

# Whole Body Mechanical Vibrations of Passengers Travelling in Busses in Sri Lanka

R. Wijesiriwardana, M. Vignarajah, P.Kathirgamanathan, T.U. Gnanasena & D.M.P.C. Dissanayake

**Abstract**— One of the main passenger transportations in Sri Lanka is the bus. Most of these busses used for the passenger transportation do not have proper vibration dampers and passengers who travel in them are subjected to severe vibration levels as most of the time they are travelling standing up rather than sitting down on comfortable seats. Severe vibration levels produced by the engines of the busses and the poor road conditions in Sri Lanka are directly transfer to the passengers due to poor vibration damping of the busses. This paper discusses the vibration levels that the passengers travelling in Sri Lankan busses encounter by using accelerometers and the mechanical modelling of the passenger whole body vibrations. A new model is put forward to account for the nonlinear effects. Also the paper compares the passenger vibration levels with the international standards for safer passenger vibration levels (ISO2631). First part of the paper discusses the power spectral densities of the vibrations generated in the busses and also transferring from the road on to different locations of the busses where the passengers are normally travelling. Also the paper further discusses improved lumped parameter based mechanical dynamics model for standing up travelers subjected these vibrations, catering for the nonlinear effects by using additional viscous springs and dampers. Final part of the paper discusses the effectiveness of the use of commonly available elastic soles, elastic insert pads or elastic slippers footwear to reduce the harmful vibrational effects of frequent travelers.

**Keywords**—whole body vibration, passenger bus, ISO2631

## I. Introduction

There are many public transport service modes in Sri Lanka. Buses, trains, cars, motor bikes, bicycles, motor bikes and three wheelers are some of the commonly used passenger travelling modes in Sri Lanka[1,2]. Out of them busses are the most commonly used transport mode in Sri Lanka [1,2]. Figure 1.0a shows a typical Sri Lankan bus. The bus mode of transportation is popular due to their availability, and economical ticket prices. However their construction is very robust and uncomfortable. These busses consist of lorry engines and chassis covered by a metal frame with seats without proper dampers or vibration absorbers for the dynamic variations. Figure 1.0b shows that only leaf spring dampers are available for damping the road vibrations from the tires. In addition, they are powered with very high power diesel engines that produce wider frequency bandwidth of high intense vibrations which are not also properly damped.



Figure 1.0a Bus in Sri Lanka

Figure 1.0b Under view chassis

Due to the poor maintenance most of these busses engines are in poor operational conditions emitting unburnt diesel and carbon particles into the atmosphere together with acoustic noise pollution. Moreover due to the uneven roads and the congested traffic conditions in Sri Lanka the passengers have to bare additional burden of vibrations and spent additional time on such a hostile environment during their daily commutes.

Usually school children, working class people and elderly people who are travelling in these busses undergoes very harsh conditions with respect to mechanical whole body vibrations during their daily commutes. On average regular passenger stay inside these busses under harsh conditions for 1 hour and 45minutes in their daily commutes [1]. Even though for non-regular passengers 1 hour and 45minutes of undergoing these vibrations are tolerable as they can rest and recover, but for daily frequent travelers especially for the school children and the elderly these conditions in addition to the short term uncomfotability, could contribute to long term health issues[3]. In addition bus drivers and the conductors are working 12 to 16 hours minimum shift per day I Sri Lanka and they are also vulnerable to have a higher dosage of vibrational energy exposures.

According to the international passenger and vibration standards [3], the maximum amount of allowable vibrations levels that the human body can tolerate depends on the location, direction of the vibration, frequency, age, duration of the vibration, posture mode (sitting or standing) and also the rest duration between vibration levels. Also according to ISO2631-1, ISO2631-4, ISO2631-5 frequencies from 0.1Hz to 0.5Hz results in motion sickness and Frequencies from 0.5 to 80Hz are transmitted from seat to the body of the seated. Higher Frequency health effects from 80Hz to 1kHz are not known due to non-availability. In addition these standards do not specify the health effects of the standing up or recumbent positions due to non-availability of data. In Sri Lanka most of the passengers are travelling standing up during the rush hours. Moreover under seated conditions according to the these standards long term high intensity whole body vibrations indicates an increased health risk to lumbar spine and the connected nervous system of the segments affected. This may trigger by the not only the

R. Wijesiriwardana  
M. Vignarajah  
P.Kathirgamanathan  
T.U. Gnanasena  
D.M.P.C. Dissanayake  
University of Jaffna  
Sri Lanka