ANALYSIS OF VIBRATIONAl ENERGY FLOW BY USE OF CONCRETE STRUCTURAL MODEL

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INTRODUCTION

For the transmission of structure-borne sound through building structures, it is very difficult to know the general propagation characteristics, because the buildings are composed of various elements, and have different shapes and structures for each one. FEM technique has been adopted for the analysis of vibration propagation, but it seems to be inefficient for time consumption and cost efficiency. In order to study the vibrational energy flow in buildings, we have adopted by method of SEA(Statistical Energy Analysis). In SEA, power flow through structural elements can be predicted by theoretical analyses on models representing equilibrium between vibrational modes of elements. In this paper, we have measured and analyzed vibrational energy flow by employing a simple model of a concrete structure box which simulates approximately one room in actual buildings.

ANALYSIS MODEL

Analyses and measurements were carried out using a concrete box(inside volume $3.0m(H)\times3.2m(W)\times4.1m(D)$, wall thickness=0.2m, ceiling thickness=0.15m, floor thickness=0.3m) shown in Fig.1. This model was installed on the concrete basement, and it was isolated from basement by the floating consruction; therefore it is not necessary to consider the power flow between model and basement. Also, it is assumed that the power flow between the outside space of model and all plates can be neglected. Figure.2 illustrates the associated power flow diagram for this concrete structure model. If plate 1 is excited by the power Plout, power balance in such multi coupled systems is given by following seven algebraic equations

$$\begin{aligned}
P1out &= P12 + P13 + P14 + P15 + P17 + Pd1 \\
P2out &= P21 + P23 + P25 + P26 + P27 + Pd2 \\
P3out &= P31 + P32 + P34 + P36 + P37 + Pd3 \\
P4out &= P41 + P43 + P45 + P46 + P47 + Pd4 \\
P5out &= P51 + P52 + P54 + P56 + P57 + Pd5 \\
P6out &= P62 + P63 + P64 + P65 + P67 + Pd6 \\
P7out &= P71 + P72 + P73 + P74 + P75 + P76 + Pd7
\end{aligned} \tag{1}$$

where Pij(i, j=1 to 7) represents net transmitted power from system i to system j, and Pdi represents the power dissipated in system i.

EXPERIMENTAL RESULTS

We have measured vibration acceleration levels on every plates when the center of the plate 1 is excited by a electro-dynamic shaker.
The results are shown in Fig.3, Fig.4 and Fig.5. Measured values are averaged over each plate. For example in case of plate 1, measurement points are arranged on 13×17 grid points with interval of 0.25m. In this case, plate 2 and plate 4 are symmetrical with respect to an excitation point, and so, it is possible to assume the equipartition principle. As to plate 3 and plate 5, same situation can be held. The experimentally obtained values of vibration acceleration level on both plates are in good agreement. These results show that vibration acceleration level of plate 1 is higher than the other, and vibration acceleration level of plate 2, plate 3, plate 4 and plate 5 are practically equal. Vibration level of plate 6

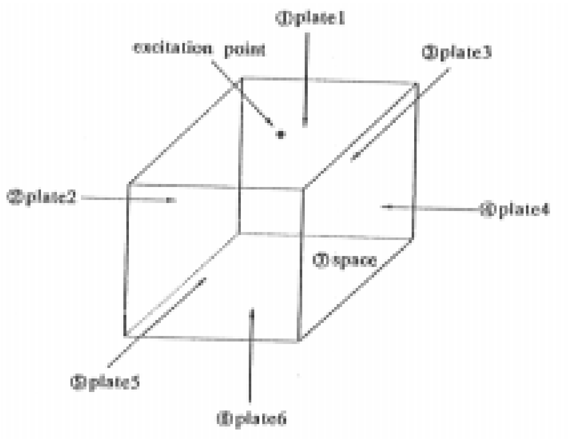

Fig. 1 Concrete box model

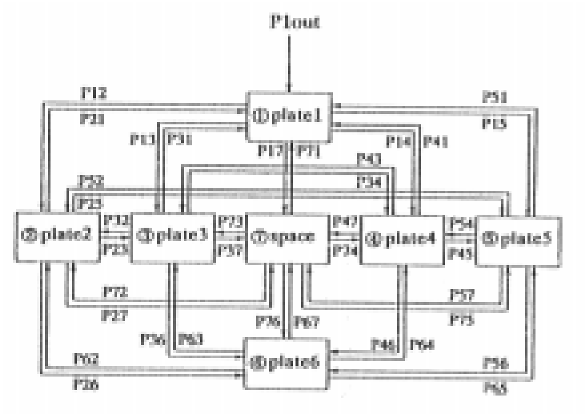

Fig.2 Power flow block diagram

is lower than the other.

COMPARISON OF MEASUREMENT AND ANALYSIS

Mean-squared vibration velocity for every plates were calculated by use of Eq.(1) and the parameters given in Table 1. The vibration velocity ratios of a plate 1 and the are shown in Fig.6, Fig.7 and Fig.8.

On the whole, calculated values are lower than mastered values. generally, the reliability of calculated values determined from SEA depends on the number of modes that exist in the frequency band of interest.

In this case, calculated values do not agree with the measured values below 250Hz. This may be caused by the lack of the number of modes at low frequencies. The calculated number of modes for every plates are shown in Fig.9.

At high frequencies above 1000Hz, agreement between calculated values and measured values are not so good, because the transmissibility of bending wave at the junction is determined only by considering the plate thickness ratio.

CONCLUSION

Generally, the reliability of analysis by SEA on the vibrational energy flow through building structures depends on the number of modes in frequency band of interest.

From the results of analysis on the simple concrete structure building model, it was found that energy flow at low frequencies where the number of mode is insufficient. On the other hand, at sufficiently high frequencies of transmissibility at the junction.

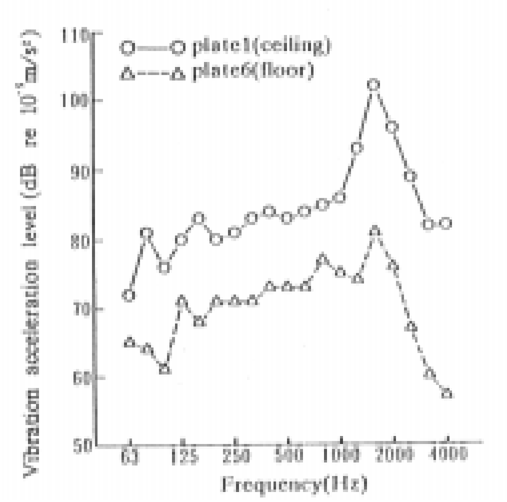

Fig. 3 Measured values of acceleration level of plate and plate 6.

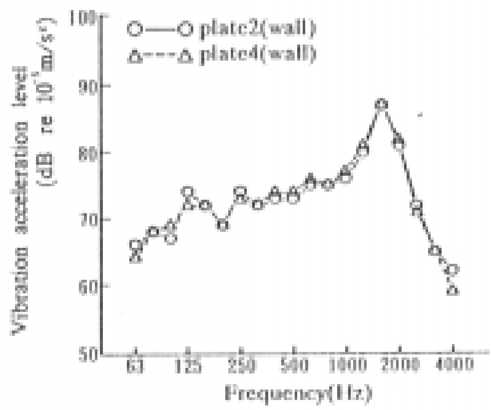

Fig. 4 Measured values of acceleration level of plate 2 and plate 4

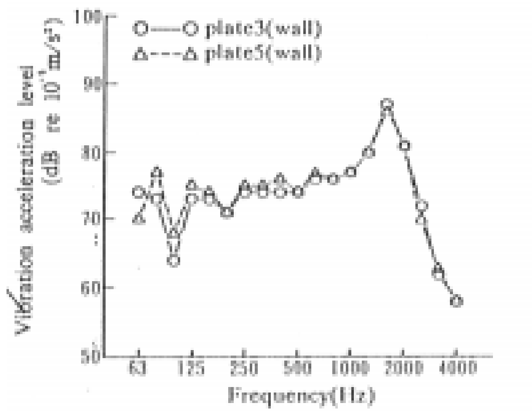

Fig. 5 Measured values of acceleration level of plate 3 and plate 5

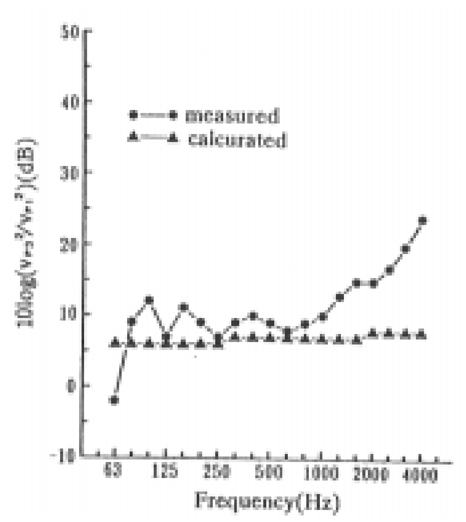

Fig. 6 The velocity ratio of plate 1 and plate 3

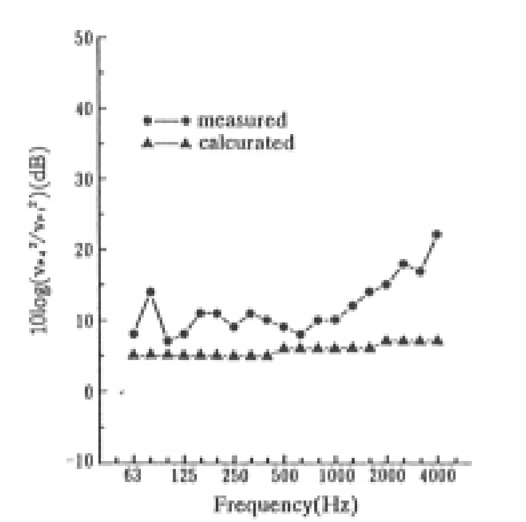

Fig. 7 The velocity ratio of plate 1 and plate 4

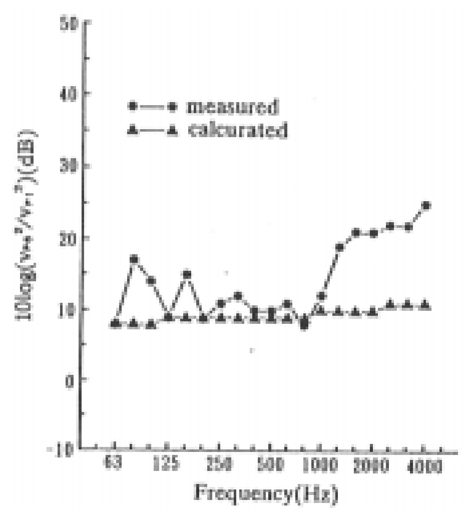

Fig. 8 The velocity ratio of plate 1 and plate 6

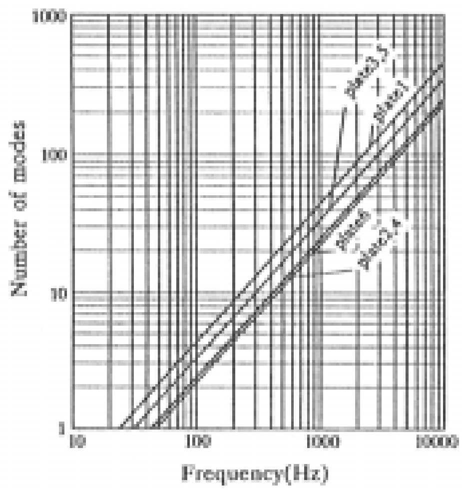

Fig. 9 The bending modes of every plates with free edges

Table 1 Parameter lists for calculation

(concrete)		(air)	
loss factor	0.005	acoustic	
density	$2300 kg/m^3$	impendance	$414 Pa \cdot s/m$
Young's module	$2.7\times10^{10} N/m^2$		
Poisson's ratio	0.17		

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