14. On the Vibrations of a Building caused by Microseisms.

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1. The vibrations of various kinds of buildings were already studied by many investigators[1], but few observations with a seismometer of long period and large magnification were made. Therefore, the vibrations of a building caused by the ground vibrations of long periods have not been investigated yet.

We observed the vibrations of the main building of the Koishikawa Botanical Garden in Tokyo, on Dec. 7th, 1948 with seismometers which have long periods (T_0=15 sec.) and large magnifications (V=1920). The seismometers were the same ones used for the study of propagations of microseisms at that place, but the periods of free vibrations were adjusted to 15 sec..

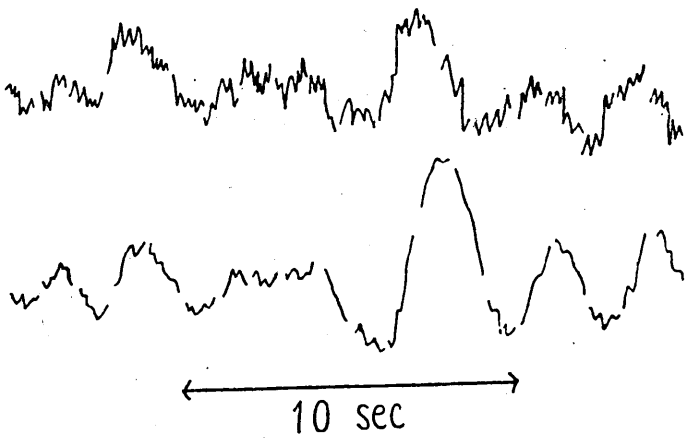

Fig. 1. The vibrations of the 5th floor (upper figure) and the 2nd floor (lower figure) caused by microseisms, when the wind died down. (Actual size.)

1) F. ÔMORI, *Rep. Imp. Earthq. Inv. Comm.*, 97 (1921), 1.
A. IMAMURA and F. KISHINOUYE, *Bull. Earthq. Res. Ins.*, 5 (1928), 143.
S. UCHIDA, T. SAIDA and K. MUTÔ, *ditto*, 6 (1929), 345.
M. ISHIMOTO and R. TAKAHASI, *ditto*, 7 (1929), 175.
K. FUKUTOMI, *ditto*, 9 (1931), 485. etc.

On that day, the amplitudes of microseisms were comparatively large, and maximum wind velocity was about 9 m/sec on the ground. We set up two seismometers in the same direction on the 2nd and the 5th floors

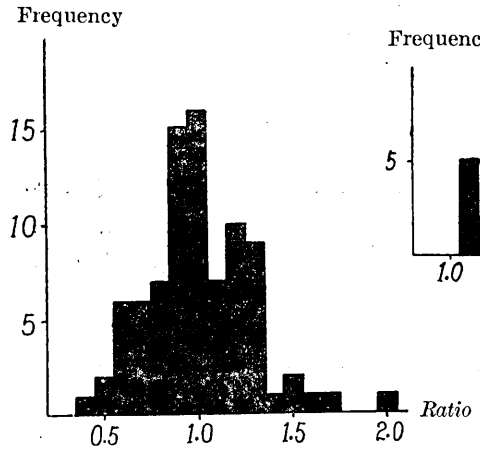

Fig. 2. The relation between the ratios of the amplitudes of about 4 sec. period vibrations on 5th floor to that on the 2nd floor and theis frequencies.

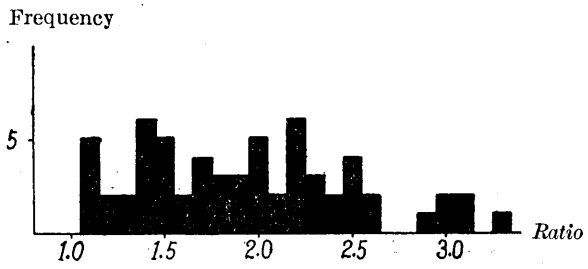

Fig. 3. The relation between the ratios of the amplitude of short period vibrations on the 5th floor to that on the 2nd floor and theis frequencies.

of the tower of that building. The observations were tried in two cases: when the strong wind was blowing against the tower and when it died down.

2. When the wind died down, the vibrations of the building were caused only by microseisms, which contained the two vibration periods, about 4 sec. and 0.25 sec.. The records of both floors are shown in Fig. 1. The amplitudes of the long period vibrations are almost equal on both floors. Fig. 2 shows the frequencies of the ratios of the amplitude on both floors, and we see that a ratio of maximum frequency is about 1.

From this result, it may be concluded that the vibrations of this building are horizontal motions which are parallel to ground motions rather than rocking motions.

But this phenomenon is not always seen in short period motions. Namely, Fig. 3 shows

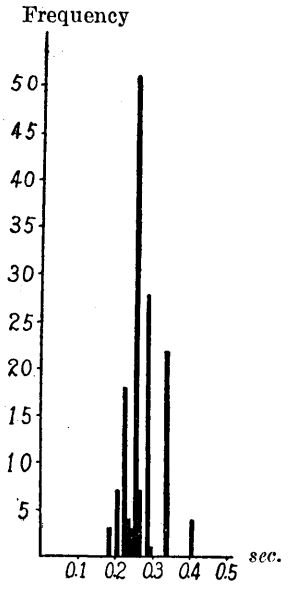

Fig. 4. The relation between the vibration period and the frequencies on the 5th floor.

the frequencies of the amplitude ratios of short period motions on both floors. In Fig. 3. we see that the values of ratios are scattered over within 1.1 and 3.3, but they are never less than 1.0. This result shows that on the 5th floor the motions caused by short period ground motions are larger than the ones on the 2nd floor. The average value of ratios was 1.89.

Judging from these observations, we deduced that this building moves equally to the ground for long period ground motions, but the 5th floor is moved two or three times more than the 2nd floor for short period ground motions.

A maximum frequency of vibration periods on the 5th floor was at 0.25 sec. as shown in Fig. 4. It is considered that this period was perhaps near the period of this building.

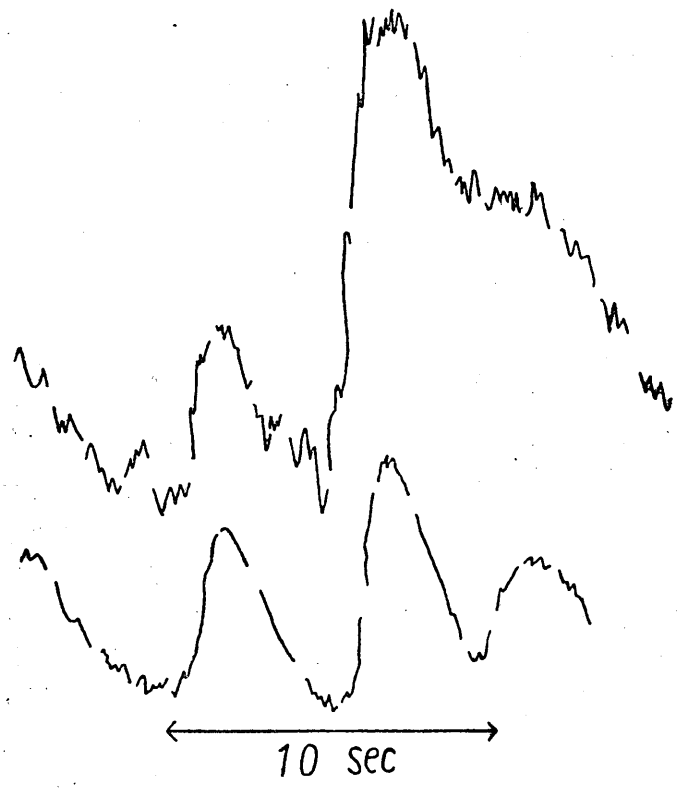

Fig. 5. One example of the records of seismometers set up on the 5th floor (upper figure) and the 2nd floor (lower figure) in the vertical direction to the wind, when the strong wind was blowing against the tower. (Actual size.)

3. When the strong wind from the north (about 9 m/sec on the ground) was blowing against the tower of this building, the vibrations of which presented another conditions.

Fig. 5 shows one example of the records of seismometers set up on both floors in the vertical direction to the wind. In these records we see the large displacements, when the strong wind was blowing against the building.

It is necessary to consider that these displacements are caused either by inclination or by parallel displacement of the whole building. If these displacements are caused by the latter, judging from the directions of displacements of records, this building must be moved to windward. This inference is inconsistent with common sense. If these are caused by the former, these imply inclination to the leeward, and this inference seems to be true.

We will discuss further that this inclination was caused either by bending or by rocking of the tower. Judging from the fact that the amplitude of short period at the time of restitution never became larger than the one at the other time, we concluded that this inclination was due to rocking and not bending.

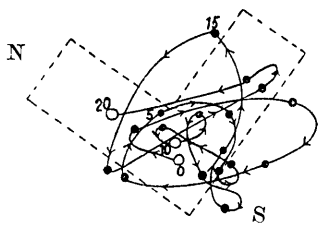

Fig. 6. (a)

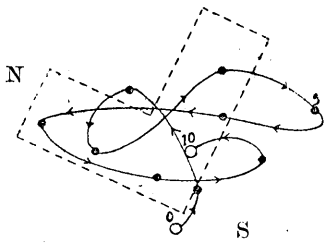

Fig. 6. (b)

The orbits of the vibration described from the records of two seismometers on the 5th floor.

(a) When the wind died down. (b) When the strong wind from the north was blowing. The dotted line shows an outline of this building.

Fig. 6 shows orbits of the vibration described from the records of the NS- and EW-components on the 5th floor. We see from these orbits that the movements of EW-direction are large, when the wind dies down, but those of NS-direction which is the wind direction become large, when the wind blows against the tower. That is to say, the displacements of this building are caused on the 5th floor by the wind as much as by microseisms.

In future we will observe the microseisms inside and outside a building simultaneously and compare both records each other. Then the motions of a building caused by microseisms will be ascertained.