AN EVALUATION OF AN ADAPTER METHOD FOR MEASURING THE VIBRATION ON THE HUMAN ARM

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Introduction

The biodynamic responses of the human body or segments to vibration exposure are likely to play an important role in developing vibration health effects.[1] However, no feasible technology has been developed to directly measure the essential biodynamic responses, such as vibration stress, strain, and power absorption density on a human subject. Their determinations generally depend on modeling of the system. The directly measureable frequency response functions, such as vibration transmissibility and driving-point biodynamic response functions, are usually used to calibrate the human vibration models. Hence, the reliability of the modeling depends on the measurement accuracy of these functions and their representation.[2] Although a 3-D laser technique has been available and applicable for the measurement in the laboratory,[4] it is very difficult to apply this technique to measure the human body vibrations in the field. This study proposed using an adapter method to measure the vibrations transmitted to the human arm and evaluated it using the measurements obtained with a 3-D scanning laser vibrometer.

Measurement Methods

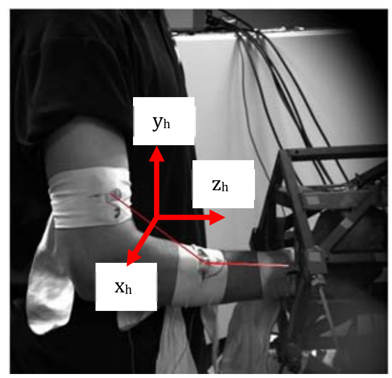


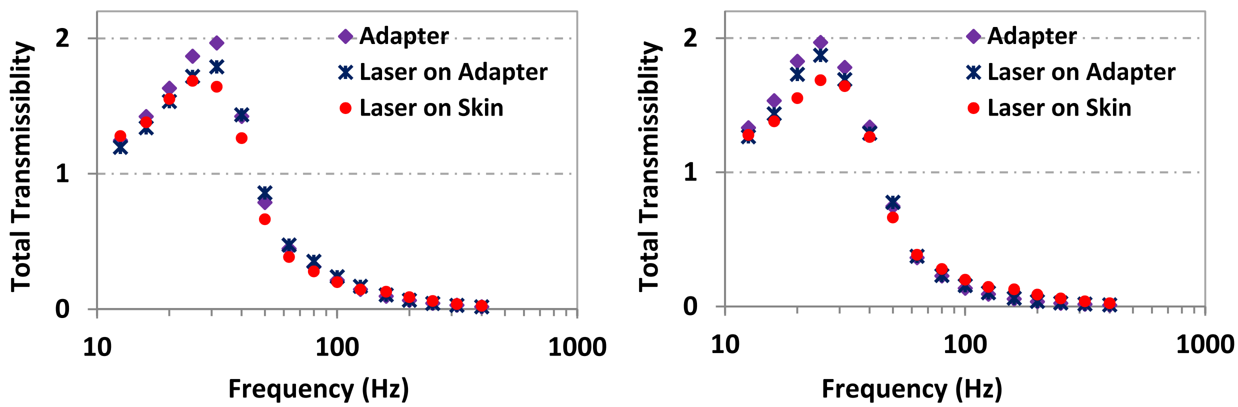
Fig. 1: Test setup and posture.

Six adult male subjects participated in the study. As shown in Fig. 1, the experiment was carried out on a 3-D vibration test system (MB Dynamics, 3-D Hand-Arm Test System). Each subject was advised to maintain a grip force of 30±5 N and a push force of 50±8 N with the elbow angle between 90° and 120° and the shoulder abduction at about 0°, similar to the postures used in the standard glove test.[3] A broadband random vibration in the frequency range of 16 - 500 Hz along each of the three directions was used as the excitation. The adapter required for the standard test of anti-vibration gloves can adapt well to the surface of the human arms; hence, three such adapters were fabricated and used in this study. Each of them was equipped with a tri-axial accelerometer (ENDEVCO, 35A) for the measurement of the vibrations in the three orthogonal directions. As also shown in Fig. 1, they were fixed at the wrist, forearm, and upper arm, respectively, using a fabric wrap on each of the adapters. Each adapter was aligned with the excitation vibration directions as closely as possible. The adapter vibrations in the three directions were also measured using a 3-D scanning laser vibrometer (Polytec, 3-D scanning laser), simultaneously with the measurements using the tri-axial accelerometers. The bare-arm 3-D vibrations were also measured using the 3-D scanning laser vibrometer at the same locations as the adapters. The three sets of the transmissibility functions were compared to assess the validity of the measurement using the adapter method. To find whether the tightness of the wrap affects the measurements, two levels of tightness were manually controlled in the adapter fixations.

Preliminary Results and Discussion

The vibration transmissibility in the individual three orthogonal directions measured using the adapter was largely different from that measured using the laser vibrometer. However, the transmissibility spectra of the total vibration measured with the three methods were fairly comparable in large frequency ranges. As an example, Fig. 2 shows the comparisons of the transmissibility functions measured at the wrist. The adapter spectra measured with the laser vibrometer and the tri-axial accelerometer are close to each other. This suggests that these two techniques can provide similar measurements of the total vibration. The large directional differences are primarily because it is difficult to align the accelerometer directions with the defined vibration directions.

The results suggest that the adapter may affect the measurement of the human arm vibration at some frequencies. It is generally hypothesized that a tighter wrap of the accelerometer/adapter on the human skin can result in more reliable measurement. Inconsistent with this hypothesis, the results shown in Fig. 2(a) indicate that a tight wrap could increase the resonant frequency or change the dynamic properties of the system.



(a) measures with tightly wrapped adapter (b) measures with loosely wrapped adapter

Fig. 2: Mean spectra of the total vibration transmissibility (vector sum of three–axis accelerations) measured at the wrists of the six subjects.

References

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Disclaimers: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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Forward – Welcome Address

On behalf of my conference co-chairs, I am pleased to welcome you to Guelph, Ontario, Canada for the 5th American Conference on Human Vibration. The 5th ACHV is being co-hosted by the University of Guelph, Laurentian University, Western University and the University of Toronto. We are honored to be hosting this biennial conference on the University of Guelph campus. As the premier North American conference for human exposure to vibration, the conference provides a unique and convenient opportunity for researchers, engineers, medical professionals and industry representatives to exchange information on all aspects of vibration control and human responses to hand-transmitted vibration and whole-body vibration. The theme for this year's meeting is "Human Vibration - From Theory to Industrial and Clinical Applications".

Founded in 1827, Guelph was named after the British Monarch King George IV, who was from the House of Hanover. Selected as the headquarters of a British development firm called "The Canada Company", Guelph was designed by John Galt, who was a Scottish Novelist. The town was designed to resemble a European city center comprised of squares, wide main streets and narrow side streets. Guelph was home to Lieutenant Colonel John McCrae, the author of "In Flanders Fields". Its references to the red poppies that grew over the graves of fallen soldiers resulted in the remembrance poppy becoming one of the world's most recognized memorial symbols for fallen soldiers. Guelph was also the home of North America's first cable TV system. Fredrick T. Metcalf created MacLean Hunter Television (now part of Rogers Communications) and their first broadcast was of current monarch Queen Elizabeth II's Coronation in 1953. With a population of over 120,000, Guelph is part of a technology triangle which is comprised of the cities of Guelph, Kitchener, Cambridge and Waterloo. Guelph is consistently rated as one of Canada's best places to live because of its low crime rate, clean environment, high standard of living and low unemployment rate. Almost one quarter of Guelph employment is provided through the manufacturing sector with over 10% provided through Educational services. The City of Guelph has identified life science, agri-food and biotechnology, environmental management and technology companies as industries on which to focus future economic development activities.

Many thanks to Elyse Dubé from Conference Services at the University of Guelph for all of her hard work in helping to plan and sort through the conference logistics. We'd also like to thank Guelph Engineering students Gregor Scott and Dan Leto as well as School of Engineering technician Carly Fennell for their help in setting up the laboratory tours. We hope that your visit to the 5th ACHV and Guelph will be both educational and enjoyable.

Sincerely,

Michele Oliver, Jim Dickey, Tammy Eger and Aaron Thompson