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Habitability under Horizontal Vibration of Low Rise Buildings

Confort des immeubles bas soumis à des vibrations horizontales

Bewohnbarkeit niedriger Gebäude unter horizontalen Schwingungen

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SUMMARY
Horizontal vibration perception tests are conducted for high-frequency horizontal vibrations expected with mid- and low-rise steel-framed buildings due to road traffic. The test results are evaluated probabilistically.

RESUME
Des essais de perception de la vibration horizontale ont été effectuées, pour des vibrations à haute fréquence dues au trafic routier, sur des bâtiments à ossature métallique de basse et moyenne hauteur. Les résultats des essais sont traités de façon probabiliste.

ZUSAMMENFASSUNG
Es wurden Tests zur Wahrnehmung hochfrequenter horizontaler Schwingungen durchgeführt, wie sie in niedrigen und mittelhohen Stahlskelettbauten infolge von Strassenverkehrserschütterungen zu erwarten sind. Diese Tests werden mit Wahrscheinlichkeitsberechnungen ausgewertet.

1. PURPOSE

Current research efforts and guidelines regarding the response of occupants exposed to horizontal motions and vibration in buildings deal only with low-frequency ranges (0.33-2.0 Hz) [1-5]. This is due to the practical requirements for the design of high-rise buildings. However, mid- and low-rise steel-framed buildings sometimes pose problems related to vibrations caused by road traffic. In this study, horizontal vibration perception tests at high frequencies around 3.0 Hz, which is the normal range for the natural frequencies of mid- and low-rise steel-framed residential buildings, were conducted. Results were evaluated probabilistically to propose guidelines for the evaluation of the habitability of mid- and low-rise steel-framed houses.

2. TEST METHOD

2.1 Test Facilities

The plan of the test room is shown in Fig. 1. The test room was set up on the fifth floor of a seven-story steel-framed experimental tower. Vibration generators were installed on the sixth floor of the tower to create the motion of vibration along one axis as shown in Fig. 1.

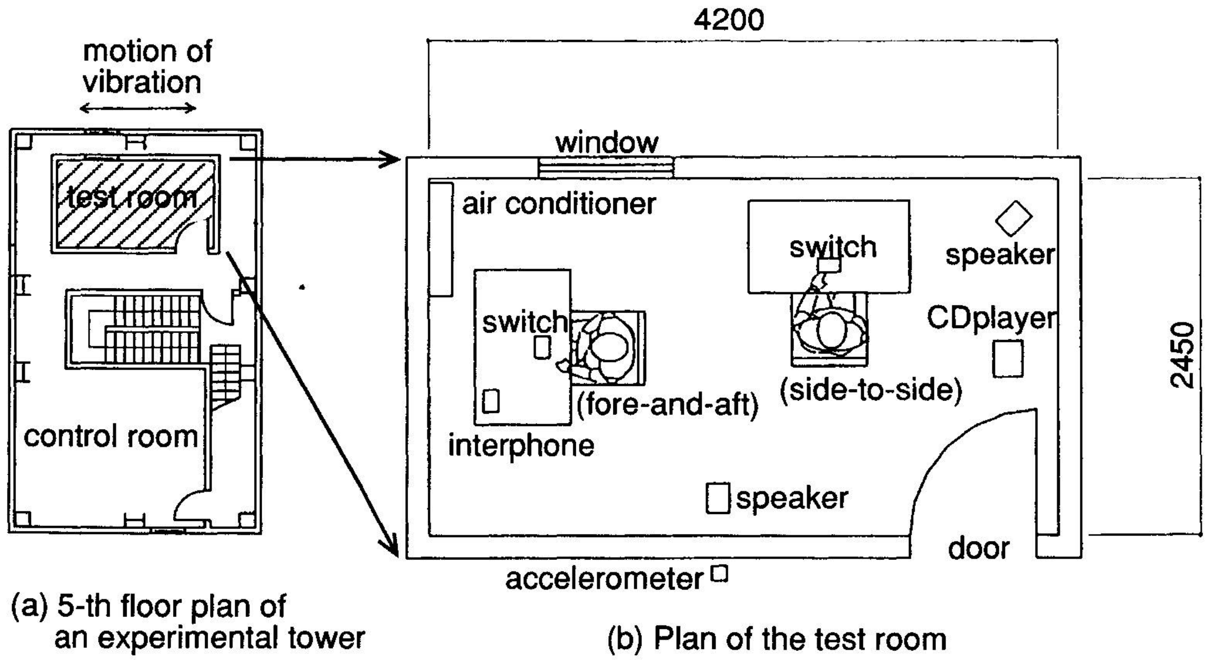

Fig.1 Test facilities

2.2 Test Procedures

The perception tests were conducted on a total of 40 subjects. Vibration was given to a seated subject in both fore-and-aft motion and side-to-side motion. Each subject's perception was detected by telling the subjects to press an "ON" button when he/she started perceiving a vibration. Sinusoidal vibrations of a certain frequency with an increasing amplitude were given. The frequency was set at 1.0, 1.9, 3.0, 4.0, and 6.0 Hz. Fig. 2 shows examples of the response acceleration of the test room at 1.0 and 3.0 Hz. The subjects were told to fill out a questionnaire, which was designed to check if they perceived any vibrations and evaluate how they were perceived, after the test.

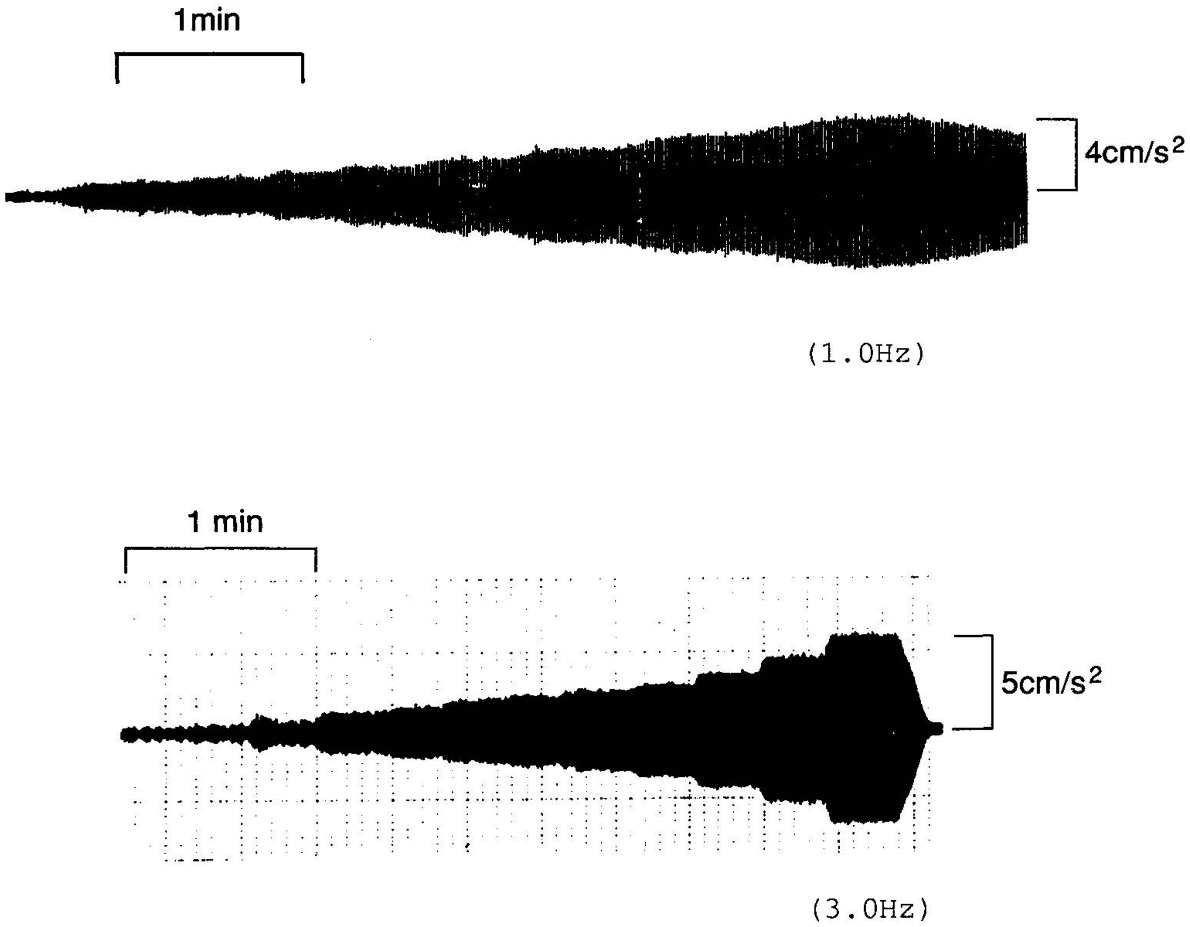

Fig.2 Examples of test room acceleration

3. EXPERIMENTAL RESULTS

Fig. 3 shows the results of the perception threshold. The mean values are indicated by a solid line. The mean values show that the side-to-side perception thresholds are lower than the fore-and-aft perception thresholds at 1.0-3.0 Hz. However, at 4.0-6.0 Hz, the subjects are more sensitive to fore-and-aft motion than to side-to-side motion. Although horizontal vibrations were given in the test room, half of the subjects perceived a vertical vibration at 6.0 Hz fore-and-aft vibration. This result agrees with the guideline in ISO 2631 [6] where the equal sensitivity curve for whole-body vibration shows that at 1.0-3.15 Hz human sensitivity to horizontal vibration is higher than to vertical vibration, and at other frequencies sensitivity to vertical vibration is higher.

Fig. 4 shows perception histograms at 4.0 Hz. These are illustrations of the determination of the probability distribution of perception limits, where the perception limits were standardized using the mean value at each frequency, and the log-normal distributions were compared.

Fig. 5 shows the probabilistic perception limits corresponding to 2, 10, 50, and 90% values. The figure also shows ISO 2631 base curve [6, 7] and the perception limits in the lower frequency range for the fore-and-aft motion by Kanda, Tamura et al. [2]. With respect to the side-to-side motion, the ISO base curve at 2.0-6.0 Hz roughly corresponds to the 10% values of our results. As for the fore-and-aft motion, the 50% values at 1.0-2.0 Hz coincide with the 50% values for the low-frequency tests [2].

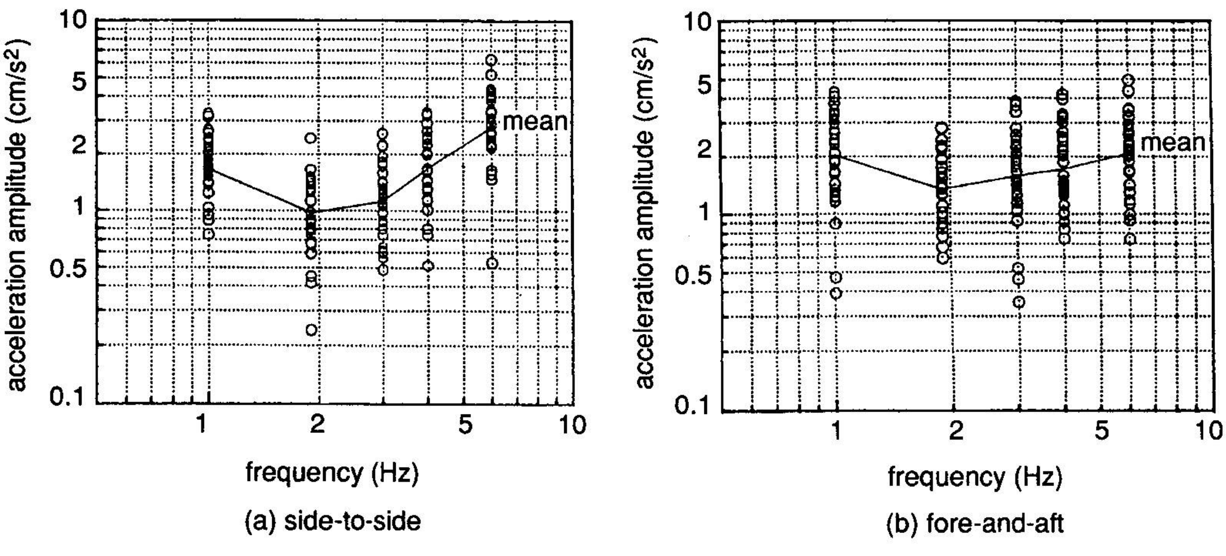

Fig.3 Perception limits

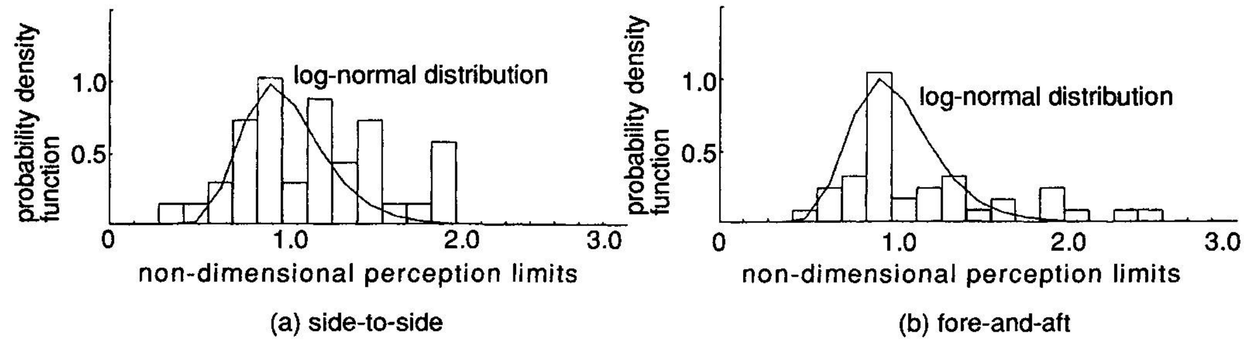

Fig.4 Examples of perception histograms (4.0Hz)

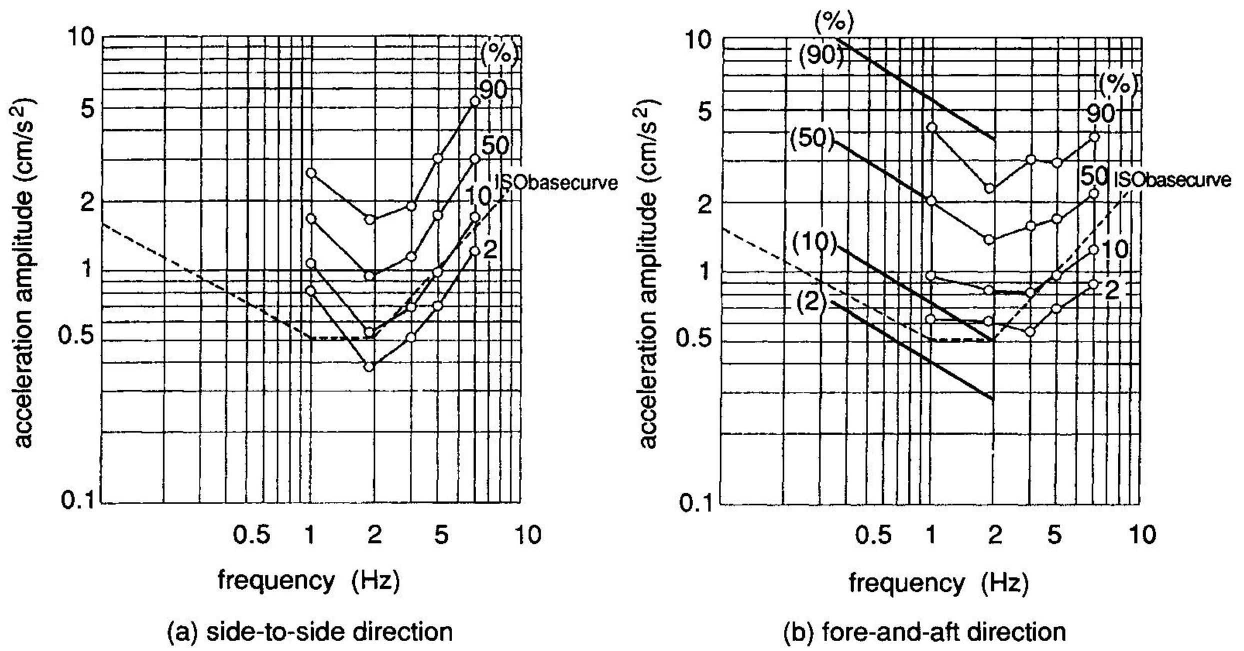

Fig. 5 Probabilistic perception limits and the comparison with other criteria and reports

4. CONCLUDING REMARKS

From the perception tests, the following conclusions were obtained:

(1) Perception limits vary with the frequency of motion and their individual variations are significant.

(2) The gradient of perception limits with the vibration frequency changes at around 2.0 Hz.

(3) The gradients of the ISO base curve and our results are almost consistent with each other.

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