

# Lightweight and Multi Material Designing and Analysis of a C9 Bus Frame Superstructure Considering ECE 066

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**Abstract** - If we see the evolution of Transportation system over the years, we draw an important inference that Buses undebatably have been a major mode of Transport. At the same time, we also observe the increasing inclination of people towards safety measures for mass transportation. The design of the bus body depends upon various parameters including road conditions, loading conditions, passenger capacity, type of usage, centre of gravity etc. These parameters are useful concerning safety as well as economics of manufacturing. Based on the above characteristics, the material, the size of the components.

The paper presents an attempt of optimizing design of a K9 bus superstructure and at the same time bring the centre of gravity at the correct position by the correct material considering rollover.

## 1. INTRODUCTION

A Spanish survey showed that the frequency of rollover was 4% of all coach accidents on roads and highways, and the risk for fatalities in a rollover was five times higher as compared to any other type of accident. Another statistic of Fatality Analysis Reporting System (FARS) also showed that rollover occurs less frequently than all other types of automotive accidents, but the probability of fatalities and severe injuries is more in rollover type accidents. Thus, rollover strength has become an important issue for bus and coach manufacturers.

### 1.1 PRESENT SYSTEM

The bus manufacturers are now a days experimenting with various materials other than the conventional materials such as low carbon steel to take advantage of various other materials available in the market (especially non-ferrous) considering their specific properties. If properly designed & analyzed, these new type of materials helps in enhancing the structural mechanical properties. The following figure shows the 3-d modeling of type II K9D bus.

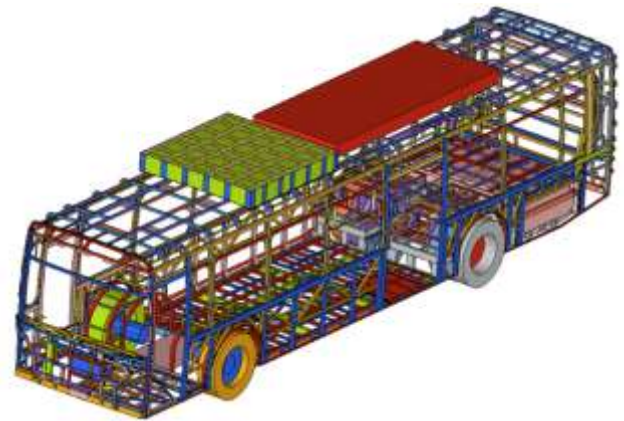


Fig 1.1: Type II K9D bus.

### 1.2 EXISTING PROBLEM

As mentioned before buses are important modes of travel & hundreds of people travel by them everyday. Their capacity may differ from 10-12 to 40-50 people. If an accident is caused due to rollover & the super structure deforms beyond the specified limit, it may seriously threaten the lives of passengers inside the bus.

Hence, prevention of rollover phenomenon & designing the superstructure with optimum strength, stiffness, weight is an important task for bus manufacturer.

For prevention of bus rollover failure, the legislation regulation number 66 of economic commission for Europe (ECE R66) has been enforced. Following of ECE R66 has to be done along with reducing the weight of the structure & prevention of superstructure from entering the residual space.

### 1.3 IMPROVISATION

While using a material for superstructure, various properties of material including strength, mass, weight, size, density along with corrosion prevention, rusting prevention, their thermal properties has to be considered.

#### 1.3.1 MILD STEEL

Because of low cost & various desirable properties, mild steel is the most commonly used material for building superstructure. It can be formed easily & although it has low tensile strength, low cost and high forming properties make it a suitable choice for super structure. Its surface hardness can be increased by carburizing. Since they have

less amount of carbon as compared to other steels, they can be easily formed by cold forming process. If we consider larger cross sections to reduce deformation of materials, then mild steel is the best choice.

### 1.3.2 MILD STEEL YST310

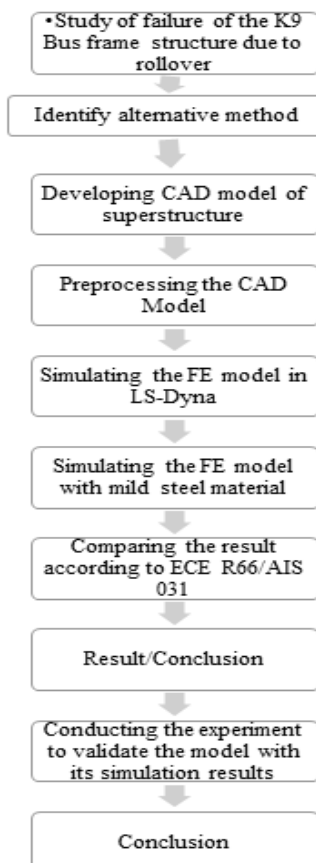
Mild steel YST310 is preferred because of its better compressive strength due to lower slenderness ratio and high yield strength. It has full strength under bending moment regardless of lateral restrains due to superior torsional rigidity. It also has low drag coefficients of closed of closed structure helps to bypass the fluid currents more effectively than conventional sections. It enhances the shear capacity due to more effective area under shear. Because of light weight, the seismic forces on the structure will be less, there by reducing the weight on the structure.

### 1.4 OBJECTIVE

Hence this paper presents light weight optimization considering the bus rollover crashworthiness design. In this study, all the sections including R.H. section, L.H. section, roof section, top section are to be critically examined in order to prevent the intrusion in residual space. Some of the examples of rollover of buses is shown n following diagrams.

### 1.5 METHODOLOGY

- Study of failure of the K9 Bus frame structure due to rollover



## 2. GEOMETRIC MODELLING

In this section, the detailed CAD models used in project are shown. CAD modeling software such as CATIA is used. The overall dimensions of various section of the bus superstructure are shown in figure.

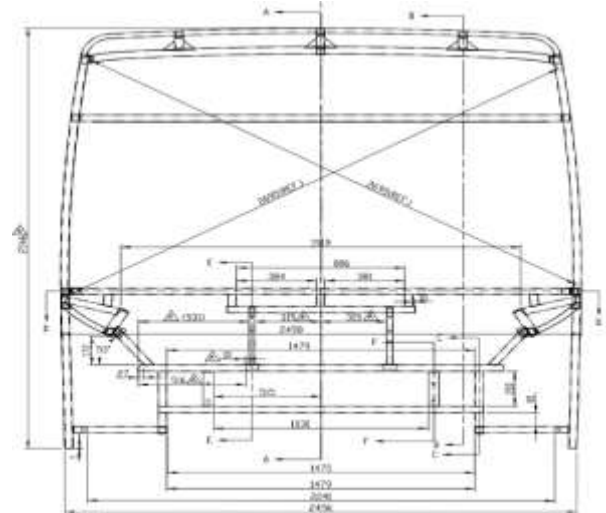


Fig 2.1: Front Structure

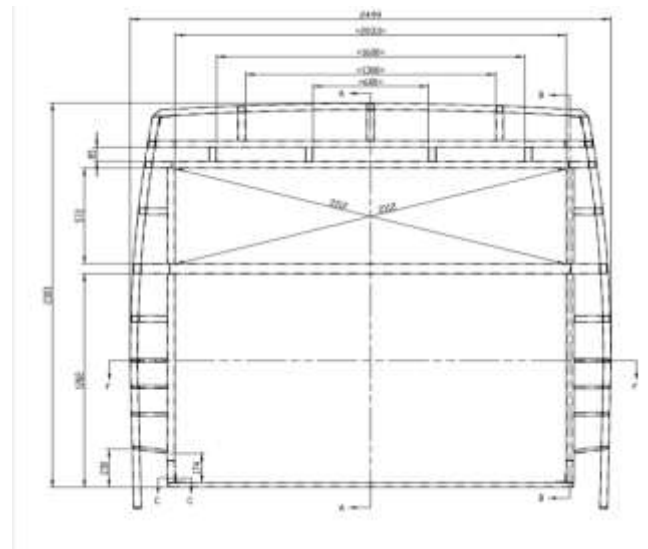


Fig 2.2: Rear Structure

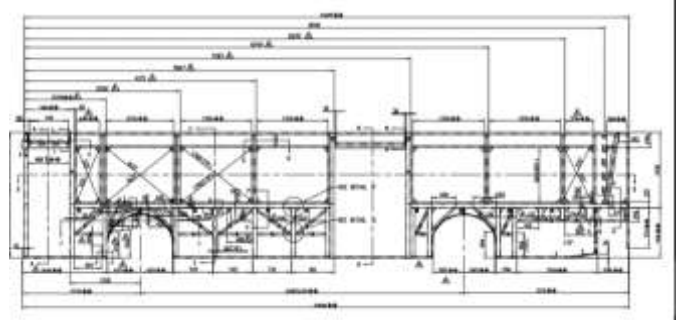


Fig 2.3:L.H. Structure

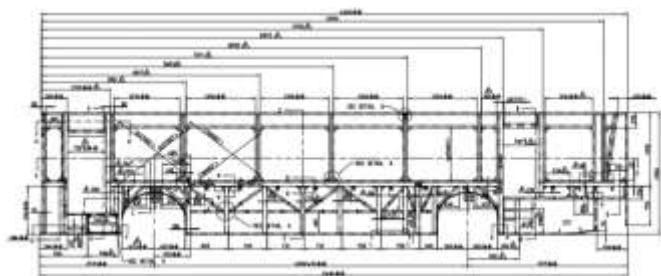


Fig 2.4:R.H. Structure

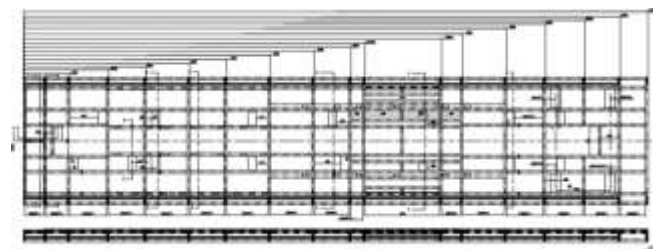


Fig 2.5:Roof Structure

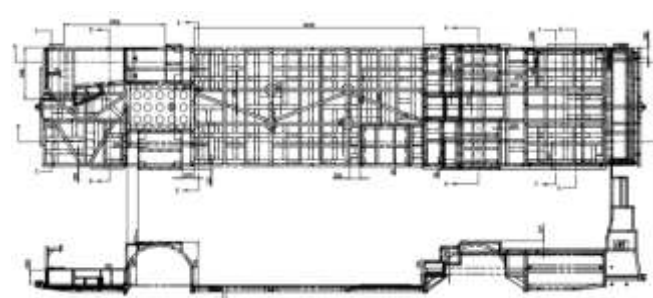


Fig 2.6:Floor Structure

Designing of the superstructure serves as one of the most important fact of the Bus production process. Out of the above shown diagram, no structure should enter the residual space of the passengers to provide a rollover preventive superstructure. The assembly of the above parts is shown in the figure.

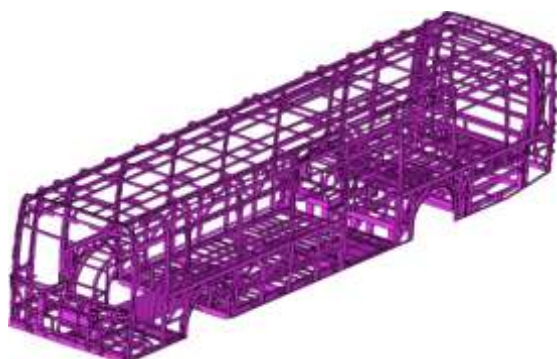


Fig 2.7: CAD model of bus frame superstructure

Table 2.1: General properties of the bus

Material	Density Kg/m <sup>3</sup>	Yield Stress (MPa)	Ultimate Stress (MPa)	% Strain
Steel	7850	310	450	8

### 3. DESIGN ANALYSIS

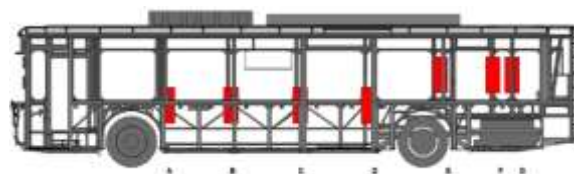


Fig 3.1:Intrusion Analysis

Table 3.1: Intrusion Analysis

Pillars	Intrusion
A	299.02
B	342.56
C	305.76
D	311.48
E	10.5
F	2
G	36.4

The above diagram shows the intrusion analysis of the shaded parts. It can be seen that all the measurements and the values of extrusion are positive and within their limits. Hence it shows that no part of the superstructure enters the residual space of the bus superstructure and hence the structure can be said as rollover preventive.

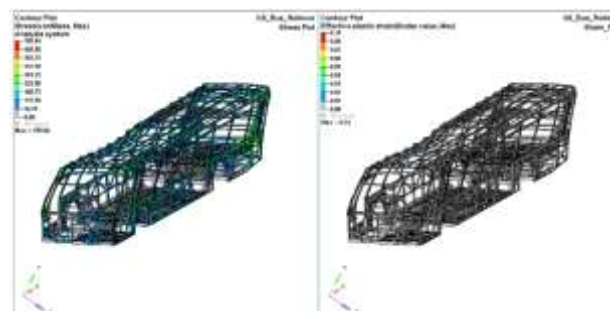


Fig 3.2: Strength Analysis

The above analysis in the software shows that Local failure is observed but overall strength meets the requirements.

Table 3.2: Energy Absorption

Energy (Kj)	Initial Energy (Kj)	Final Energy (Kj)	Absorbed Energy (Kj)	% Absorbed Energy
Kinetic Energy	130.93	29.44	101.49	77.52

### 3.1 AUTOMOTIVE STANDARD ECE R66 REQUIREMENTS

1. The superstructure of the vehicle shall have the sufficient strength to ensure that the residual space during

and after the rollover test on complete vehicle is unharmed.

-Superstructure of the vehicle for modification model with SWR is 6.80 which is satisfying the above standard requirement.

2. No part of vehicle which is outside the residual space at the start of the test (e.g. pillars, safety rings, luggage racks) shall intrude into the residual space during the test. Any structural parts, which are originally in the residual space (e.g. vertical handholds, partitions, kitchenettes, toilets) shall be ignored when evaluating the intrusion into the residual space.

-Satisfying the above standard requirement. (Residual space has been maintained and not intruded by any other object during impact.)

3. No part of the residual space shall project outside the counter of the deformed structure. The counter of the deformed structure shall be determined sequentially, between the every adjacent window and the door pillar. Between two deformed pillars the counter shall be a theoretical surface, determine by straight line, connecting the inside counter points of the pillar which were the same height above the floor level before the roller rest.

-Satisfying the above standard requirement.

#### 4. RESULT

As mentioned above, the superstructure analysis clearly states that it is safe from rollover failure. All the regulations regarding ECE 066 were followed and there was reduction in weight with optimizing of superstructure. As per the analysis in the software LS Dyna, Local failure was observed but overall strength meets the requirements. Also no part of any superstructure was intruding in the residual space of the superstructure. All these results show that the process of using the metal YST 310 was successful.

#### 5. Conclusion

In this projectwork, designing and dynamic analysis is done on the baseline model with Mild steel YST 310. Here the software Catia was used for designing of the superstructure initially and then analysis was done on the software LS Dyna.

By the above result and analysis, we can say that the modified model with material Mild Steel 310 is extremely crashworthy. Along with it, the superstructure was optimized regarding the weight, its centre of gravity resulting in stabilizing of the structure.

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