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Experimental biodynamic investigation on vibrational exposure of human body during a vehicle ride

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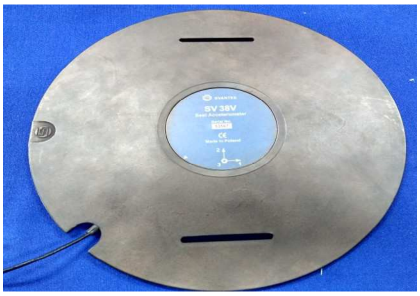
Abstract

Whole body vibration produces serious human health problems in the long term for example disc degeneration and low back pain[1,2]. Literature reports seated human subjects being exposed to vertical whole-body vibration during vehicle ride[3,4]. The biodynamic responses of the human body to these vibrations depend on many factors, such as body anthropometry, posture, magnitude, and frequency. Most of the experimental human vehicle vibration studies involved measurement at seat base. Head motion is usually not investigated. This lacuna has been addressed in this work. The primary objective of this study was to investigate the acceleration transmissibility through the human body during vehicle ride. For this, an experimental investigation on human body response at seat base and head of the driver-passenger was undertaken. The equipment's details and measurement process are depicted in Figure 1. The one tri-axis accelerometer was mounted at seat base and another was used for the measurement of head acceleration[5]. The seat pad accelerometer was correctly aligned for x-y directions and placed firmly between cushion and pelvis to ensure that the x-z plane represents sagittal surface. In the case of driver, a single-axis accelerometer was mounted on the head helmet and for the passenger, the accelerometer was placed at the mouth with the help of a mounting pad. The driver and passenger were asked to maintain the correct sitting posture with inclined back support. On a highway, measurements were taken with a vehicle speed of 60 km/hr. The approach speed on speed breakers was 25 km/hr. Here, a speed breaker comprises of 6 small bumps with width, height and separation between two consecutive bumps being 30 cm, 4 cm and 40 cm respectively. The seat pan angle and backrest inclination angle were 12° and 7° respectively.

(a)



(b)

(c)

(d)

(e)

(f)


(g)


(h)

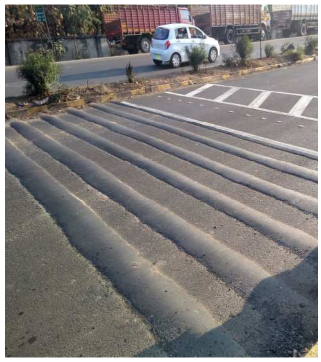

(i)

Figure 1: Experimental equipment's and setup: (a) SV 106A Six-channel human vibration meter and analyzer (b) SV 38 IEPE Whole-Body Seat Accelerometer seat pad, (c) piezoelectric accelerometers (d) seat pad with accelerometer in seat (e) pair of tri-axis accelerometers connected to vibration meter, (f) accelerometer mounted on the driver head, (g) driver with accelerometer at base and other at head (e) passenger with accelerometer at mouth (f) speed breaker profile.

The experiments were conducted on a state highway road with the speed breaker. The data was recorded and stored in SV 106A six-channel human vibration meter and analyzer. The root mean square (RMS) acceleration results obtained for driver and passenger are summarized in Table 1.

Table 1: Experimental results of vehicle occupants sitting with backrest support.

Sr. No		Road Profile	Seat Pad RMS Acceleration (m/s^2)			Head RMS Acceleration (m/s^2)		
			a_x	a_y	a_z	a_x	a_y	a_z
1	Driver	Highway	0.140	0.095	0.333	---	---	0.561
2		Speed breaker	0.377	0.224	0.823	---	---	1.18
3	Passenger	Highway	0.087	0.086	0.399	0.322	0.376	0.592
4		Speed breaker	0.363	0.173	0.846	0.576	0.301	1.21

Variation in experimental data was observed for the two different subjects. In case of driver, the hands are placed on steering wheel and head movement is measured by mounting accelerometer on helmet. The results indicate that acceleration is amplified by the human body as head acceleration is more than seat base acceleration in the corresponding. The acceleration value in vertical (z) direction is greater as compared to fore-aft and lateral direction as major component of vibrations arise from the vertical road-tyre interaction. As expected, the peak acceleration on speed breakers is higher than those obtained during the highway ride. The acceleration values on speed breaker are in the uncomfortable zone according to ISO $0.8 - 1.6$ m/s^2[6] and this may lead to guidelines for design of speed breakers.

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