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Effect of vibration on commuters using experimental techniques

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ABSTRACT

In this investigation, the analysis of research areas i.e. the laboratory study for floor to head transmissibility (FTHT), floor to knee transmissibility (FTKT) in standing postures were measured and analyzed with the discussion crafted on effect of inter subject variability, effect of vibration magnitude and effect of posture. In the laboratory study section like subject's anthropometric data, postures, experimental setup, vibration parameters used for the experiment, experimental tasks, its performance evaluation and test procedures have been extensively discussed.

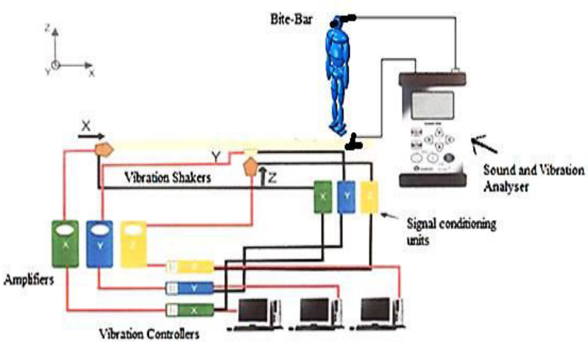
Keywords
("Anthropometric, Vibration, Transmissibility").

1. INTRODUCTION.

In present days of busy life people are using cars, buses and trains for travelling to other places or offices etc., and they are daily exposed to vibration not only while sitting but also in standing position. However, only a few studies of the transmission of floor vibration to the knees and to the heads of standing subjects have been published. Most of the relevant investigations concern the transmission of vertical vibration. There are many un-investigated variables that could influence the transmission of vibration in each axis, and the effect of holding the handle onto a handrail. Matsumoto and Griffin compare the biodynamic response in sitting and standing postures and concluded that there was a greater transmission of vertical vibration to the pelvis, lower spine and greater relative motion within the lower spine in the standing posture than in the sitting posture at the principal resonance and at higher frequencies (1). Matsumoto and Griffin, investigate the influence of the posture of the legs and the vibration magnitude of the dynamic response of the standing human body exposed to vertical whole-body vibration (2). Harazin and Grzesik, computed the magnitude acceleration in the Z-axis direction of six body segments: the metatarsus, ankle, knee, hip, shoulder and head during exposure to random vibration (3). Paddan and Griffin, measured the head motion of standing subjects while they were exposed to floor vibration occurring in each of the three axis: fore & aft, lateral and vertical and it was concluded that during fore & aft vibration the head motion occurred mostly in the mid sagittal plane and rigid grip to the handrail resulted in higher transmissibility than a light grip (4). In an earlier study, Bhiwapurkar et al., measured the head motion using bite bar technique (Fig. 2.1) for the measurement of head motion. In this study the bite bar is held in place by gripping the mouthpiece between teeth (5). The design of the bite bar used in the present study ensured no resonances of the various attachments up to 60 Hz, which is greater than the frequency of interest. In the present study, the same bite bar is used for measurement of head motion using bite bar technique in measuring transmissibility of accelerations to the head from the excitation floor in vertical (z) and lateral directions (y)

2. MATERIALS AND METHODOLOGY - EXPERIMENTAL SET UP

In all the experiments performed on standing postures and sitting postures the study has been conducted in the vibration simulator in the natural laboratory environment, in the Vehicle Dynamics Laboratory, IIT Roorkee, India (Narayanamoorthy et al., 2008 (a, b and c)). It consists of a platform of 2 m × 2 m size made up of stainless steel corrugated sheets, on which two vertical pipes of outer diameter 1.5in and height 2.1m is rigidly fixed with plates of 6in × 1in × 0.5in which is further securely fixed to the platform (6). The above mentioned setup does not have any resonance within the frequency range studied (up to 20 Hz) in any of the three axes. Three Electro-Dynamic Vibration shakers are used to provide vibration stimuli in vertical (Z-axis) with a capacity of 1000 N with a stroke length of 25 mm (peak-to-peak). For simplicity and safety reasons the internal positioning accelerometers of the shakers were continuously used for motion feedback. The tri-axial accelerometers (PCB356A32 Piezoelectric) are placed on head positions (through the attachment of bite bar) in order to measure the transmissibility of vibration from floor to head



(FTHT) standing postures and seat to head (STHT) sitting postures and the transmissibility of vibrations from floor to knee (FTKT) is measured by mounting tri-axial accelerometers (PCB 356A32 Piezoelectric) at the right knee with the help of Velcro and rubber strap,and the subject was further asked to maintain a steady head position while data is acquired.

Fig. 2.1 Schematic drawing of experimental setup to find transmissibility from FTHT in normal standing posture

The signal from the accelerometers were amplified using (for head, knee and floor) three-channel lightweight ICP® sensor signal conditioner and then the data was collected by using SVAN 958 Four channel human vibration meter and analyzer. Each subject was further asked to maintain a steady head position while data is measured.

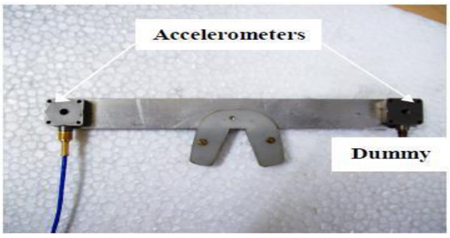


Fig. 2.2 Bite-bar used in the experiments (Bhiwapurkar et al., 2011)

2.1. EXPERIMENTAL TASKS

The experiments were performed to measure the vertical vibration transmission to head under sinusoidal vibration magnitude of $1m/s^2$ in vertical direction with the sinusoidal frequencies 3, 5, 6, 8, 10, 12 and 15 (Hz). Six healthy subjects with an average age of 24 years, average height of 174.5 cm took part in the experiment. The physical characteristics of test subjects are summarized in Table 2.1. Each subject asked to stand in erect posture by holding the bite bar in the mouth to that accelerometer attached to measure the acceleration at the head. To minimize variability, the subject was requested to look straight ahead, and try not to change it during the excitation. The separation between the feet was set to 30 cm and handle should be held by right hand. Each subject was further asked to maintain a steady head position while data is acquired. The posture which was used in the experiment was the postures adopted by the commuter's travelling in public transportation buses while standing in the erect posture on the vibrating floor. Anthropometry details are referred from Debkumar Chakrabarthi, (1997).

Table 2.1 Anthropometric data for standing test subjects

Subjects	Age (Years)	Weight (Kgs)	Height (cm)
Sub 1	24	68	168
Sub 2	24	60	167
Sub 3	24	76	178
Sub 4	24	66	175
Sub 5	23	72	177
Sub 6	23	78	183

2.2 TEST PROCEDURE

The test subjects will stand erect with 30 cm feet apart in relaxed posture on the platform of vibration simulator such that these are excited with the same frequency as the platform, up to 20 Hz. Each participant began the experiment by filling out a general questionnaire about his personal information. This is followed by a brief introduction about the experiment to each subject. Subject's height and weight are measured. A written consent is taken from each participant before the tests commenced. The study of each subject involved about one hour of test each day to avoid the influence of fatigue. The test was conducted for one subject at a time; it is required to perform the task silently. Each subject is exposed to a total of 10 conditions from an individual level of vibration magnitudes, one level of subject's posture and 9 levels of vibration frequencies sinusoidal under uni-axis of excitations in vertical direction with a 1-min break between consecutive sessions as shown in Table 2.2. The vibration conditions are presented in a sinusoidal manner. The test subjects are instructed to occupy themselves with the prescribed posture to perform the assigned task during the vibration exposure. The 1-main break is introduced after exposure to each condition wherein the stimuli are stopped and the subjects are required to rate their perceived difficulty using Borg CR10 scale. This procedure is repeated for all the vibration level, direction and posture.

Table 2.2 Borg CR10 scale (2001).

0	Nothing at all
0.5	Extremely weak (hardly noticeable)
1	Very weak
2	Weak (light)
3	Moderate
5	Strong (heavy)
7	Very strong
10	Extremely strong (almost maximal)
*	Absolute maximum

3. RESULTS -RESPONSE DATA ANALYSIS

Table 2.3 Shows the respective inter subject FTHT transmissibility and mean FTHT transmissibility in normal standing posture exposed to vertical excitation of floor with 1 m/s^2. From the Fig 2.3 it was observed that the effect of inter subject variability and mean transmissibility on measuring the transmissibility of subjects in normal standing posture exposed to vertical sinusoidal vibration at 1 m/s^2 r.m.s. The floor-to-head transmissibility was measured for 6 subjects. The minimum and maximum transmissibility from the entire subject varies between 0.33 – 2.45 $m/s^{2.}$ From the mean transmissibility measured, the value was observed 1.98 at 5Hz as shown in Fig. 2.3.

Fig. 2.3 Inter –subject FTHT Transmissibility and Mean FTHT Transmissibility in normal standing posture subjects exposed to vertical excitation with 1 m/s^2.

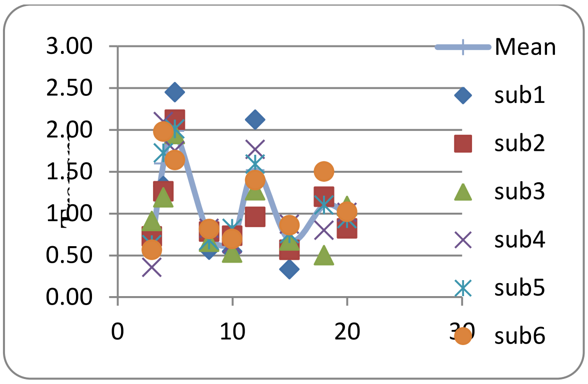


Table 2.3 Shows the respective inter subject FTHT transmissibility and mean FTHT transmissibility in normal standing posture exposed to vertical excitation of floor with 1 m/s²

Frequency (Hz)	Sub1	Sub2	Sub3	Sub4	Sub5	Sub6	Mean
3	0.80	0.72	0.90	0.35	0.62	0.56	0.66
4	1.32	1.26	1.19	2.09	1.72	1.97	1.59
5	2.45	2.12	1.95	1.75	2.01	1.64	1.98
8	0.56	0.78	0.66	0.82	0.67	0.81	0.72
10	0.54	0.73	0.53	0.63	0.82	0.69	0.65
12	2.12	0.95	1.27	1.76	1.58	1.39	1.51
15	0.33	0.56	0.67	0.87	0.75	0.85	0.67
18	1.5	1.2	0.50	0.80	1.10	1.50	1.11
20	0.98	0.82	1.09	1.01	0.93	1.01	0.97

4. Conclusion

The floor to head and floor to knee transmission measures of biodynamic responses of standing human exposed to whole body vibration were investigated through measurements performed with 6 adult male subjects, and varying standing posture conditions.

Measured vertical as well as lateral floor to head and floor to knee transmissibility biodynamic response were characterized to examine the effects of the two postures while holding the handle and while holding the handrail as found in Indian buses. Excitation magnitude is 1m/s^2 r.m.s in the frequency range of 3-15 Hz.

In vertical direction, the resonance peak is found at 5 Hz at the head and at the knee in both the postures and in lateral direction, the resonance peak is observed at near 6 Hz of head in both the postures. But the resonance peak of knee in lateral direction is observed at 8 Hz in both the postures. It is observed that a significant fall in the head transmissibility which isless than 0.01m\s^{2}in the lateral direction compared to the result of otherbody part and of the vertical direction.

The Floor-to-Head transmissibility of different subjects in vertical direction is slightly increased while holding the Handle as compared to while holding the Handrail. It is also observed that the transmissibility is increased in lateral as wellas in vertical direction in both the postures while compared with normal standing human.

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