy and Practice, December 2007.
[6] G.J. Dunlop, “The Industrial Field Bus”, at IEE Colloquium on Buses for Instruments: VXI and Beyond, August 2002.
[7] Wen-Ku Shi, Zhi-Yong Che, Fu-Xiang Guo, Zhi-hong Shen, “Finite Element Modal Analysis for a light bus”, at Asia-Pacific Conference on Computational Intelligence and Industrial Applications, February 2010.
[8] Liu Donpo, Mo Xuhui, “Bus Frame Dynamic and Durability Analysis of using Virtual Proving Ground”, at International Conference on Consumer Electronics, Communications and Networks, May 2011.
[9] Zhang Xingwang, Tao Zhen, “A Study on Shape Optimization of Bus Body Structure based on Stiffness sensitivity analysis”, at IEEE 10th International Conference on Computer-Aided Industrial Design & Conceptual Design, January 2010.
[10] Li Zhaokai, Shen Fulin, Xiao Yuan, Xie Xuliang, Wang Gaoqing, Zhou Wenguang, “Finite Element Analysis of Body Framework for Large Size Bus”, at International Conference on Electric Information and Control Engineering, May 2011.