EXPLICIT DYNAMIC ANALYSIS OF AUTOMOTIVE BUS BODY STRUCTURE DURING CATASTROPHIC FRONTAL CRASH WITH EXPULSION SYSTEM

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ABSTRACT:

Investigation of accidents for buses and Automotive, Accidents involved frontal crash creates a vital portion among all bus accidents. Through this sort accidents, front body of the bus structure gets severely damaged and this will lead drivers and crew injury risk. And most of the frontal crash accidents ends up with the death of the driver. As a result of this, the protection of the driver and crew ought to be ensured within the case of frontal crash accidents. Providing the safety of the driver is crucial, since bus driver is a key person for keeping the control of the bus within the event of accidents, safety of the passengers are going to be ensured. Usually the bus structures are developed in consideration of less weight, efficiency and safety. Due to fragile structure it causes a more damage during an accident. Thesis proposes a new method for designing a bus body structure in 3 Dimensional modelling software creo-3.0. Finite Elemental Method and Ansys Software are being used to analyse crash simulations. The nonlinear dynamic explicit finite element method is used to establish the frontal crashworthiness model of vehicle, the finite element model is consistent with vehicle improving stiffness. The result analysis of Dynamic simulation calculation and Boundary condition of front crash is processed to a particular bus chassis model, which improve the front crash safety performance the safe ejections of passengers. In This Proposed thesis, result analysis are carried in three type's Numerical and Simulation method. Experimental method is analysed in Scale module bus chassis and structure stiffness is examined by the Simulation analysis. It is vital important role so to understand the Dynamic impact load Analysis are which are examined in Ansys/ Finite Elemental Method software.

Keyword: *Crash analysis, Volvo bus, B9R explicit, Dynamic Analysis, Design enhancement. ANSYS.*

1. INTRODUCTION

Vehicle crash safety has been a strong point of interest for long time in many countries due to the reason that safety statistics show high fatality rate of vehicle occupants involved in road accidents. All vehicles which are going to appear on the road must go through several serious crash investigations to approve whether they conform to the relevant safety standards.

The structural capacity of the vehicle to absorb the kinetic energy that results from an impact and to maintain the integrity of the occupants is called the "crashworthiness" or IAC (Impact Absorber Capacity), wherein this quality must be maximized by means of the adequate spatial distribution of the flexibility in the structure analyzed.

Studies on crashworthiness and safety of vehicles have gained concerns at intervals the past years with a stress on examination of coach safety (Prochowski et al. 2011, Al-Thairy and Wang 2014). analysis on buses and coaches safety is obvious restricted. Some rules obligatory for vital vehicles unit obligatory for rider protection Federal automobile Safety Standards (FMVSS) 220 establishes performance needs for varsity bus change protection within the us. In Europe, international organization Economic Commission for Europe (UN-ECE) Regulation-66 regarding with the strength of bus construction beneath dynamic lateral change take a look at and ECE R80 specifying the strength of seats and their anchorages area unit enforced. However, rules and/or tips specifically organized for frontal collision of bus structure directly involved with the protection of the driving force and crew don't exist. However, the passengers area unit in a lot of larger risk if the driver isn't protected throughout the course of accident. The ECE R29 regulation is obligatory to produce the protection of the truck cabin and therefore the driver beneath frontal crash (Mirzaamiri et al., 2012).

1. PROBLEMS STATEMENT

The most of the frontal crash accidents lands up within the death of the driver, as a results of this, the protection of every the driver and also the crew need to be ensured among the case of frontal crash accidents. To providing the driving force safety is crucial since driver is that the key person for keeping the control of the bus within the event of accidents so as thereto safety of the passengers are getting to be ensured. Some accidents case figures Nowadays there is few international regulation providing protection for the bus drivers in case of frontal collisions. Based on the technical analysis of real bus head on impacts this paper tries to collect the major issues which may help to develop international regulations in this subject

Fig 1

Fig 2

Fig 3

A. Scope and Objective

After studying the results and the stress pattern on the bus, benefits of Frontal Crash Analysis using FEA analysis in ANSYS as under:-

Critical/Weak members are strengthened to increase the strength of structure.

- Safety of the Driver/Co-Driver/Passengers.
- Time saving.
- Cost saving.
- Reduction in number testing vehicle.

- Design change suggestion to design team as per analysis report.

II. METHODOLGY

Crashworthiness and safety of the paratransit bus shall be assessed by either:

- Simulation by Using Explicit dynamic Analysis tool
- Numerical analysis.

Both methods are considered equivalent and either one may be selected by the bus manufacturer for the bus approval. The paratransit bus is considered to be crashworthy and safe if it's residual space.

Explicit Dynamic Analysis

Explicit uses explicit time integration to solve the equations of motion. It solves short-duration problems with complex material response yet makes it easy to set up a problem with minimum input and effort. Explicit simply handles the retort of materials from impacts, high pressures, and other forms of loading that result in distortion, failure and destruction.

In nonlinear implicit analysis, solution of each step requires a series of trial solutions (iterations) to establish equilibrium within a certain tolerance. In explicit study, no iteration is Obligatory as the nodal accelerations are resolved directly.

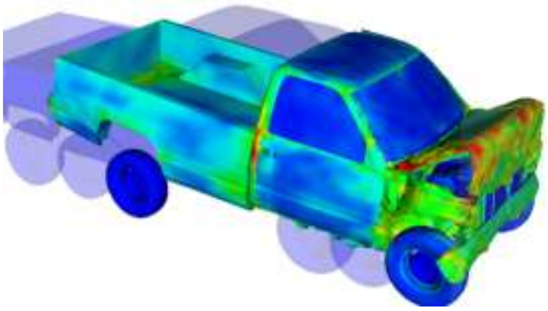


Fig 4

A. *Filed Study.*

To understand the more level collision effects on the frontal accidents of Volvo B9R so made visit to accident location which is took place in 2016. Which is in Haveri District NH4 highway 350 km away from Bangalore. Figure below.

Fig 5

Fig 6

Fig 7

B. *CAD Design.*

Developed VOLVO B9R Model using CREO 3.0.

In proposed Research project developed a CAD model by using CREO 3.0 software were all the dimensions are considered from the Original model of VOLVO B9R in 1:1.

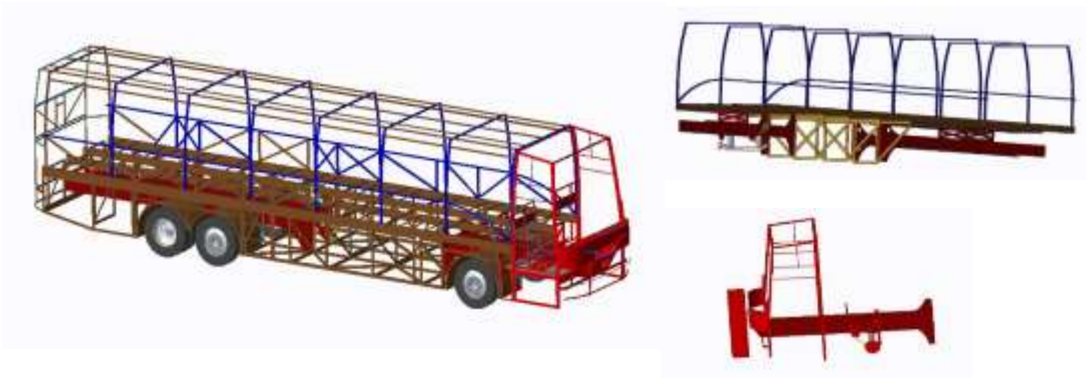
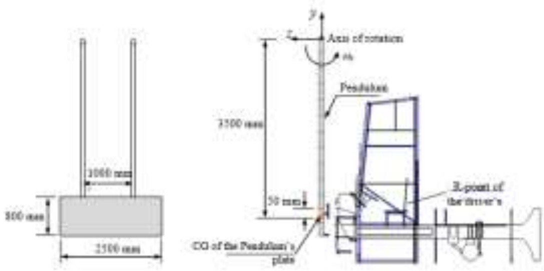


Fig 8

In bus frontal collision, the driving force safety is illustrated to two opposite effects: deformation of driver compartment measured by intrusion; and swiftness felt by the driving force measured by the amplitude and time period of the crash pulse the utilization of parts capable of buckling in an exceedingly controlled progressive folding pattern is employed as a mean to enhance crashworthiness for vehicle resident protection in traveler cars. Thin-walled steel tubes collapsing underneath axial crushing may be as energy absorbers, most ordinarily exist as either sq. or circular cross sections. The unskillfulness in style causes the frontal longitudinal tubes to collapse in an exceedingly bending mode instead of progressive axial crushing.

C. *International Standard for Safety*

According to front impact test in ECE R29, for vehicles with a gross vehicle mass exceeding 7.5 tons, the pendulum impact energy of 55 kJ must be applied. The pendulum has a striking surface of 2500 mm x 800 mm, and is made of steel with evenly distributed mass of at least 1500 kg. The pendulum is suspended by two rigid beams of 1000 mm apart and not less than 3500 mm long from the axis of suspension to the geometric center of the impactor. Its striking surface shall be in contact with the foremost part of the vehicle and the vertical position of the pendulum's center of gravity (H-point) is 50 + 5/-0 mm below the R-point of the driver's seat. To meet the requirement, there should be no contact between the driver manikin and the non- resilient parts of the bus structure after the impact.



Frontal impact test according to ECE-R29

Fig 9

The impact angular velocity, ω can be calculated by the applied impact energy E, as

$$E = \frac{1}{2} I_{xx}\omega^2$$

where Ixx (= Ixc +mL2) is the equivalent mass moment of inertia about x-axis at the pendulum pivot, Ixc is the mass moment of inertia about xc-axis passing through the H- point, m is the pendulum mass and L is the distance between the pivot and the H-point.

III. Analysis of Baseline Design

The frontal crash analysis of the complete baseline bus structure is first simulated to research crashworthiness of the bus in keeping with ECE-R29 and determine the components of the structure wherever strengthening or modifications square measure needed to satisfy the regulation. The finite component model includes 3 parts: the bus body,the apparatus impact or and therefore the driver dummy.

The baseline bus body is a high-decker bus of

- 2.52 m width,
- 14.5 m length and
- 3.25 m height.

The bus frames are made of steel with rectangular cross section of

- 50x25x2.3 mm and 50x50x2.3 mm.
- The material density is 7,860 kg/m3,
- elastic modulus is 210 GPa and
-
- Poisson's ratio is 0.3

The chassis and the front bumper is made of structural steel with

- yield strength is 370 MPa
- ultimate strength is 540 MPa

The total weight of the bus structure is 25 tons. The front parts of the bus body are meshed with linear S4R shell elements while the rear parts are modelled with 11,381 beam elements as depicted. The mesh size is chosen to be 5 to 25 mm where the deformations are large whereas the 60-mm element size is applied farther away from the impact location. The boundary conditions are according to the actual test specified in the regulation.

A. *Impact Load Calculation.*

Total Load distribution on the frontal surface of the bus

Height of the bus: 2885 mm

Total weight applying on the surface: 7812500 Newton's

Load distribution $= \frac{weight}{Area} = \frac{W}{l \times w} = \frac{7812500}{2885 \times 800} = 3.3849$ N/mm^2

Let's consider weight applying width 25mm and length is 800mm

= w x l x load

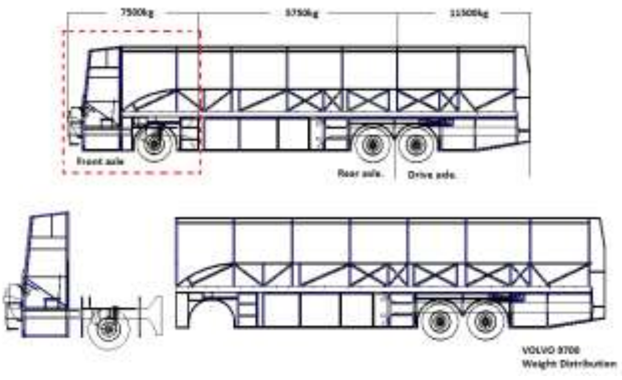


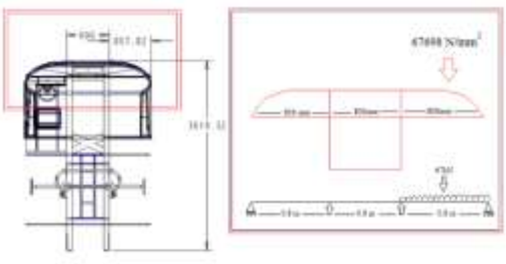
Fig10

= 25 x 800 x 3.3849

= 67680 N/mm^2

As we can noticed that when a 25000 kg mass of bus with speed of 90km/hr collides to a stationary object which causes heavy impact load and that is 3.3849 N/mm^2 on to the surface of the frontal collision.

B. Side Impact load Test(Structural Analysis)



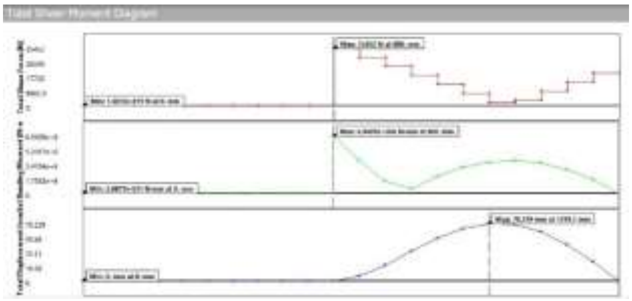


Fig 11Fig 12

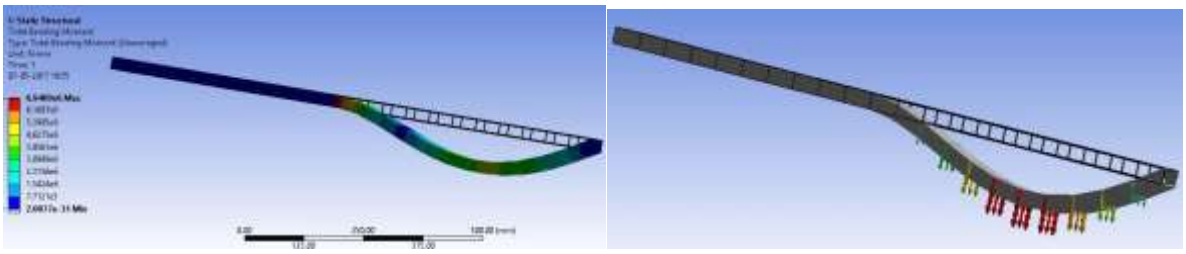


Fig 13

Enhancement New design

To reduce the impact load on Collison occurrence the following design is developed on the basis earlier Static and Dynamic test. Design is made up of Stainless steel is recommended for the roller to support extensive absorption capacity when collision occurs it absorb energy and redirect to the other direction.

C. Design Specification

To reduce the impact load on Collison occurrence the following design is adopted on the basis earlier Static and Dynamic test. Design is made up of Stainless steel recommended for the roller to support extensive absorption capacity when sudden collision occurs it absorb energy and redirect to the other direction. The Proposed safety component design is consisted with Roller, The supporting plate is made of steel. As the Collison occurs the safety barrier component is absorbs the energy and deviates the direction. And hence it produces a less impact on the Frontal portion and Driver cabin could get less damage

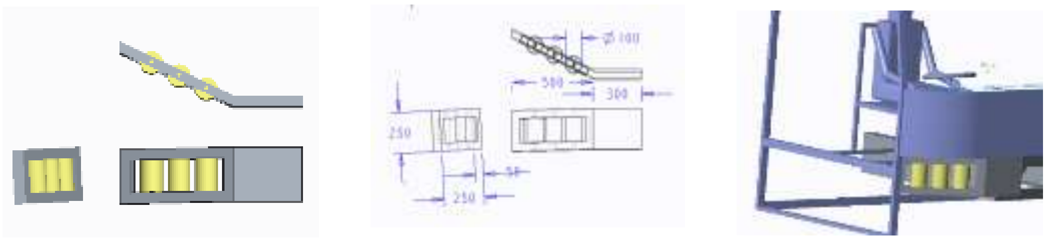


Fig 14

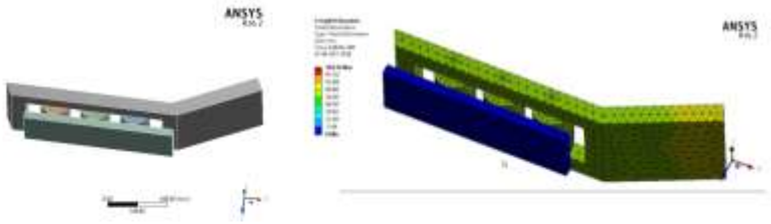
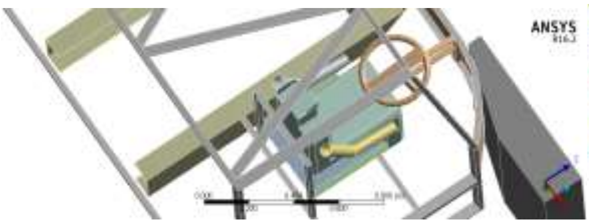
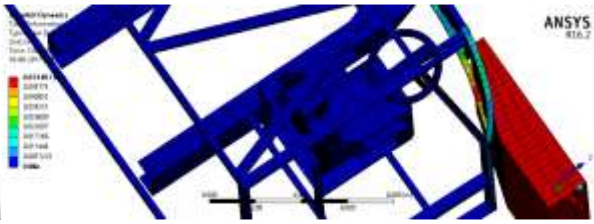


Fig 15 , Basic & Simulation design .

D. Base Model Front Frame crash Analysis.

Base Model Front Frame Crash analysis using explicit tool: Object is stationary and the vehicle is at the velocity of 70m/s since the mass of the frame is 1450kg so it unable to produce enough strength for deformation.

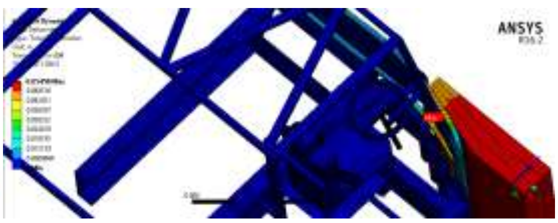




Front Frame Design Fig 16Explicit Simulation design 17

E. New Design Model Front Frame Crash Analysis.

In Design 1 model the frame is attached with Roller support. The collision effects is deviate after the effect. And it also Two part of safety Design component is added at the below the steering wheel bottom of the Front face of the Bus.



Frame Design Fig 18Explicit Simulation Fig 19

The Different testing are featured as below.

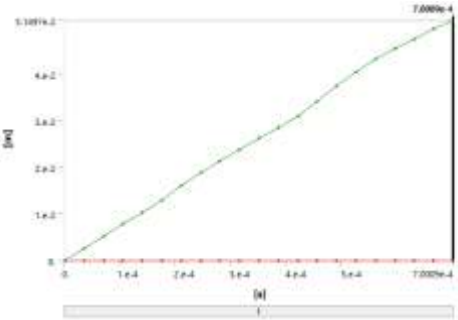
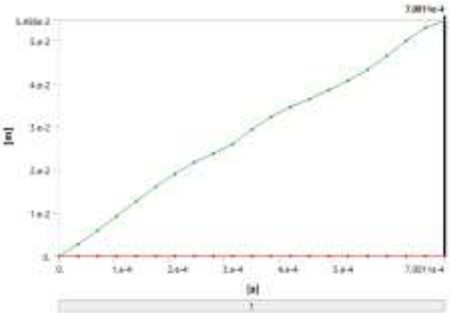
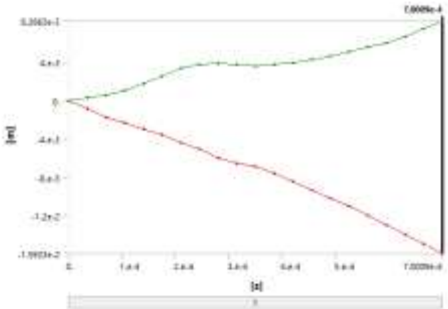
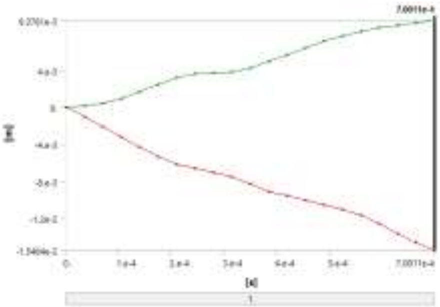
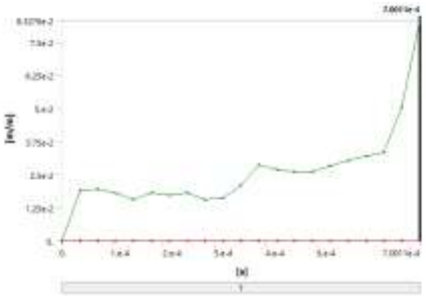
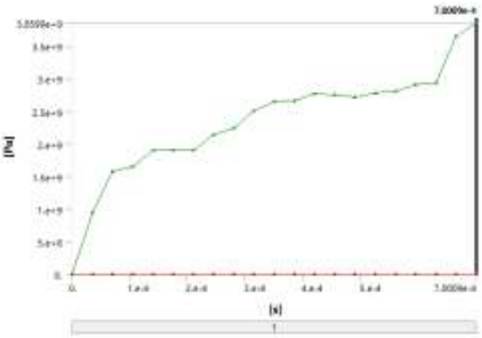
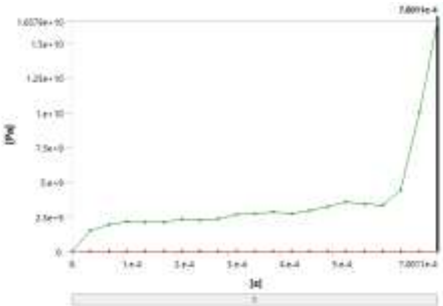
	New Design	Base Design
Total Deformation	5.1497e-002m 	5.458e-002m 
Directional Deformation	8.2863e-003m 	9.3761e-003m 
Vo-Mises Equivalent Elastic Strain	3.0894e-002 mm 	8.3276e-002 mm 
Von-Mises Equivalent Stress	3.85 Gpa 	16.57 GPa 

Fig 20

CONCLUSION

- The baseline design was tested numerically based on the ECER29 regulation for bus cabin. The reason behind this to improve the regulation, In terms of the safety of the driver and crew. In case of frontal Collison, The pendulum is tested numerically in form of Explicit Dynamic with force effect of 70m/s .
- Analysis shows that baseline design does not satisfies the requirement for ECE R29. Modification is adopted and design have been made In order to satisfy the requirement. Global buckling absorbed in some of the axial profile direction of crush during the impact which was the main reason for penetration to the survival space.
- It Is also absorbed that after specifying the boundary condition with Base model and improved design model the Total deformation was Decreased from 5.458e-002m/s and 5.1497e-002m/s respectively from with time frame of 7.0011e-004. Equivalent stress Decreased from 16.570 GPa to 3.85 GPa respectively.
- The Stiffness of these profiles was increased by design changes in order to prevent buckling. Weak parts of the front body were strengthen by making the roller solid frame model. Along with these improvements in the structure of the front body, designs were adopted to the structure.
- The bus drivers have a vulnerable position within the DC, one of the buses is concerned in a very partial head on impact. International regulation is required to safeguard the seriously vulnerable drivers.
- The approval tests is also derived from the quality accident things. 3 reasonably (independent) approval checks appear to be required to resolve this problem: one general setup impact test, one pole-like intrusion check and one check on the “soft part” of the DC. These last 2 checks may well be static loading test.
- The energy conditions of the approval tests (e.g. energy input, made by the pendulum, energy to be absorbed by the DC, etc.) additionally be also derived from the accepted standard accidents.”

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