IMPACT ON BUS SUPERSTRUCTURE DUE TO ROLLOVER

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ABSTRACT

Bus is a popular and common transport in the world. The safety of bus journey is a fundamental concern. The risk of injuries and fatalities is severe when the bus structure fails during a rollover accident. Adequate design and sufficient strength of the bus superstructure can reduce the number of injuries and fatalities. This study examines the deformation response of a typical bus structure during a rollover test simulation. A simplified box structure was modeled using finite element analysis software and simulated in a rollover condition according to the requirements of UNECE Regulation 66. The same box model was fabricated to validate the results obtained from finite element analysis simulation. After successful validation of the box model simulation, a complete bus structure with forty four passengers' capability was developed using finite element analysis software. The simulation of the bus was conducted using the same inputs used in box model simulation. Four simulations have been conducted to get the dimensions of different members of the superstructure of bus which is capable to protect rollover crash. The analysis suggested that, the failure of bus frame during rollover situation is basically dependent on the total mass of bus and on the strength of bus superstructure.

ABSTRAK

Diantara jenis-jenis pengangkutan awam , penggunaan bas awam telah menjadi pilihan dan penting di mata masyarakat dunia. Oleh kerana itu faktor keselamatan dari segi struktur bas berkenaan menjadi keperluan utama di dalam proses mereka bentuk sesebuah bas. Kebanyakkan kecederaan dan kemalangan maut berpunca daripada kegagalan struktur bas apabila kemalangan yang melibatkan bas berkenaan terbalik. Kajian ini adalah bertujuan meyelidik kekuatan rangka bas dalam meyediakan melindungi penumpang apabila kemalangan berlaku. Satu model keberkesanan telah diterbitkan menggunakan kaedah unsur terhingga dan simulasi model ini dilakukan mengikut piawai yang telah ditentukan oleh peraturan 66 UNECE. Model bas berkenaan telah dihasilkan di dalam makmal bagi menentu-sahkan analisis yang menggunakan kaedah unsur terhingga. Setelah berjaya proses menentu-sahkan analisis berkenaan, model simulasi bas dengan 44 penumpang telah dijalankan.Sebanyak 4 proses simulasi telah dijalankan untuk mendapatkan perihal atau kelakuan rangka bas yang pelbagai mengikut keadaan. Berdasarkan kajian ini, mendapati bahawa kegagalan sesuatu rangka bas apabila kemalangan melibatkan bas terbalik, adalah bergantung kepada jumlah berat tanggungan dan kekuatan rangka bas berkenaan.

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CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, highway traffic safety is a very important issue over the world. Everyday a noticeable number of vehicles are facing different types of accidents. Rollover is one of the severe types of accidents. Accidents due to rollover are very frequent over the world. Rollover fatalities have become a major safety issue. Most rollover crashes occur when a vehicle runs off the road or rotate sidewise on the road by a ditch, curb, soft soil, or other objects. Besides, the forward speed as well as the sideways speed of a vehicle causes rollover that greatly increases the extent of damage to the vehicle and its occupants during rollover.

Rollover accidents are also very common and frequent in Malaysia. In most of the rollover accidents of buses, its roof faces strong impact with the surface of road. However, this impact leads to collapse of bus roof causing severe injury to the occupants and extreme damage to the frame of bus. National Highway Traffic Safety Administration (NHTSA, 2002 b), USA, reported that only about 3% of all crashes are rollovers that caused 33% of total crash related deaths. This example clearly showed the severity of rollover crashes compared to other types of crashes.

Rollover may be of different types depending on the reasons that commence it. The definitions include the following factors:

(i) Trip-over: If the lateral motion of the vehicle is suddenly slowed or stopped, it increases the tendency to rollover of bus. The opposing force may be produced by a curb, pot-hole or pavement in which the bus wheels dig into.

Figure 1.1: Trip over of a vehicle on road surface.

(ii) Fall-over: This type of rollover occurs when the road surface, on which the bus is traveling, slopes downward in the direction of movement of the vehicle such that the center of gravity (c. g.) becomes outboard of its wheels (the distinction between this code and turn-over is a negative slope).

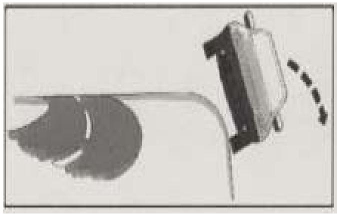

Figure 1.2: Fall over of vehicle out of road.

(iii) Flip-over: When a vehicle is rotated along its longitudinal axis by a ramp-like object such as a turned down guardrail or the back slope of a ditch. The vehicle may be in yaw when it comes in contact with a ramp-like object.

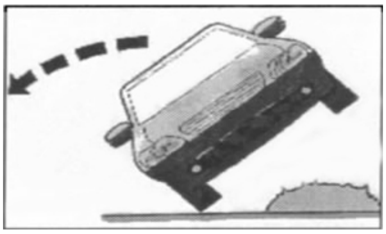

Figure 1.3: Flip over of vehicle on road surface.

(iv) Bounce-over: When a vehicle rebounds off a fixed object and overturns as a consequence. The rollover must occur in close proximity to the object from which it is deflected.

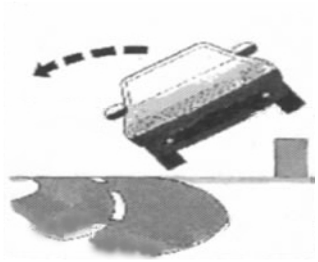

Figure 1.4: Bounce over of vehicle after facing impact sidewise.

(v) Turn-over: When centrifugal forces from a sharp turn or vehicle rotation is resisted by normal surface friction (most common for vehicle with higher distance between road surface and c. g.). The surface includes pavement surface and gravel, grass, dirt, etc. There is no furrowing and gouging at the point of impact. If rotation and/or surface friction causes a trip, the rollover is classified as a turn-over.

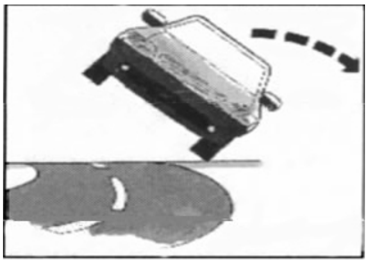

Figure 1.5: Turn over motion of vehicle.

(vi) Collision with another vehicle: when a vehicle impacts sidewise with another vehicle, it causes rollover. Mostly, rollover is the immediate result of an impact between two vehicles.

(vii) Climb-over: when vehicle climbs over a fixed object (e.g. guard rail, barrier) that is high enough to lift the vehicle completely off the ground, the vehicle must roll on the opposite side from which it approached the object.

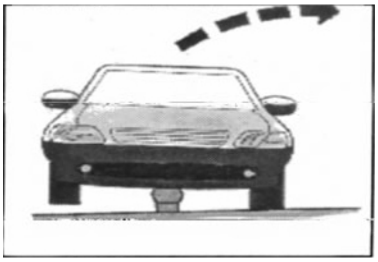

Figure 1.6: Climb over situation of vehicle.

(viii) End-over-end: when a vehicle rolls primarily about its lateral axis, i.e. the pitch motion of a vehicle is called end-over-end.

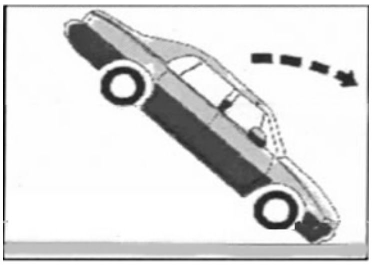

Figure 1.7: End-over-end motion of vehicle.

1.2 Problem Statement

Rollover crashes cause extreme damage to both of the occupants and to the bus frame in several ways. Firstly, when a bus faces rollover, its roof impacts with the surface of road. If the roof of bus is not enough strong to withstand that impact, it collapses and presses the occupants on the seats (Figure 1.8 and Figure 1.9). Secondly, if the roof of bus is too rigid to resist the force of impact, it does not collapse. However, the inertia of occupants produces high speed to them and presses them with the roof. In the second case, the extent and the number of injuries can be decreased by using seat belt with sufficient strength. In contrast, in the first case there is no way to protect occupants from serious injuries. Because if the roof of bus fails, then the occupants must be pressed on the seats.

Figure 1.8: The severe damage of bus after rollover accident (Courtesy of www.thestar.com.my).

Figure 1.9: The damage of a bus frame after rollover crash (Courtesy of www.thestar.com.my).

From the above discussion, it is clear that, the effect of rollover on the superstructure of bus and the detailed analysis of that is very important to decrease the extremity of damages on both of the occupants and the bus frame.

1.3 Objective of Study

The objective of the project includes the investigation of the effects of initial impact due to rollover of a bus on its frame according to UN-ECE Regulation 66. Initial impact indicates the first impact of the bus frame with the surface of ground. Main focus is given on the impact of a bus with road surface only. The impacts of bus frame due to rollover with other materials are not included.

1.4 Scope of Project

The scope of the project includes the following analyses.

(i) Simulation of bus frame: It includes the simulation of bus frame using appropriate finite element analysis software to observe the effects of initial impact due to rollover.

(ii) Numerical analysis: It includes to analyze the box model for potential energy, kinetic energy and centre of gravity during rollover motion.

(iii) Dynamic analysis: This part is related to investigate the natural frequencies and mode shapes of box frame during first impact of rollover.

(iv) Rollover test: Experiment is to carry out on a simple box model to check the reliability and acceptability of the results obtained from the simulation of same model.

(v) To suggest the possible and relevant improvements in the design of bus frame to prevent the damage of rollover crash.

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