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Rollover Analysis of Bus Body to Meet AIS-052 regulations and Optimization of the Body

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Abstract
A rollover accident is one of the most crucial hazards for the safety of passengers and the crew riding in a bus. In the past years it was observed after the accidents that the deforming body structure seriously threatens the lives of the passengers, thus th rollover strength has become an important issue for bus and coach manufacturer.
This project presents the modeling of a bus superstructure and its strength analysis and evaluates the requirements of Regulation No. AIS-052 using the finite element method, with consideration of materials and geometry. The analysis includes a strength test simulation in the form of a rollover test, which was performed in accordance with the requirements specified in AIS standards set by ARAI. Regulation No. AIS-052(031).

Keywords: *rollover test, strength analysis, AIS standards.*

1. Introduction

Our society's increasing requirements for mobility with simultaneously growing environmental sensitivity is a big challenge for the traffic policy makers and the transport corporations including private fleet operators. Consequently, it is also indispensable for the manufacturers of light and heavy passenger vehicles and the body builders to adapt to the ecologically motivated requirements, which becomes more and more important without compromising on basic minimum requirements of safety and comfort. The CMVR(Central Motor Vehicle Rule) – Technical Standing Committee under the then Chairman Shri B. Bhanot, addressed the problem areas and the whole exercise was aimed towards standardizing the essential aspects involved in the construction of the bus body considering the minimum requirements of Safety and Comfort for a passenger.

In most parts of the world, especially in Europe, safety requirements are continuously visited to improve passenger safety in buses or coaches. Since there are many seriously wounded passengers in traffic accidents of buses, more careful analysis and simulation for impact accidents should be investigated. Distribution of fatal crashes by crash type is indicated in figure 1.

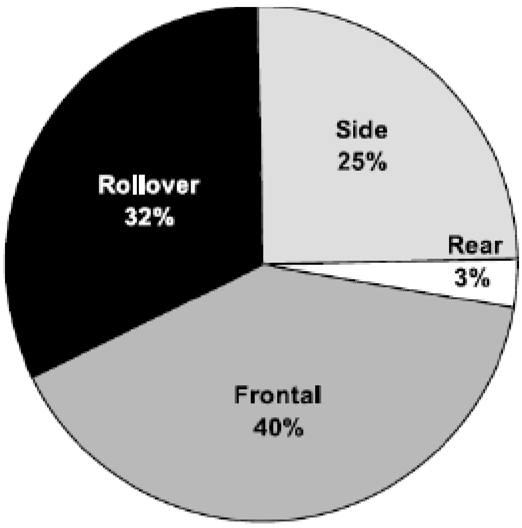

Fig.1 Distribution of fatal crashes by crash type [3]

To define the required protection level for all bus categories, to specify the same (similar, equivalent) safety for all kind of bus occupants, at least the following questions should be analyzed and answered:
During a bus or coach rollover, the occupant will have a larger distance from the center of rotation as compared to that of a car occupant. For this reason, the Automotive Industrial Standard (AIS 031) titled "Resistance of the Superstructure of Oversized Vehicles for Passenger Transportation" has been in force to prevent catastrophic consequences during rollover accidents, thereby ensuring the safety of bus and coach passengers. The specifications of rollover test are given in figure 2.

a) In which kind of rollover accidents (group of accidents) shall be the bus occupants protected? The protection generally means to provide high level probability of survival and to reduce the casualty risk.
b) What are the general requirements to protect bus occupants, to provide the required safety level?
c) How to specify the requirements of the approval (approval test) for all bus categories?

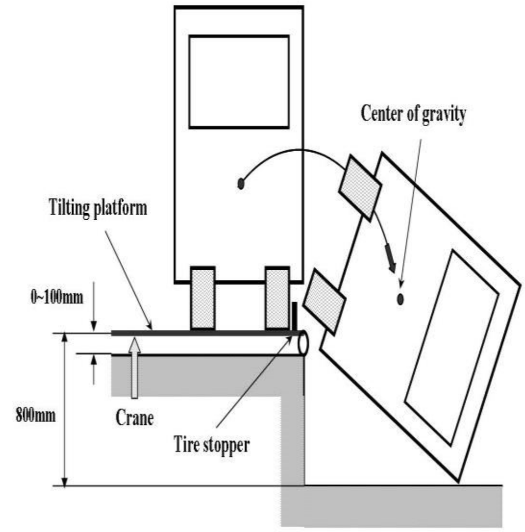

Fig2. Specifications of the rollover test[5]

2. Literature Survey

Hee-Young Ko, Kwang-Bok Shin, Kwang- Woo Jeon(2009) conducted Material tests to determine the input parameters of the composite laminate facesheet model and the effective equivalent damage model for the orthotropic honeycomb core material. Crashworthiness and rollover analysis of the low-floor bus was conducted using the explicit finite element method (FEM) analysis code LS-DYNA3D with the lapse of time. The crash condition of the low-floor bus was a frontal accident with a speed of 60 km/h. Rollover analysis was done according to the safety rules of the European standards (ECE-R66). The angular and translation velocity and its angle with the ground just before impact for rollover were calculated using the dynamic analysis program. The results showed that the survival spaces for the driver and passengers were secured against frontal crashworthiness and rollover of the low-floor bus. In addition, the modified Chang-Chang failure criterion is recommended to predict the failure modes of the composite structures for crashworthiness and rollover analysis. This paper discussed the results of the numerical simulation on crashworthiness and rollover characteristics of the low-floor bus.

Ignacio Iturrioz(2009) presented in paper a proposal of methodology for a structural optimization, applying Genetic Algorithm, of a bus rollover. The simplified finite elements model of the bus is constructed with beam elements and, in places with localized large plastic deformation, plastic hinges are added to the structure. Experimental and numerical methods are used to determine the plastic hinge properties. With this numerical model of the bus rollover, parameters are extracted to compose the different proposals of objective functions and, thus, diverse optimized projects are analyzed, aiming to find the optimum project for each study.

Sandor Vincze(2010) described the first full-scale roll-over tests of coaches and buses, in Europe, have been started at the beginning of 70's in Hungary. Later in 1986, the European Committee of Economy has accepted and issued a new regulation related to the bus and coach superstructures' strength. The previous methods and all the four test methods, accepted in the ECE R66, are discussed technically and critically in his paper.

3. Objective

The objective is to design a robust bus body structure y and to perform finite element analysis (FEA) of the model, to obtain the deformations at different pillars of bus body. And hence by doing satisfactory design change the optimization is to be done to obtain satisfactory results for passenger safety.

4. Finite Element Modeling

4.1 Preprocessing

Computational vehicle models need to capture the deformation and interaction of vehicle parts and subsystems occurring during impact. The accuracy with which the crash behavior of a vehicle is simulated depends on the quality of the computer aided design (CAD) data and its meshing. CAD geometry should be accurate in shape and size to resemble the actual vehicle. The FEM mesh should be dense enough to ensure computational convergence and to keep the computational time reasonably low.

For meshing purposes, HyperMesh software was used. HyperMesh is a high performance finite element pre- and post-processor that allows building finite element models, views their results, and performs data analysis. Figure 3 indicates finte element modeling process. These CAD models of the bus were provided by the local bus manufacturing company. Then models were called into the HyperMesh. First mid-surfaces were extracted from these models. Then geometry cleaning was done by using options like "geom cleanup" and "defeature" to modify the geometry data and prepare it for meshing operations.

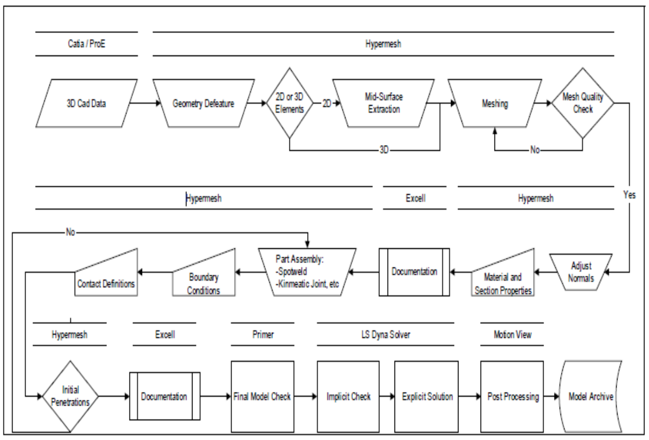

Fig 3. FE modeling process [3]

This process involved deletion of holes and curvatures of a very small radius (less than 5 mm), which have less structural significance. The geometries with holes were always difficult to mesh, because they distort mesh generation. Holes with a radius of more than 5 mm were meshed by surrounding it with minimum six elements. Very small parts, like nut-bolts, also were removed from the geometry, and then spot-welds were created in their places to represent bolts, rivets, and welds.

The figure 4 shows the side view of meshed structure satisfying all meshing criteria to ensure quality of work, to obtain precise results.

Fig4. Meshing of Bus Body Data (side view)

4.2. Load Application on Bus Body

The various loads are to be acting on bus body, while rollover accident. These forces are needed to be applied on CAD model. By obtaining data from customer requirement, to test load bearing capacity of bus body structure, various loads are supplied in system on CAD model. 1 KN of force is acted on body, which is shown in figure 5 as shown; 1kN Force is applied perpendicular to the parts through the ram with the help of RBE2 elements.

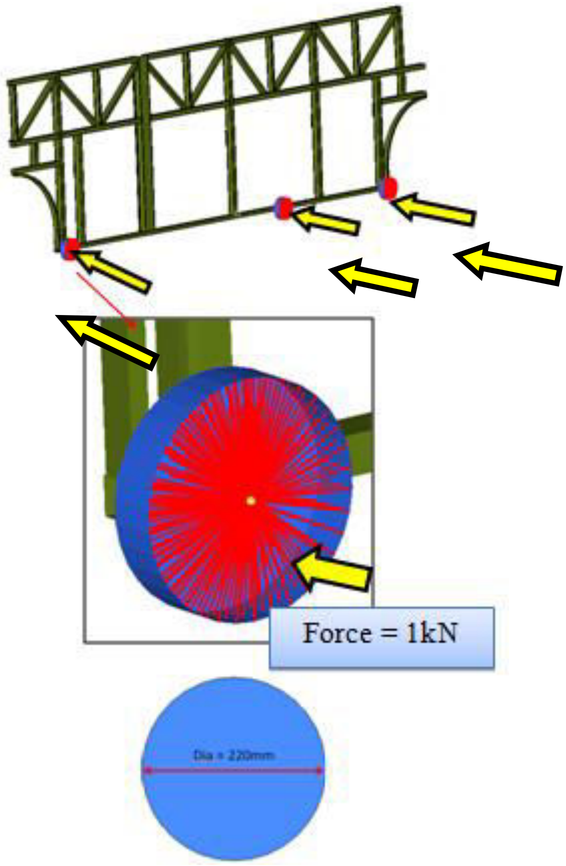

Fig5. Loading Conditions

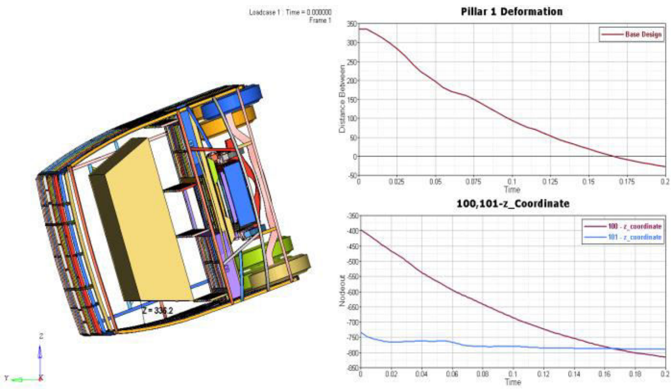

Fig6. Deformation of pillar (Base Model)

5. Results & Discussion

Base model is checked for deformations by using LSDYNA software at different pillars of bus body, as represented in figure 6. The graph is plotted for y axis as defrmation of pillar and on X axis as time. It is observed that our model is not fulfilling our strength requirements. And hence there are some design changes need to be done.

The design change is proposed with the addition of C brackets to roof bars, to add more strength to bus body structure as indicated in figure 7. The structure with additional C brackets is again checked for deformations of pillars of bus body as indicated in figure 8, here no part of structure in introducing into residual space, and hence we are satisfying our safety requirement.

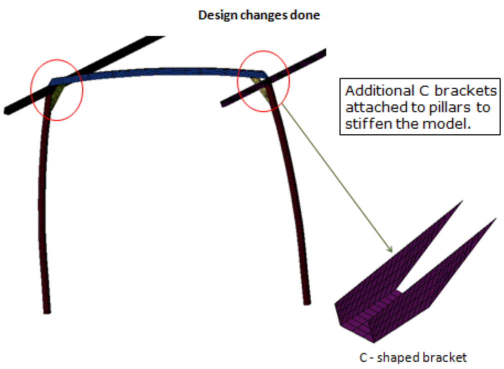

Fig7. C-brackets

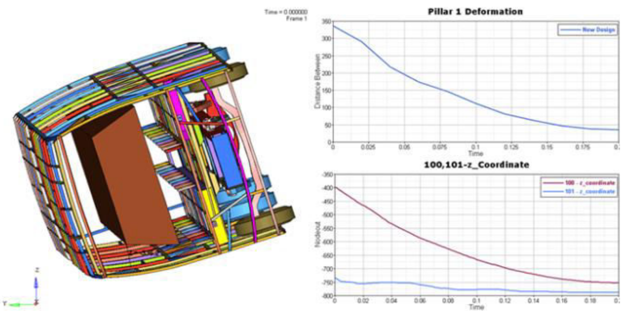

Fig8. Deformation of pillar (Stiffed model)

6.1 Deformation Comparison

Deformations are compared as indicated in figure 9. Same deformation study is carried out for different pillers. For this iteration we meet our requirment i.e. that the pillars are not getting introduced in occupant space (residual space) of bus body.

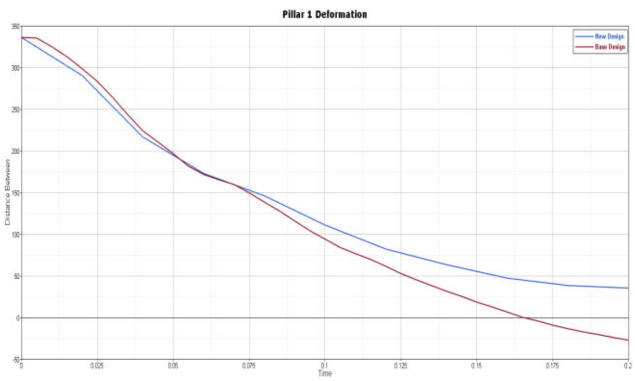

Fig9. Comparison of Deformation of pillar

Conclusions

1) The strong A and B pillar ring is the most important component of robust roof strength.
2) All the Components and systems of the vehicle must be well designed to absorb or distribute the energy of roof crush in order to prevent intrusion into the occupants compartment.
3) The strength of all inner reinforcement parts in the front pillar is a core element that determines the vehicle's roof stiffness, while that of Each part around the door openings should be well connected as a circular linked structure with the high-density spot welded joint. (Examples – front roof rail, A&B pillar and front header)

References

[1]. C. C. Liang & G. N. Le, "Lightweight optimization of bus frame structure considering rollover safety" Vol. 2 1185.

[2]. Cezary Bojanowski , Bronislaw Gepner , Leslaw Kwasniewski Christopher Rawl,

Jerry Wekezer, "Roof Crush Resistance and Rollover Strengthof a Paratransit Bus", 8th European LS-DYNA® Users Conference, Strasbourg - May 2011.

[3]. D.A. Micu, M.D. Iozsa, Gh. Fraţila, "A Rollover Test Of Bus Body Sections Using Ansys" 24- 25 October 2013.

[4]. Ignacio Iturrioz, "Structural Optimization of a Bus in Rollover Conditions" 2009-36-0131.

[5]. K. Kang, H. Chun, W. Na, J. Park, J. Lee, I. Hwang, H. Hong "Optimum Design Of Composite Roll Bar For Improvement Of Bus Rollover Crashworthiness" Seoul, KoreaVol. 3 1282-2008.

[6]. Kadir Elitok, Dr. Mehmet A. Guler, Bertan Bayram, "An Investigation on the Roll-over Crashworthiness of an Intercity Coach, Influence of Seat Structure and Passenger Weight", Paper Number 13-0173.

[7]. Lu Yong, Jiang Kaiyong and Zhou Fangming, "Study on Key Technologies Based on the Bus Rollover Security" July 05, 2013.

[8]. Magnus Hult ,Scania Cv Ab Sweden, "R66 Ansa & Meta Toolbox For Bus Body Development" 5th ANSA & μETA International Conference.

[9]. Matyas Matolcsy, Scientific Society of Mechanical EngineersHungary "The Severity of Bus Rollover Accidents" Paper Number: 07 0989.

[10]. Mertcan Kaptanoglu, Ozgun Kuçuk "Rollover Crashworthiness Of A Multipurpose Coach" 26 - 27 Mayıs 2014, Bursa.