Review on “Design and impact Analysis on a frameless chaises Construction of Volvo Bus for Different Speeds”

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Abstract

Impact analysis on frameless chaises at different speeds is a dynamic analysis but for this review paper we did its equivalent “Static Structural analysis” using the data from the original research and taking some assumptions. The main aim of that research was to analyze frameless chaises with presently used material steel and replacing with composite material like Carbon Epoxy, E-Glass Epoxy. Impact analysis was done in the research on the frameless chaises of bus for different material at three different speeds. It also compared the results for the present design with the improved design by themselves which was designed using CERO and all analysis were done using COSMOS software.

Keywords: FEM, ANSYS, Composite material, Crash Worthiness, COSMOS, HSLA

I. Review

In the paper titled “Design and impact analysis on a frameless chaises construction of Volvo bus for different speeds” researchers collected data of currently made frameless chaises of Volvo bus from one of manufacturers, then they worked on the impact analysis for the structure, for varying speed, depending upon its design and material used and tried to improve it for better result to increase the safety factor, these tests lie in category of Crash Worthiness test for automobile.

The main aim was to reduce the impact by modifying the existing design of structure. For that, first step was to study the structure, its importance and its main working and functions and the factor on which those factors depend upon, and these functions includes Load Carrying capacity of structure, supporting element for the remaining parts of vehicle, Withstanding centrifugal forces and different type of stresses at different situations.

The second step included the literature review, as automobile chasses are being made from a long time and their design and functionalities depends upon application of usage. For particularly bus construction the chasses are improved and changed many times which brought advantages as well as disadvantages to the automobile itself and passenger safety. One of main change was reducing the length which reduced the weight making it cheaper and fuel economical, but disadvantage was that it made the repairing process more costly and difficult and decreased their crash worthiness.

Before analysis, the design was improved by adding few structures in the existing one and then analysis was done first using steel as structure material and impact test was done using COSMOS software and FEM, for different speeds after that for same structure “Carbon Epoxy” and “Glass Epoxy” were used as structure material and the same impact test for same different speeds were repeated and results were compared at the end.

The research was concluded as the frameless chassis was designed using data from one of the manufacturers and the material already used was steel and it was replaced by Carbon Epoxy and E-Glass Epoxy. By replacing with these materials, the overall weight of chassis was reduced four time due to lesser density and other properties offered by these composites. Impact analysis was done for different speeds 75 km/hr, 150 km/hr and 300 km/hr. By observing the results, the displacement and stress values are less for E – Glass epoxy than Steel and Carbon Epoxy. By observing the impact analysis on modified design, the displacement and stress values are reduced than the present design. So, we can conclude that E – Glass epoxy is better material for frameless chassis and by modifying the design some advantages can be found (i.e.) decrease of stress and displacement values.

II. Methadology

As per the project instructions and requirement, we did this impact analysis using static structural analysis. Hence, we first studied the impact analysis, and the author did that and what factor they included and all. Then as the static structural is not for body in motion we had to calculate equivalent forces which body will have at the time of impact and apply those condition to perform the impact test.

For that we calculated the impulse response for the crash to calculate the reaction force applied on the frameless chaises. Because the time of a crash is like an impulse, in research the impulse time of $20\mu s$. But, as different analysis was performed in the paper, we had to take some assumption and approximate values to meet our project requirement of performing static structural analysis. Although, the analysis type was different but the process we used and steps we followed were same as followed in the original research.

III. Softwares

In the original research the model was made using CERO software but, in our project, we made the model using SOLIDWORKS and imported that to ANSYS 2019R3 software to perform the analysis, but COSMOS was used in the original research hence some approaches like setup etc. were different because of different platforms.

IV. Mathematical Calculations

As mentioned earlier, we must do equivalent force calculations for static structural analysis. We already have some given data from the research paper regarding properties of frameless chaises shown in fig 1.1.

For structural analysis we needed to calculate the reaction force which the rigid body would apply to the frame when it has impact at different velocities.

Assumption:

$$\textbf{Impact time} = 4\ ms = 0.004\ s$$

$$\textbf{Final velocity} = V_f = \frac{V_i}{2}\ ms^{-1}$$

Then for V_i, impulse would be:

$$F \times t = mv_f - mv_i$$

$$F = m\frac{v_f - v_i}{t}$$

$$F = m\frac{\frac{v_i}{2} - v_i}{0.004}$$

$$F = m\frac{-v_i}{2 \times 0.004}$$

Then for different material and velocities we calculated the reaction force, given in table 1.1.

	ALLOY STEEL			CARBON EPOXY			E-GLASS EPOXY		
	STRESS N/mm2	DISP mm	STRAIN	STRESS N/mm2	DISPLACEMENT mm	STRAIN	STRESS N/mm2	DISPLACEMENT mm	STRAIN
75 Km/hr	6210	1.80046	0.020261	678	0.459936	0.00279	361.913	0.44251	0.00543
150 Km/hr	3251.74	0.950993	0.010666	1357.07	0.920092	0.00560	725.164	0.885161	0.01087
300 Km/hr	6214.61	1.80024	0.020259	2710	1.84126	0.01123	1455.94	1.77189	0.02182
WEIGHT (Kg)	10864			2257.65			2822		

Fig 1.1

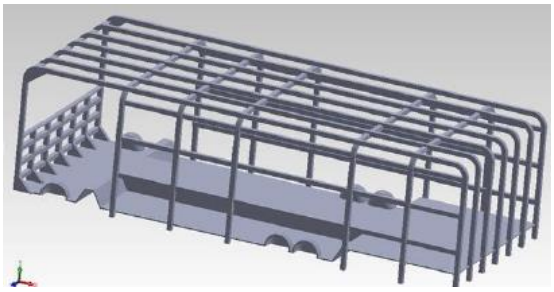
Speeds →	$75\ km\ hr^{-1}$ or $20.83\ ms^{-1}$	$150\ km\ hr^{-1}$ or $41.6\ ms^{-1}$	$300\ km\ hr^{-1}$ or $83.33\ ms^{-1}$
Material |	Force (N)	Force (N)	Force (N)
Alloy Steel	28287140	56492800	113162140
Carbon Epoxy	5878356.18	11739780	23515726
E-Glass Epoxy	7347782.5	14674400	29394657.5

Table 1.1

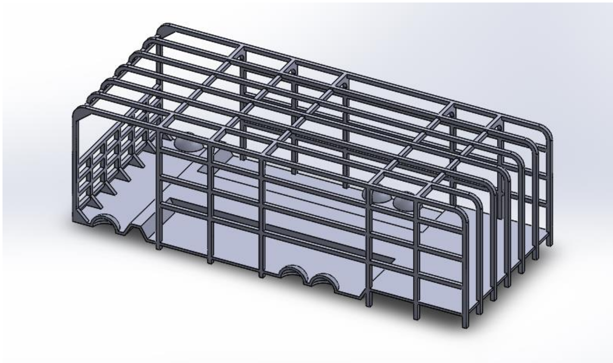
V. Results and Discussion

Old Model

Modified Model



Our Model



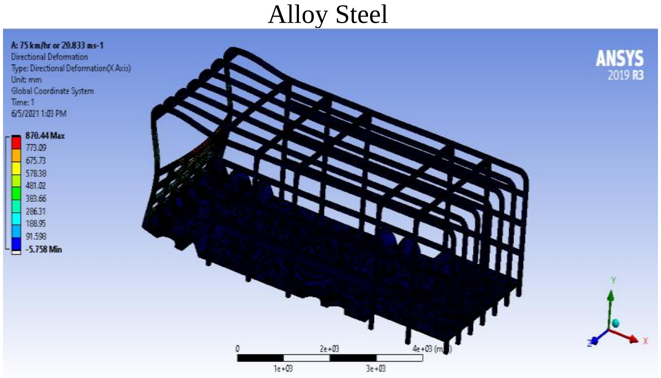
Static Structural Analysis

Setup

Entity	Value
Impact time	4 ms
Element Size	30 mm
Connector	0
Connections	0
Result types	Directional Deformation, Von-misses Strain, Von-misses Stress
Stress Convergence Plot	2 %

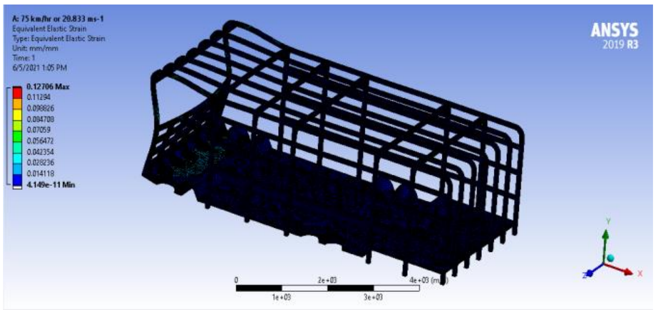
Table 1.2

Alloy Steel



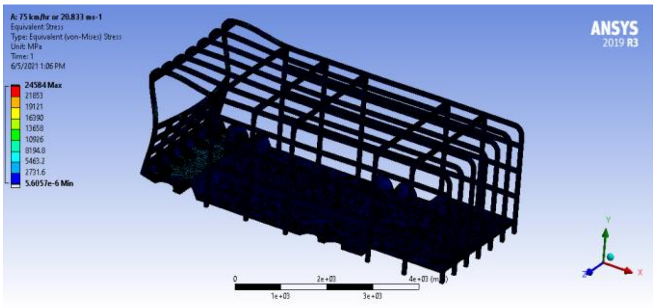
Tabular Data

	Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1	1.	-5.758	870.44	86.068



Tabular Data

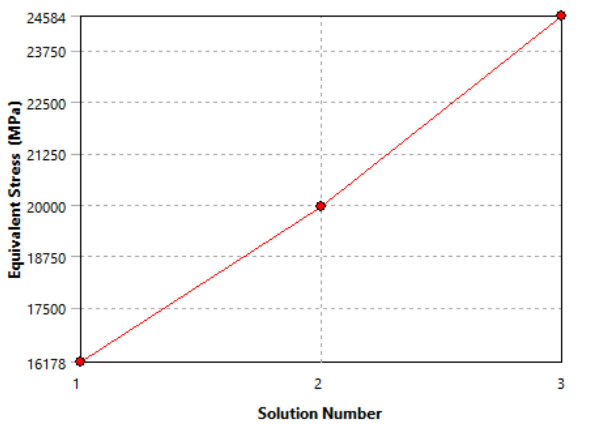
	Time [s]	Minimum [mm/mm]	Maximum [mm/mm]	Average [mm/mm]
1	1.	4.149e-011	0.12706	6.7115e-003



Tabular Data

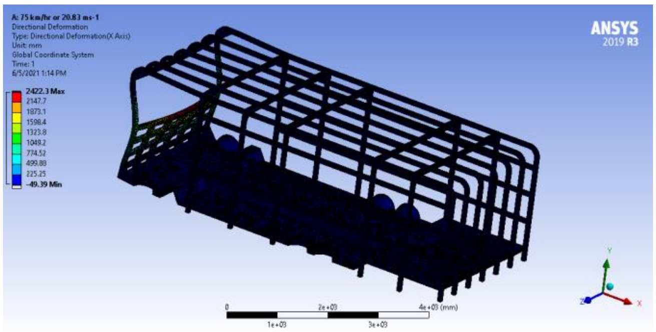
	Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1	1.	5.6057e-006	24584	1329.7

Convergence History



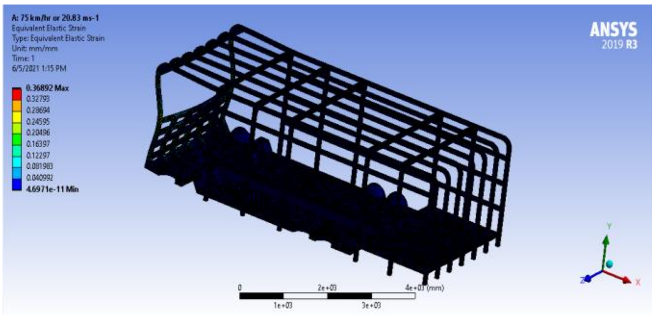
	Equivalent Stress (MPa)	Change (%)	Nodes	Elements
1	16178		356305	174360
2	19940	20.827	389065	194728
3	24584	20.864	530654	284789

Carbon Epoxy



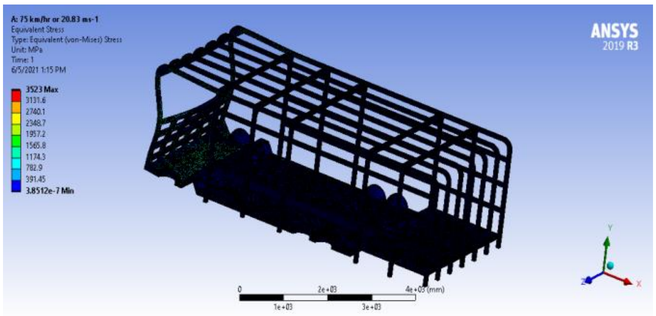
Tabular Data

	Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1	1.	-49.39	2422.3	57.612



Tabular Data

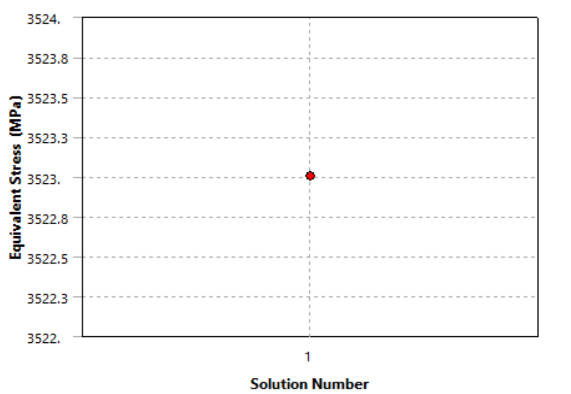
	Time [s]	Minimum [mm/mm]	Maximum [mm/mm]	Average [mm/mm]
1	1.	4.6971e-011	0.36892	8.3781e-003



Tabular Data

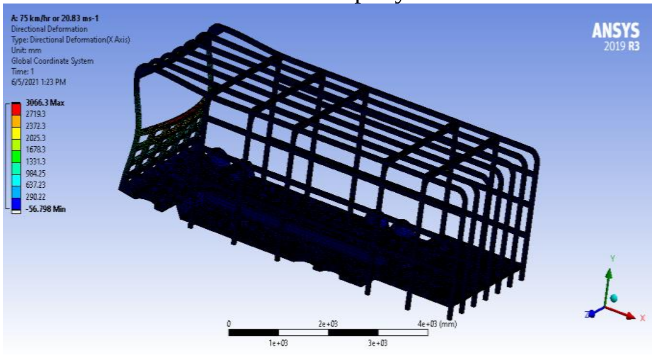
	Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1	1.	3.8512e-007	3523.	111.98

Convergence History



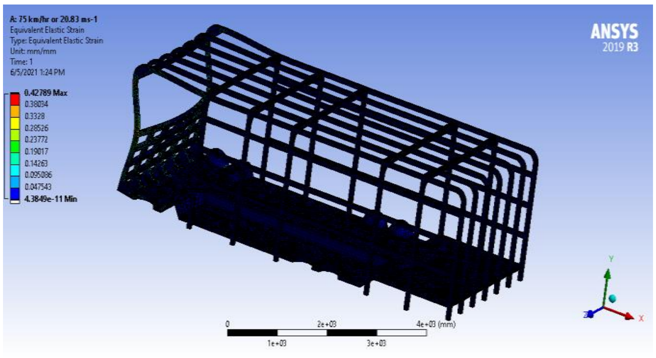
	Equivalent Stress (MPa)	Change (%)	Nodes	Elements
1	3523.		356305	174360

E-Glass Epoxy



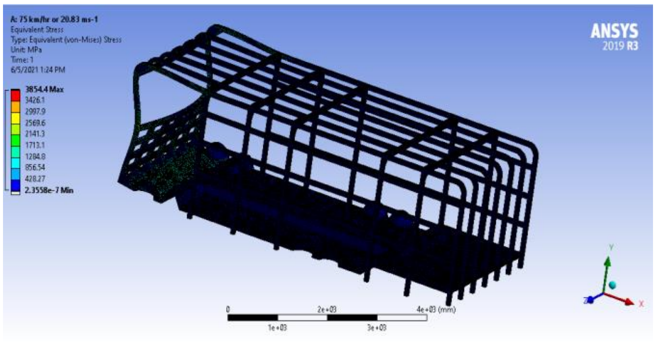
Tabular Data

	Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1	1.	-56.798	3066.3	82.569



Tabular Data

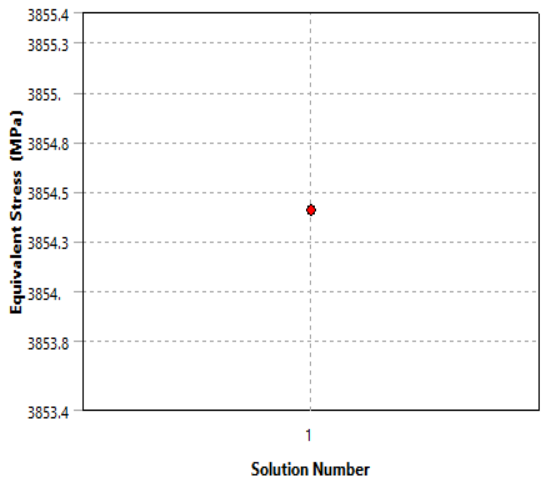
	Time [s]	Minimum [mm/mm]	Maximum [mm/mm]	Average [mm/mm]
1	1.	4.3849e-011	0.42789	1.0539e-002



Tabular Data

	Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1	1.	2.3558e-007	3854.4	132.61

Convergence History



	Equivalent Stress (MPa)	Change (%)	Nodes	Elements
1	3854.4		356305	174360

Original Results

	ALLOY STEEL			CARBON EPOXY			E-GLASS EPOXY		
	STRESS N/mm2	DISP mm	STRAIN	STRESS N/mm^2	DISP mm	STRAIN	STRESS N/mm2	DISP mm	STRAIN
75 Km/hr	1359.51	0.462389	0.00482	426.164	0.437768	0.002574	347.026	0.463127	0.0054199
150 Km/hr	2720.15	0.925276	0.00965	851.737	0.875923	0.005151	693.928	0.926536	0.0108466
300 Km/hr	5440.78	1.85143	0.01933	1701.3	1.75293	0.010306	1386.71	1.85419	0.02170825

Our Results

	Alloy Steel (Avg Values)			Carbon Epoxy (Avg Values)			E-Glass Epoxy (Avg Values)		
	Stress MPa	Disp mm	Strain	Stress MPa	Disp mm	Strain	Stress MPA	Disp Mm	Strain
75 Km/hr	1329.7	86.068	0.00671	111.98	57.612	0.00837	132.61	82.569	0.01053
150 Km/hr	2655.6	171.89	0.01340	223.65	115.06	0.016732	264.84	164.9	0.021047
300 Km/hr	5319.6	344.31	0.02684	447.98	230.47	0.03351	530.52	320.32	0.04216

Table 1.3

As the exact material used in the original research were not mentioned so we picked randomly like the mentioned were Alloy Steel, but which alloys was not mentioned so we choose HSLA (High Strength Low Alloy Steel), and Carbon epoxy was mention so we used Epoxy Carbon UD (230 GPa) prepreg and E-Glass Epoxy was mentioned and we used Epoxy E-Glass UD. Hence, due to all these assumptions we have different percentage error depending upon unknown material property deviation. For HSLA the percentage error is very less as compared to other elements but still the overall result of the experiment is same comparatively.

VI. CONCLUSION

In our project we repeated the whole research performed in paper titled "Design and Impact Analysis of Frameless Chaises of Volvo Bus for different Speeds" but due to project requirement we did the equivalent "Static Structural Analysis" rather than "Dynamic Analysis" specifically drop test, so we made the model on SOLIDWORKS imported it in ANSYS software and from the data given in research derived mathematical equation of impact analysis for equivalent impulse reaction for $t = 4\ ms$. We also had to pick material from our own as full details or sub-category of materials were not mentioned in the original research and we did the static structural analysis on the frameless chaises. In our analysis, by observing the results, the displacement and stress values are less for Epoxy Carbon UD (230 GPa) prepreg. This result does not match with the original research and the reason is change of material (which was because complete detail of sub-category of materials were not mentioned in the paper). But we can conclude that major results of our project and original research matches as both results shows that Composite materials are better in term of weight, stress and displacement values as compared to Alloy Steel.

REFERENCE

[1] **Design and impact analysis of frameless chassis of valvo bus for different speeds** BOIDAPU JASWANTH KARTHIK M. Tech-MACHINE DESIGN pursuing Student, viswanadha institute of technology and management, , Mr. K.RAVINDRA Associate Professor