PROPAGATION AND REDUCTION OF STRUCTURE-BORNE NOISE GENERATED BY SUBWAY TRAIN

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INTRODUCTION

Recently, buildings such as hotels, apartment houses, concert halls etc. wherein silent environment is required have been built at the sites near by subway. In this case, it is necessary to reduce sufficiently structure-borne noise generated by subway train. This time, the room enclosure vibration-isolated from surrounding structure was constructed in the building built between two subway lines for the reduction of structure-borne noise generated by subway train, and the investigations into the reduction effect and the vibration propagation characteristics in the building were carried out.

In this paper, the important results of investigation were described.

OUTLINE OF BUILDING

The building is an office building which has four basement floors and twenty-three floors as shown in Figure 1. The basement structure is made by steel-frame reinforced concrete and the structure on the ground is made by steel-frame.

The building is constructed between two subway lines (A and B), and the conference

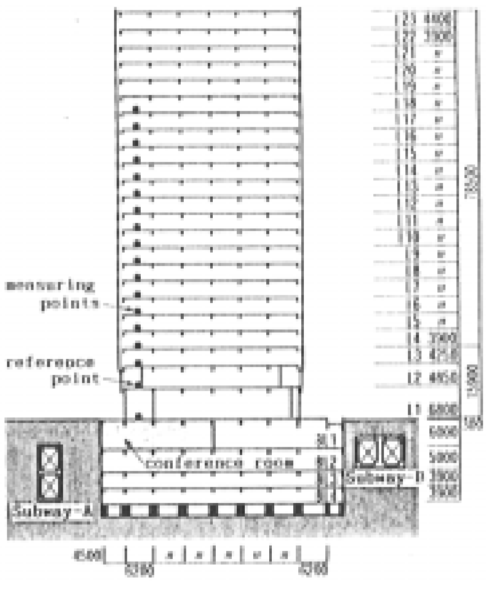

Fig. 1 Investigated building.

room is located at the site near by subway-A line.

The soil mixing wall (600mm thickness) was constructed at the exterior of the underground wall of the subway-A line site and continuous underground wall (600mm thickness) was constructed at the site of subway-B line only by considering the construction procedures.

The room enclosure which is vibration-isolated from surrounding structure was used for the reduction of structure-borne noise generated by subway train at the conference room. The room enclosure was supported by isolation rubber pads as shown in Figure 2. The fundamental resonance frequency of the system is 15Hz.

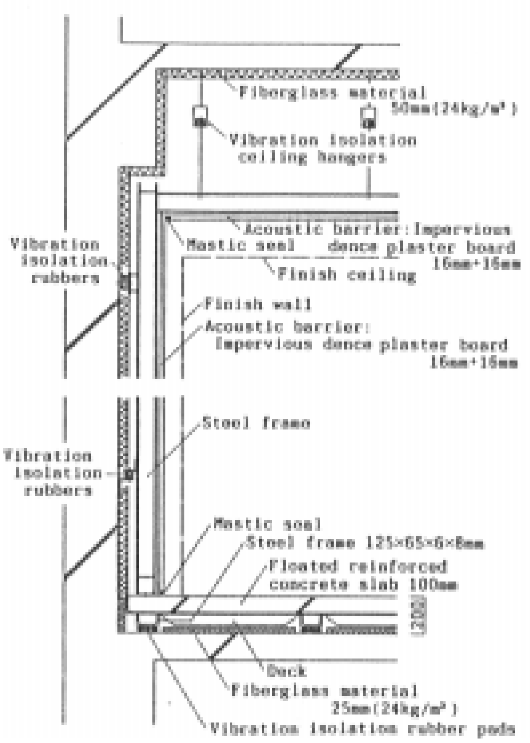

Fig. 2 Cross section of room enclosure vibration isolated from surrounding structure.

MEASUREMENTS

Measurements of the vibration of ground and the building structure, and of structure-borne noise in the building generated by subway trains were carried our before and after the construction of the room enclosure.

RESULTS OF INVESTIGATIONS

<u>Vibration of Ground and Building Structure</u>

Vibrations of ground near by subway-A and of the structure of the conference room generated by subway-A train have the frequency characteristic that the value at 63Hz octave band is predominant as shown in Figure 3. The propagation characteristic from ground to building structure shows a tendency of decrease at the floor beam and amplification at the floor slab.

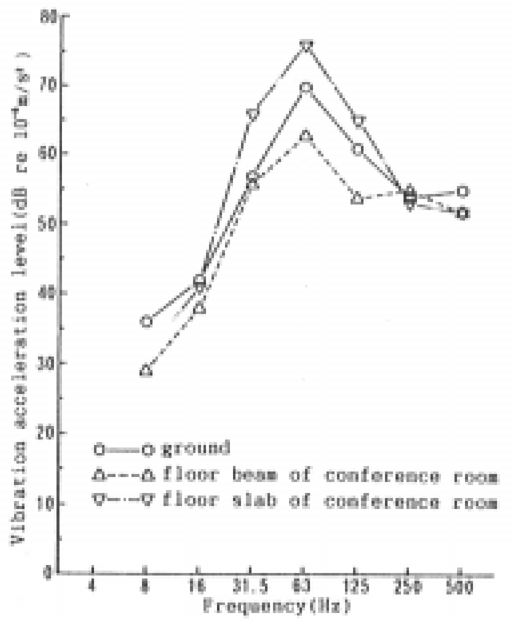

Fig. 3 Vibration of ground and structure generated by subway-A train.

<u>Propagation Characteristics of Vibration in Building</u>

The propagation characteristics of vibration arranged under the vibrations of each floor generated by subway-A and B respectively are shown in Figure 4. Here the abscissa shows the height from the first floor level. In this figure, the curved lines are obtained by the least square method putting the measured values in the equation (1).

$$L_r = L_{ro} - N \log(r/r_o) - M(r/r_o) \qquad (1)$$

Here the L_r represents the vibration acceleration level(dB) of each floor, L_{ro} the vibration acceleration level(dB) of the second floor, r the height(m) from the first floor, r_o the height(m) from the first floor to the second floor, N, M the constant values. In this equation, the second term express the attenuation due to spreading and the third term the attenuation due to dissipation. Here N value is equal to 0, because we suppose that the attenuation due to spreading does not occur in vertical direction.

From this result, it is shown that the propagation characteristics of vibration generated by subway trains have a decrease tendency according as the height increase and these tendencies obtained by subway-A and B differ. The caluclated curved lines agree with measured values fairly well.

M values which were caluclated by measured calues and equation (1) is shown in Figure 5. It is shown that M values are nealy the same at each frequency band.

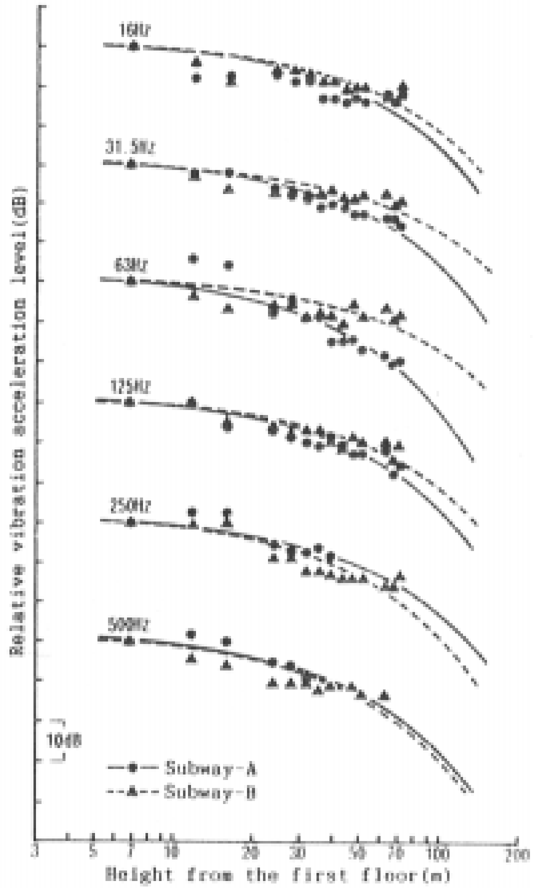

Fig. 4 Propagation characteristics of vibration generated by subway train.

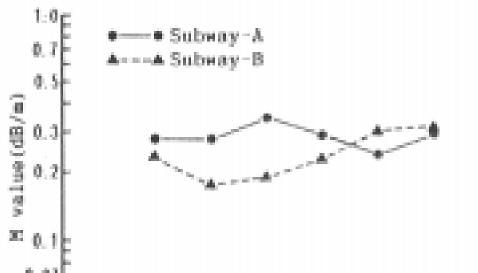

Fig. 5 Calculated M value.

Effect of Structure-Borne Noise Reduction by Room Enclosure

Figure 6 shows the comparison of structure-borne noise generated by subway-B trains which are obtained by construction of room enclosure that is vibration-isolated from surrouding structure at the conference room. It is shown that the amounts of reduction of structure-borne noise are over 15dB at each frequency band.

On the other hand, the comparison of structure-borne noise in the conference room applied room enclosure and that in the other room with general finish generated by subway-B train is shown in Figure 7, and the clear difference of the noise level is indicated.

Effect of VIbration Reduction by Room Enclosure

Figure 8 shown the difference of the vibrations of the room enclosure's floor and the vibrations of the structure of the conference room before construction of the room enclosure. Form this result, the reduction effect is shown at over 63Hz frequency band.

(2)under the assumption that the stiffness of floor structure is infinite and the room enclosure is a mass is shown in this figure.

It is shown that the caluclated curved line agrees with measured values fairly well at frequency band under 50Hz. Here Tr denotes the force transmissibility, ζ the damping ratio, fr thenatural frequency of sytem, f the frequency.

$$Lt = 20 \log (1 / Tr)$$

$$Tr = \sqrt{\frac{1 + (2\zeta f / fr)^2}{(1 - f^2 / fr^2)^2 + (2\zeta f / fr)^2}} \qquad (2)$$

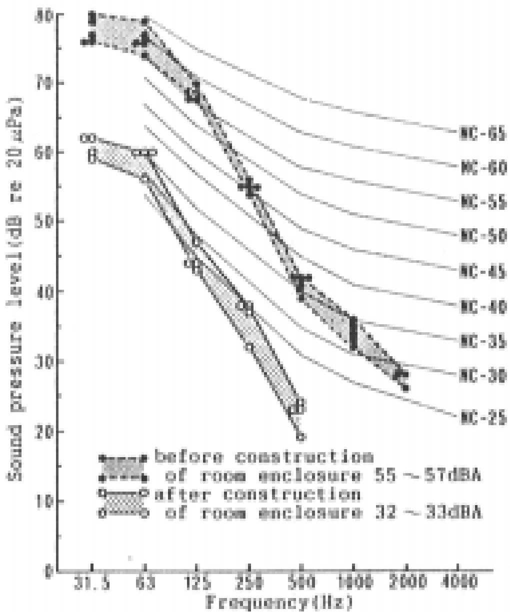

Fig. 6 Structure - borne noise (generated by subway - B train) obtained by construction of room enclosure.

CONCLUSION

From the results of our investigations, it is concluded that the reduction of structure-borne noise generated by subway trains which is obtained by the vibration-isolated room enclosure from surrounding structure is over 15dB and the vibration propagation characteristics in the building obtained by two kinds of subway lines are different.

REFERENCE

[1] Matsuda, "Propagation Characteristics of Solid-borne Sound in Building Structure", (in japanese), J.Acoust.Soc.Jpn. vol.35 No.11

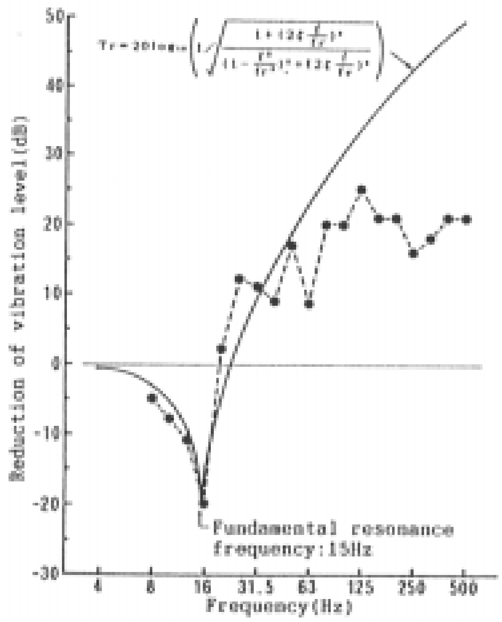

Fig. 8 Reduction of vibration (generated by subway - B train) obtained by construction of room enclosure.

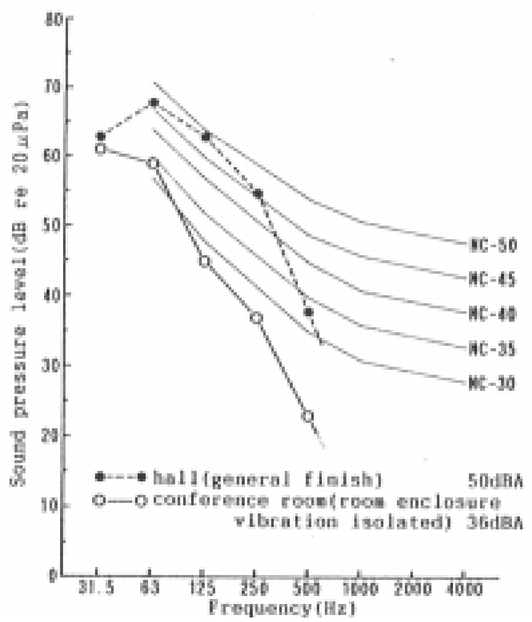

Fig. 7 Structure - borne noise (generated by subway - B train) in rooms obtained by two kind of finish.