

Ergonomics of Field Machines

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Introduction

The effects of different frequencies and magnitudes of vibration on aspects of human performance, such as manual control, vision, perception and cognition are being concerned. Surveys and investigations were done on manual tracking and visual acuity during vibration exposure and have been well-studied with documented.

It has been confirmed that vibration does not significantly affect human performance on straightforward perceptual tasks such as auditory or visual detection of signals. In the following section, the potential health and safety impacts of whole-body vibration would be explicated.

Manual Tasks and Tracking Performance Studies Review

The range of vibration frequency which is believed significant for health, comfort and perception is 0.5 to 80 Hz [1]; the investigation of this project will be limited to range 0.5 to 10 Hz which is the most common vibration frequency in daily life.

Tracking errors generally increased while the vibration magnitude increased, and the error was most responsive to 5 Hz of z-axis vibration [2]. Also tracking performance of vertical vibration have been found that in range of frequencies between 2 and 12 Hz, came with the maximum reduction occurring at the lowest of the frequency range. It can be concluded that the vibration magnitude had a superior consequence on tracking performance than the vibration frequency did [1].

Manual tasks performance is disturbed in the range of whole-body resonance. This range is between 2 and 10 Hz for vertical vibration. From the result of a series of experiments, different manual tasks performance would be affected by of different frequencies and amplitudes of vibration. Such as, for writing tasks, it is most difficult to perform with vertical vibration frequencies between 4 and 6 Hz. Also, tracking error at specified vibration frequencies was showing linear trends approximately with vibration magnitude, while 5 Hz vibration has the steepest slope.

Visual Performance Studies Review

Vibration would procure relative movement between the retina and the visual display. It may produce an unclear image and degrade visual performance. These movements may happen when there is vibration of display, vibration of observer, and vibration of both display and observer.

The early studies indicated that visual performance declined with increasing vibration magnitude, but there was no agreement on how vibration frequencies affected visual performance. For vertical

vibration, there were 3 frequency-related factors that influence visual performance:

- a. Compensatory tracking eye movements, which protect visual acuity for low frequency vibration below about 1 to 2 Hz,
- b. Amplification or attenuation of vibration from the seat to the head, and
- c. Resonances within the eye at high frequency which above 20 Hz [2]

Visual performance was affected by vibration frequencies range 10 to 25 Hz [3]. By comparing vibration of observer only and vibration of display only, vibration would affect observer while frequency is over 10 Hz; and vibration would affect acuity while display frequency is below 10 Hz [4].

Studies also have done on the transmission of vibration from vibration platform (seat) to head whether it would produce an impact on performance of reading of numerical displays. It was found that the performance of reading errors followed linear direct proportional with increasing vibration magnitude. The most sensitivity for reading errors arose with z-axis vibration frequencies around 11 Hz.

In testing of the relationship between reading distance and reading errors caused by vibration, low frequency vibration around 3.15 Hz was found to cause reading errors only at short reading distances. Higher frequencies around 16 Hz affected reading accuracy at any distances, with direct proportional linear increasing in error with vibration magnitude [5,6].

For the vibration frequency transmitted from the vibration platform which is below 2 Hz, the transmissibility is coherent and there is no significant body resonance. The maximum transmission occurs at frequency range 2 to 10 Hz, which is the major natural frequency of the human body and primary resonance occurs. From 10 to 20 Hz, secondary body resonances may occur, and, above 20 Hz, the vibration is weakened by the body structures and the transmission is less than which in the case of below 2 Hz [7].

Vibration is believed having a negative effect on complex cognitive tasks; however, the vibration frequency and magnitude reliance have not been proven. Also, vibration leads comfort problems (such as perceptual) as well as health problems (such as cognitive). Comfort problem is entirely subjective which cannot be measured by observation, questionnaire is needed to help.

Effect of Vibration to Human Perceptual Performance

Basically, vibration can be divided into 2 groups:

- a Free vibration

It occurs on an object which vibrates without external force affect, and vibrates with its natural frequency.

b Forced vibration

It occurs due to external force. If the external added frequency is same as the object's natural frequency, resonance occurs.

Resonance produces a large amount of vibration inside the object structure which may harm the object itself and should be avoided. Each part of human body has their own natural frequency and it varies according to mass of body (Table 1).

In the design of questionnaire of the survey of this project which measure the uncomfortable of human body due to vibration, it includes the area which presented in the following table:

Body part	Resonance frequency (Hz)	Symptoms
Whole body	4 – 5, 10 – 14	General discomfort
Upper half of body	6 – 10	
Head	5 – 20	Visual difficulties
Eye balls	1 – 100, Mostly above 8	Tone change
Skull, jaw	Maximum at 20 - 70	
Throat	100 - 200	
	5 – 20	
Shoulder	2 – 10	
Lower arm	16 – 30	
Hands	4 – 5	
Body trunk	3 – 7	Chest pain
Heart	4 – 6	Abdominal pain
Chest	60	Urgency
Stomach	3 – 6	
Abdominal	4 – 8	
Bladder	10 -18	
Heart and blood vessels	2 – 20	
Bain	Below 0.5	Sports vomiting disease

	1 - 2	Sleepy
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Table 1: Resonance of Vertical Vibration and Human Body Part

Effect of Vibration to Human Cognitive Performance

From previous research, vibration does not have significant effect on simple cognitive task performance, but it degrades the performance on complex tasks [8], especially for long vibration duration. And in most cases, vibration has more important effect in vertical direction than horizontal directions. Aside from manual control performance and visual acuity, how complex cognitive tasks performance affected by vibration is still not clear; therefore, the survey of this project is of interest to understand how vibration affect on human cognitive performance as well as perceptual performance [9].

For perceptual performance, questionnaire will be used as a tool to measure; for cognitive performance, after comparing, a tool called 'Raven's Progressive Standard Matrices (SPM)' which compiled by British psychologist Raven. It is a well-developed assessment tool which suitable for general people who is 5.5 – 70. A comparison and evaluation of different cognitive assessment tools would be presented in later chapter.

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