Rollover Analysis of Heavy Vehicle Bus

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Abstract. Rollover is motor vehicle accident that occurs when vehicle is tipping over onto its side or roof. Due to its fatality rate, the Malaysian government reinforced an Economic Commission for Europe of the United Nations (UN/ECE) Regulation no. 66 (R66) upon bus construction. This is to prevent the catastrophic consequences of rollover accidents. The R66 regulation provides an option of certification based on full-scale vehicle testing that maintaining the survival space. Therefore research that contribute to the development of safe transportation vehicle under rollover is really important. The physical prototype of rollover test can be simplified using simulation model. Using this motivation, the characteristic of heavy vehicle rollover is investigated in this paper. The simulation was performed using ANSYS simulation tool and simplified by locating the position of the bus in unstable equilibrium, just before it hit the ground. Another method is to perform a quasi-static loading test. The quasi-static simulation test was performed using impact load that directed towards the side of beam around the centre of frame body. The dynamic response due to rollover impact was determined using an Explicit Dynamic Analysis in ANSYS. The stress maximum stress first developed around the impact area before lag the stress stream to the opposite side. It can be observed that the maximum stress point is located at the middle structure of impact side. After few times of impact, the maximum stress starts to changes to the opposite side. Quasi-static simulation result in higher total deformation on impact side area. It also indicates high maximum stress point around the middle structure.

Introduction

Rollover is the most dangerous heavy vehicle accident [1]. Statistics show that the average casualty rate is 25 victims per accident. Failure of the side and roof vehicle structures to sustain the passenger safety compartment can cause severe and fatal injuries to the trapped occupant inside. Statistics related to rollover impact from all around the word excluding Europe is 11% accident rate before year of 2001, 38% from 2001 to 2003 and 49% from 2004 to 2006. Vehicle crashes involving lorries and buses in Malaysia is 22.4% and 7.9% from the total accident around 2007 till 2010 respectively [2]. 11.1% of bus accident is caused by the factor of superstructure under rollover with highest percentage of fatalities occurrence (60%) [3]. The rollover test approach normally involve the lateral tilting test [4]. It is performed by locating a simplified vehicle on the tilting platform, with blocked suspension. The vehicle is lifted slowly to its unstable equilibrium position. This test can be further simplified by positioning the vehicle in unstable equilibrium at point of rollover. The contact position is set very close to the ground as depicted by Fig. 1. In quasi-static loading test, the load that applies to the beam around the body section is derived from the mass of the structural bays and elements that connecting them as shown in Fig. 2.
Rollover Simulation Model

The simulation process involved nine main stages as shown in Fig. 3. Two simulation tests were performed using ANSYS simulation tool referring to R66 [5]. The bus frame components is divided into several parts to process the results easily. R-side structure refers to impact side area, L-side refers to opposite side of impact, roof refers to top of the bus, and middle is the critical position as the frame needs to maintain the survival space.

Results and Discussion

The simulation results indicate a variation of negative plastic strain around the frame at the early stage of impact. The non-linear trend was consistent due to unstable distribution of impact. The rollover test simulation shows that R-side of structure deform towards the concrete surface, L-side deform towards the impact point, the roof structure deform outwards, away from bus occupant as shown in Fig. 4. The deformation behaviour of frame structure undergoing quasi-static loading test is depicted by Fig. 5. It can be observed that R-side deform towards the inner compartment, L-side deforms away from occupant space and the roof deformation follows the direction of impact from right to left. Fig. 6 shows that the maximum stress experienced by the middle frame of R-side structure, while the back compartment hit the maximum total deformation as shown in Fig. 7. During quasi-static load impact, the maximum stress measured around a middle structure of the bus frame, and the maximum total deformation occurs on the side impact of front compartment as shown in Figs. 8 and 9 respectively. It must be bear in mind that the quasi-static loading test was conducted by adopting a fixed support on the tire, hence provide a different result compared to basic rollover test that has no fixed rotation or displacement.
**Conclusion**

The rollover analysis of heavy vehicle bus was conducted in this paper by using an Explicit Dynamic Analysis of ANSYS 15.0 simulation tool. The method used in this paper can be adopted to model the actual full-scale superstructure bus. The provision of R66 approval testing related to
rollover strength of bus frame were considered. It can be observed from the rollover simulation test that the impact of vehicle rollover that hit a deformable ground can cause fatal accident of its occupants. A quasi-static simulation test was also performed. This alternative method is also capable of demonstrating the correct behaviour of rollover case as shown in basic rollover test simulation. This test provide small deformation and do not intrude towards the survival space. Therefore, the fixed support of the tire and the survival space body can be neglected during the analysis. The results from both simulation tests suggest the side of body framework requires further development with a superstructure shape to provide better protection for occupant.

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References


