An Overview of Strength Improvement of a Bus Body Structure with Design Modifications

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Abstract— *In our society mobility requirements are increasing drastically with growing population and simultaneously environmental sensitivity is also increasing. Therefore it is making a big challenge for transport corporations of government and private operators to manage vehicles and traffic policy makers to handle them. Consequently, the light and heavy passenger vehicle manufacturers as well as vehicle body builders have to adopt new market requirements along with minimum basic safety of the passenger.*

To ensure strength of the bus body, all the bus body builders have to analyse their design in any one of the FEA (Finite Element Analysis) tool. With the help of FEA tool one can obtain accurate results of strength of design in less time. In this paper overviews of various works are done. This paper tries to give an idea about the previous researches and their finding about study of design of bus body structure to improve strength.

Keywords— Bus Body Structure, FEA, Strength Improvement, Vehicle Body Builders

1. INTRODUCTION

India's one of the largest government passenger transport corporation is Maharashtra State Road Transport Corporation (MSRTC) operates a fleet of buses. MSRTC runs approximately 23,500 number of buses in 18,700 routes, carrying 7 million passengers on daily basis. All these buses are manufactured at MSRTC's in-house workshops at Aurangabad, Nagpur and Dapodi, which include different type of busses i.e. ordinary bus, city bus, Asiad and Parivartan on Ashok Leyland and TATA chassis. An average of 2000 number of buses will be manufactured per year. This corporation has 32 divisional workshops and 9 tyre retreading plants.

The body structure of the bus is designed, manufactured and assembled on the chassis with fixed joints in the central workshop of the corporation situated in Dapodi of Pune district. The important aim of this assembly plant is, every bus must withstand all load conditions with safety of the passenger.

The project includes detailed design, development and analysis of the body structure of bus. According to AIS code, performance parameters have to be followed by the bus body builders to ensure required strength. To ensure strength of the bus body, all the bus body builders have to analyse their design in any one of the FEA (Finite Element Analysis) tool. With the help of FEA tool one can obtain accurate results of strength of design in less time. As notified in Rule number 126 of the CMVR 1989, all bus body builders have to use anyone of the FEA tools by themselves or with authorized test agencies to verify the strength.

2. A METHODOLOGY FOR REPLACEMENT OF CONVENTIONAL STEEL BY MICROALLOYED STEEL IN BUS TUBULAR STRUCTURES

Magnus Cruz, et al. [1], published a paper on "A Methodology for Replacement of Conventional Steel by Microalloyed Steel in Bus Tubular Structures". Authors used HSLA (Structural Micro Alloyed Steel) instead of conventional type of steel in a vehicles used for passenger transport of more than 20 people capacity, tubular structures. They used simple type of tests and specific tools in finite element type of analysis for the new material used. Therefore time required for the test and analysis was very less and the designer can optimise the material and replacement time of the component. The validation of the methodology is based on the ECE R66-00 regulation and on the Brazilian CONTRAN 811/96 resolution, which regulate minimal conditions of safety for this kind of vehicle. The methodology has four sequential and dependent stages, where the main focus is related to the experimental tests through the models that are simplified initially for later calibration using finite element method. Modular structures made of two different materials were tested and analyzed to confirm the present methodology, first the structure made of steel that is used by the bus industry in Brazil was tested and then it was compared with the new microalloyed steel. Experimental values are compared with calculated ones, foreseeing parametric optimisation and keeping the security levels according to legislation.

3. STRENGTH ANALYSIS OF BUS SUPERSTRUCTURE ACCORDING TO REGULATION NO. 66 OF UN/ECE

J. Karliinski, et al. [2], studied “Strength Analysis of Bus Superstructure According to Regulation No. 66 of UN/ECE”. They considered nonlinearity of the material and their geometry and analysed for a bus super-structure model using a finite element analysis software to find the strength of the materials. This was done to evaluate regulation No. 66. The strength was found for the roll-over test. The values of rules and FEA results were compared to validation. To test this vehicle will be placed on a platform and the platform is tilted to roll the vehicle and fall on a surface of concrete, which is as shown in Figure 1.

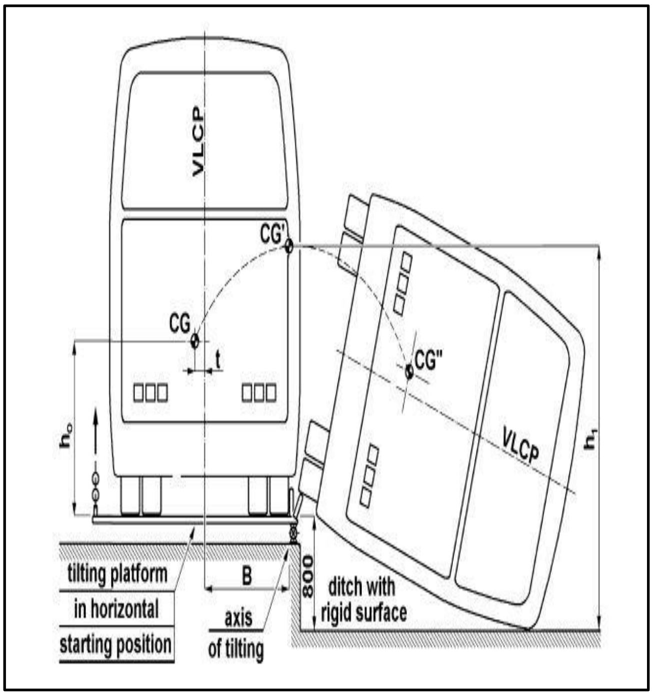

Fig-1: Roll-Over Test

4. METHODOLOGY FOR BUS STRUCTURE TORSION STIFFNESS AND NATURAL VIBRATION FREQUENCY PREDICTION BASED ON A DIMENSIONAL ANALYSIS APPROACH

A. Gauchia, et al. [3] published a paper on “Methodology for Bus Structure Torsion Stiffness and Natural Vibration Frequency Prediction Based on a Dimensional Analysis Approach”. They studied that engineering bus design requires testing of bus structures prototypes in order to guarantee a certain level of strength and an appropriate static and dynamic behavior of the bus superstructure when exposed to road loads. But, experimental testing of real bus structures is very expensive as it requires expensive resources and space and if testing was done on a scale bus model the previous required expenses are considerably reduced. Therefore, they proposed a novel methodology based on dimensional analysis applied to bus structure prediction to evaluate the bus structure static and dynamic performance. The static performance is evaluated attending to torsion stiffness and the dynamic in terms of the natural vibration frequencies and rollover threshold. A scale bus has been manufactured and dimensionless parameters have been defined in order to project the results obtained in the scale bus model to a larger model. Finally, Validation of this proposed methodology has been carried out under experimental and finite element analysis.

5. THE STUDY OF BUS SUPERSTRUCTURE STRENGTH BASED ON ROLLOVER TEST USING BODY SECTIONS

Guosheng Zhang, et al. [4], studied "The Study of Bus Superstructure Strength Based on Rollover Test Using Body Sections". In this study they took a full load bus as the research object, the finite element analysis theory was applied to build the finite element model of the bus and the numerical simulation environment of the structural strength of the superstructure. According to the ECE R66 equivalent authentication method, they calculated gravity center position of the bus and the rollover test of bus body section is carried out. The deformation of the superstructure and its invasion to residual space of passengers were evaluated. After comparing the rollover test result with the numerical simulation result, they found that there is a good agreement between the two results. On this basis, the energy-absorbing situation of the side wall pillars during the rollover process is studied and evaluated. The results show that the body section of bus is complied with the regulatory requirements; its structural safety characteristic is good. This design method of the rollover crash safety has important significance to research and development of manufacturer.

6. DYNAMIC STRESS ANALYSIS OF A BUS SYSTEMS

H. S. Kim, et al. [5], published paper on "Dynamic Stress Analysis of a Bus Systems". They presented the effective method for dynamic stress analysis of structural components of bus systems or general mechanical systems. The proposed method is the hybrid superposition method that combined finite element static and eigenvalue analysis with flexible multibody dynamic analysis. In the stress recovery, dynamic stresses are calculated through sum of pseudostatic stresses and modal acceleration stresses, which are obtained by applying the principle of linear superposition to the modal acceleration method. This proposed method is more effective than conventional methods, that is, the mode displacement method or the mode acceleration method. Numerical example of bus systems estimates the efficiency and accuracy of the proposed method.

7. COMPUTATIONAL ANALYSIS OF INTERCITY BUS WITH IMPROVED AESTHETICS AND AERODYNAMIC PERFORMANCE ON INDIAN ROADS

Sachin Thorat, et al. [6], published paper on "Computational Analysis of Intercity Bus with Improved Aesthetics and Aerodynamic Performance on Indian Roads". In this work emphasis is given on the redesign of an intercity bus with enhanced exterior styling reduced aerodynamic drag and increased comfort for the passengers. They carried out Extensive product study and market study. Existing intercity bus is benchmarked and analyzed for styling, aerodynamic performance and comfort. Fluent, a CFD code is used to evaluate the aerodynamic performance. They used principles of product design to analyze the styling and comfort. The benchmarked high- floor bus is redesigned with low - floor for reduced aerodynamic drag. The exterior of the chosen bus is redesigned with emphasis on improvised aerodynamic performance and appealing looks. The interior was modified to meet aspirations of the commuters. The results of the redesigned exterior body showed a reduction of Cd from 0.581 to 0.41 at a speed of 100 km/hr and overall aerodynamic drag reduction by about 30% due to combined effect of reduced Cd and frontal area.

8. TRIZ METHOD FOR LIGHT WEIGHT BUS BODY STRUCTURE DESIGN

Suthep Butdee, et al. [7], published a paper on "TRIZ Method for Light Weight Bus Body Structure Design". Their purpose of the work is the generalization of available data on averting and using the thermal deformations in the technology, the analysis of the methods of compensating the thermal deformations with the use of tools TRIZ (Principles, Contradictions, Su-Field analysis, Trends of Development); the determination of the promising tendencies in region (in accordance with the Trends of the Development of Technical Systems). TRIZ methodology is employed to assist the way to get new drawing which is used to resolve the contradictions. The 40 engineering principles are also used as the design guideline. In order to ensure that the trusts, the components of the frame, remains as the new bus body structure frame is sufficient strong, the FE method is used to validate the strength of the new body design based on the material property selection. Individual frame analysis is implemented. TRIZ is a problem solving method based on logic and data, not intuition, which accelerates the project team's ability to solve these problems creatively. TRIZ also provides repeatability, predictability, and reliability due to its structure and algorithmic approach. TRIZ is the (Russian) acronym for the, Theory of Inventive Problem Solving. TRIZ is an international science of creativity that relies on the study of the pattern of problems and solutions, not on the spontaneous and intuitive creativity of individuals or groups. TRIZ principle and parameters are applied to assist a light weight bus body design which is compared to the existing design. The bus body model is created by CAD and transfer data to CAE using FE analysis. The weight reduction process is then followed up from the analysis. The new light weight bus body design is tested by the same method of FE analysis. The same result of body strength is accepted and can use for design and manufacturing. Tested TRIZ method can save material used, production cost and time.

9. A NEW DESIGN AND ANALYSIS OF BUS BODY STRUCTURE

Prasannapriya Chinta, et al. [8], published a paper on "A New Design and Analysis of BUS Body Structure". In this paper they proposed a new method for designing a bus body. Structure is designed and modeled in 3D modeling software Pro/Engineer. They redesigned the original body 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. They replaced this material 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. Finally Analysis is done in Ansys. They observed the analysis results and the displacement and stress values obtained are within the limits for the modified model. By using composite materials also, the stress values are within the limits, and strength of the composite materials is more. So they concluded that by reducing the thickness and also using composite materials yields better results than original model and conventional steel.

10. CONCLUSION

From the literature survey it is seen that the strength improvement of a bus body structure has been a hot research topic for many researchers, due to its important role in adoption of new market requirements along with minimum basic safety of the passenger. The researchers started from developing theories related to general behavior of bus body structure and further moving to implementing the optimizing various parameters according to their application. In order to improve the strength of bus body structure it is necessary to optimize the design space and weight to effectiveness ratio to get better realistic results.

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