14. The Earthquake-Motions on Various Formations of the Earth's Surface. (II) Observations at Gobō and Kiribe.

By Shūzō SAKUMA,

Earthquake Research Institute.

(Read Feb. 18, 1947.—Received March 31, 1949.)

1. INTRODUCTION.

The damages on buildings by earthquakes are always seriously affected[1] by geological and geographical conditions of the ground on which they are built. At the time of the Nankai Earthquake of 1946 also the remarkable effects of surface-layers on the damages were noticed. The writer attempted to treat this problem by simultaneous observations of earthquake-motions on various grounds, availing himself of the after-shocks. The observations were carried out in the vicinities of Gobō and Kiribe in Wakayama Prefecture. The outline of the work is reported here.

2. THE INSTRUMENTS AND METHOD OF THE OBSERVATIONS.

Two microseismographs of the same type (Improved Ishimoto's Type) were used for the present purpose. One of them was set at a fixed station (the standard station) and the other was transported from one field-station to another on the ground of various geological conditions. The distance between the two stations did not exceed 2.4km, which was small enough when compared with the epicentral distances of earthquakes actually used in comparison. Then, the effects due to the difference in epicentral distance and azimuth about each earthquake could be reduced greatly and those due to the surface-layers were examined. The constants of each seismograph are as follows:

Geometrical magnification:	150
Period:	1.0 sec
Damping ratio:	1:10

The characteristics were proved to be perfectly the same by calibration at the standard station. N-S component of earthquake was simulta-

1) loc. cit. in p. 61 of this Bulletin.

neously recorded at two stations. In most cases three or more available records of earthquakes were obtained in one or two days.

3. STATIONS OF OBSERVATION.[1]

(a) Gobō (Fig. 1)

(1) The Gobō Middle School (standard station) : gravels and sand.
(2) The Gobō Girls' High School (0.3km SW of (1)) : gravels and mud.
(3) Maruyama (2.0km N of (1)) : slightly weathered mesozoic rock.
(4) Matubara (1.2km SW of (1)) : thin muddy soil covered with ballast, near sandy coast.
(5) Sinhama (1.5km SW of (1)) : fine sand.
(6) Wada (2.4km W of (1)) : soft mud containing fine sand.
(7) Nisi-Gobō (1.3km S of (1)) : reclaimed land by ballast.

The damages due to the Nankai Earthquake were not remarkable in this district and, at Gobō, only cracks on walls were seen. At Wada, however, tiles of roofs slipped down and many houses tilted and were half-destructed. On the other hand, at Maruyama the seismic intensity was far less than that at Gobō and no damage was caused.

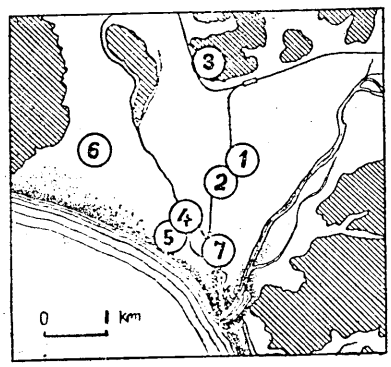

Fig. 1. Stations near Gobō.

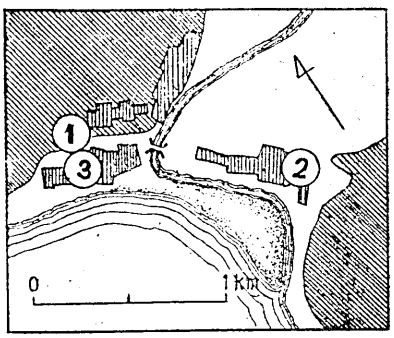

Fig. 2. Stations at Kiribe.

(b) Kiribe (13km SE of Gobō) (Fig. 2)

(1) The Kiribe Primary School (Uedō) (standard station) : on the coastal terrace of mesozoic rock covered with gravels.
(2) Simada (1.2km SE of (1) : water-rich mud and gravels.
(3) Motomura (0.3km S of (1)) : gravels and fine sand.

1) S. MIYAMURA, Same Bulletin p. 101-104.

The damages were concentrated to Shimada, where several houses were destructed. At Motomura, walls and roofs were slightly injured. No damages at Uedō.

4. Results of Observation.

In the vicinities of Gobō, the observation was done during 12th—25th, Jan., 1947, and at Kiribe during 24th—27th. The frequency of the duration of preliminary tremors (P-S time) of the recorded earthquakes is shown in Fig. 3. The after-shocks occurred far and wide as illustrated in this figure and as reported by T. Hagiwara and S. Murauchi.[1)]

In comparing the seismograms each other, the earthquakes, the epicentral distances of which were large enough in comparison with the distances between the stations concerned, were taken up.

Remarkable differences were found among the seismograms on the grounds of various formations, that is, in both amplitude and period.

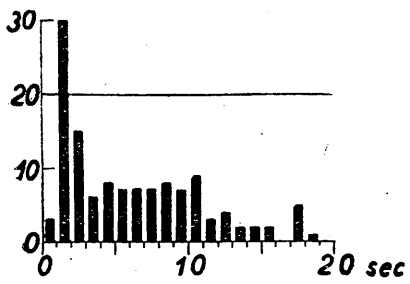

Fig. 3. Frequency of P~S time at Gobō.

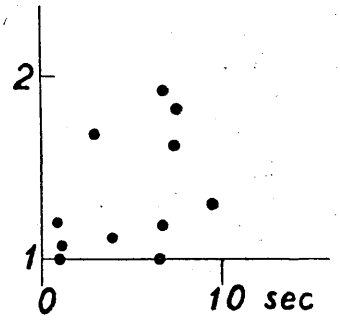

Fig. 4. Ratio of the maximum amplitude (in ordinate) and P~S time (in absissa). [Gobō (2) : (1)]

(a) Amplitude

With regard to the amplitude, comparison was done for the maximum ones. The mean values of the ratios of the maximum amplitude of field-stations to standard stations are tabulated on Table I with probable errors. Fluctuation in the ratio among several earthquakes which were recorded at a definite field-station and at a standard station may be due to the characteristics of incident waves. It may not be so unreasonable to suppose that these incident waves of different characters cause different modes of vibration near the earth's surface. The ratio of amplitudes of eleven earthquakes of various P-S time, obtained simultaneously at (1)

1) T. Hagiwara, S. Murauchi & J. Yamada, *Bull. Earthq. Res. Inst. Supplement* Vol. 5 (1947), p. 164 (In Japanese).

and (2) of Gobō, are shown in Fig. 4 as an example.

Nevertheless, the difference of the mean value of ratio is remarkable enough among the stations on various sediments. That is, the amplitude is greater on alluvial formations than on hard rocks, and especially on soft muddy soil such as at Wada, the amplitude attains about three times more than on mesozoic rock. Another interesting result is the smallness of amplitude on sand.

Table I. Ratio of Max, Amplitude and Predominant Period.

Station	Ratio	Predominant Period
(a) Gobō		
(1) Middle School (standard)	1.0 ± 0.0*, (4)**	0.4—0.5 sec.
(2) Girls' School	1.3 ± 0.3, (11)	0.2, 0.4 ,,
(3) Maruyama	0.7 ± 0.1, (4)	0.2, 0.4 ,,
(4) Matubara	1.0 ± 0.1, (5)	0.4—0.5 ,,
(5) Sinhama	0.8 ± 0.1, (3)	0.6 ,,
(6) Wada	2.4 (1)	0.2, 0.5 ,,
(7) Nisi-Gobō	1.5 (1)	0.5—0.6 ,,
(b) Kiribe		
(1) Uedō (standard)	1.0***	0.2 sec.
(2) Simada	1.4 ± 0.1, (3)	0.3—0.4 ,,
(3) Motomura	1.2 (1)	0.2 ,,

Note: * The result of calibration
** The number of earthquakes compared
*** Setting standard station as 1.0

(b) The Period of Earthquake-Motions

Intervals between successive peaks on seismograms were read and frequency of occurrence was obtained for several records at every station. The predominant periods are not always the same for the earthquakes recorded at the same station. The examples of distribution of frequency are illustrated in Fig. 5. This character may probably be due to the same causes as mentioned before with regard to the fluctuation of the ratio of amplitude. With a glance at Table I, one can conclude that, on alluvium and reclaimed land, periods are always longer than on hard rocks. The long period at Sinhama is also interesting. It may not be decided now, whether this is caused by character of sand or by the same manner as Wada and Nisi-Gobō.

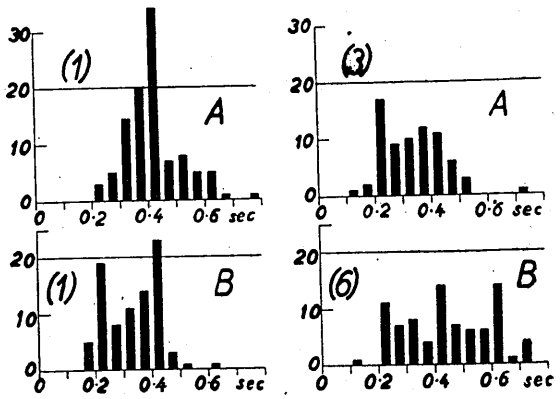

Fig. 5. Frequency of period of two Eqks.,
A: Jan. 16, P~S time 6.6 sec.; B: Jan. 21, P~S time 8.9 sec.
Station (1): Middle School; (3): Maruyama; (6): Wada.

5. Conclusion.

The damages on houses are connected with the amplitude and period of earthquake-motions. The results which were obtained at Gobō and Kiribe affirmed this fact quantitatively. Detailed studes of virbations in surface-layers are interesting problems in future.

In conclusion, the writer wishes to express his thanks to Dr. T. Minakami for his guidances and valuable advices.