VIBRATION SPECTRAL CLASS CHARACTERIZATION OF LONG HAUL DUMP MINING VEHICLES AND SEAT PERFORMANCE EVALUATION

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Introduction

Long-haul dump (LHD) vehicles used in underground mining are known to expose workers to important levels of whole-body vibration[1]. These vehicles are generally designed without suspension and may be categorized as small or large LHDs depending on whether their respective load capacities are lower or larger than 3.5 cubic yards. While the majority of older vehicles are equipped with a rigid or unsuspended seat, more recent LHDs often incorporate a suspension seat.

The objective of this study was to define the vibration spectral characteristics of most commonly encountered large and small LHD vehicles operating in mining operations. This was done in an effort to categorize the vehicles in terms of vibration spectral classes to be reproduced on a laboratory whole-body vibration simulator to assess the vibration attenuation performance of a typical LHD suspension seat.

Methods

Vertical vibration measured at the seat attachment point of 8 small and 8 large LHD vehicles operating underground in typical mining operations under loaded and unloaded conditions was considered as the basis for defining the spectral classes. By regrouping the data collected for each LHD vehicle size and load condition, the overall distribution of acceleration power spectral density (PSD) of measured floor vibration was determined over the 0.5 to 20 Hz frequency range. Mean and envelopes of maximum and minimum values of PSD spectra were computed to define the spectral classes, along with the corresponding values of frequency weighted rms acceleration determined in accordance to the ISO 2631-1 standard[2]. These spectra were further used to calculate the displacements needed to drive a whole-body vibration simulator consisting of a platform supported by two servo-hydraulic actuators having a total stroke of ±100 mm. For validation purposes, the vibration acceleration spectra measured on the simulator were compared with the target spectra representing the spectral classes. Finally, the vibration transmissibility characteristics of a typical suspension seat were determined under sine sweep excitation using both a rigid mass load and a human subject having a mass of 62 kg and 85 kg, respectively. The SEAT value, representing the ratio of seat to base frequency-weighted rms acceleration, was further measured under each of the defined LHD vibration spectral classes by loading the seat with an 85 kg subject. Tests were repeated three times and the mean SEAT values were determined to assess the seat's ability to reduce exposure to whole-body vibration in LHD vehicles.

Results

Three spectral classes applicable to both loaded and unloaded conditions were defined as shown in Figure 1: one for large and two for small LHDs. The influence of load on frequency-weighted rms acceleration was found to be negligible for large and Class I small LHDs, while a shift of the peak acceleration PSD to lower frequencies was noted for the loaded vehicles. The influence of load was found to be more important for Class II small LHDs. Table 1 provides a comparison of frequency weighted, a_w, and unweighted, a, accelerations and dominant frequencies for the mean, maximum and minimum spectra associated with the different spectral classes. These were reproduced on a vibration simulator and used to assess the performance of a typical LHD suspension seat. The results obtained suggest that the seat cannot provide attenuation of the vibration at the dominant frequencies of the vehicles which range from 2.6 to 3.4 Hz . The measured SEAT values ranging from 1.25 for large LHDs to 1.35 for Class II small LHDs confirm that the seat is not adapted to these vehicles.

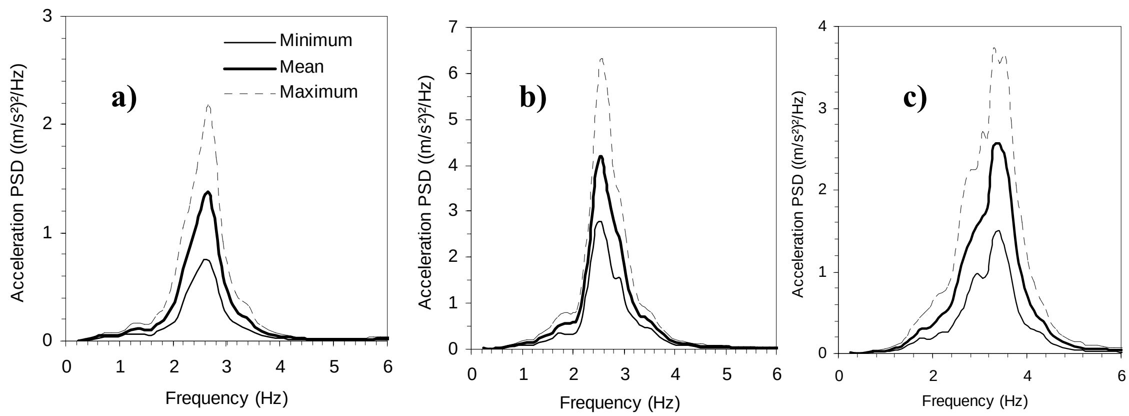

Figure 1 : Vibration spectral classes :a) Large LHDs; b) small LHDS Class I; c) small LHDs Class II

Table 1: Characteristics of the spectral classes for large and small LHDs.

Spectrum	Large LHDs		**Small LHDs-Class I**		**Small LHDs-Class II**	
	a	a_w	a	a_w	a	a_w
Minimum (ms^{-2})	0.89	0.62	1.63	1.16	1.38	1.13
Mean (ms^{-2})	1.20	0.85	2.03	1.45	1.88	1.55
Maximum (ms^{-2})	1.52	1.09	2.45	1.76	2.36	1.95
Dominant frequency	2.7 Hz		2.7 Hz		3.4 Hz	

Discussion

The vibration measured in LHD vehicles can be categorized into three spectral classes, two of which apply to small LHDs. In general, small LHDs lead to much higher vibration levels than large LHDs and the spread of values is more important, particularly for class II vehicles for which the dominant vibration frequency is considerably higher than that of the other categories. Laboratory evaluation of a typical suspension seat recommended for use in these vehicles has shown that it is more likely to provide amplification of whole-body vibration under normal operating conditions.

Acknowledgment

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References

1. Village, J., Morrison, J., Leong, D. (1989). Whole-body vibration in underground load-haul-dump vehicles, Ergonomics. 32(10), 1167-1183.
2. International Standard ISO 2631-1 (1997). Mechanical vibration and shock-Evaluation of human exposure to whole-body vibration-Part 1: General requirements.