30. *Earthquake Observations in Kawasaki and Turumi Areas and the Seismic Qualities of the Ground. (Part II).*

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1. Introduction

In our previous paper[1] we analyzed the seismograms obtained at nine observation stations in the Kawasaki and Turumi regions, a short distance to the south of the Tokyo area, and discussed the seismic qualities of the ground of nine locations where the seismometers were installed. In grading the seismic qualities of the ground of the respective locations, the vibration characteristic of the Keio Station, station S*, was used as the standard. Referring to this standard station the relative seismic qualities of the ground of the other stations were described.

In the course of our analysis of the seismographic records obtained at the respective stations, we came to the conclusion that station S probably recorded a somewhat larger amplitude because of the high cliff of some 30 meters, near the edge of which the station was situated. In order to give reasonable correction to the amplitude of station S, we hoped to change the standard station from S to another standing on ground with better conditions.

On the other hand, as we stated in the previous paper, the studies of the connection between ground vibration and seismic destruction have mainly been developed in the Tokyo area where many seismic observations had been carried out. In discussing the seismic quality of the ground of these locations, their vibration characteristics were compared with that of the Hongo location where our Institute stands, and by doing so the relative grade of the seismic quality of the locations in the Tokyo area was described. For the purpose of giving wider application to our former study, it is intended in this paper to attempt a

1) S. OMOTE, S. KOMAKI and N. KOBAYASHI, *Bull. Earthq. Res. Inst.*, **34** (1956), 335.

* In the present paper, S stands for the Keio High School instead of S-1 used in the previous paper.

comparison between the vibration characteristics of the Kawasaki and Turumi stations and that of the Hongo observation station, station H*.

The seismic observations at the Hongo station were carried out in the same way as in the Kawasaki and Turumi areas, using the same type of the seismometer to register the same component of the earth vibration and covering the same observation period. Though the commencement of the seismic observation by means of the said seismometer was somewhat later than had been expected, at station H, we could have many seismic records for making a comparative study in relation to those of our previous study. Such seismic records were laid at our disposal by the courtesy of the Observation Branch of our Institute. The present report is the result of interpretations studied with these records.

2. Period interpretations

Of the twelve earthquakes analyzed in detail in our previous paper, three earthquakes, Nos. 10, 36 and 38, were recorded at station H. The histograms due to the vibration periods of these earthquakes are illustrated in Fig. 1. From these were calculated such factors and predominant periods as were defined in the previous paper. These are; the sharpness factor $s_H(N/2)$, the flatness factor $f_H(N/2)$, the predominant period $T_H(N/2)$ due to the larger waves, the predominant period $T_H(A)$ due to the summed-up amplitudes, and the predominant period $T_H(W)$ due to the weighted frequencies. In them the suffix H represents the values of station H.

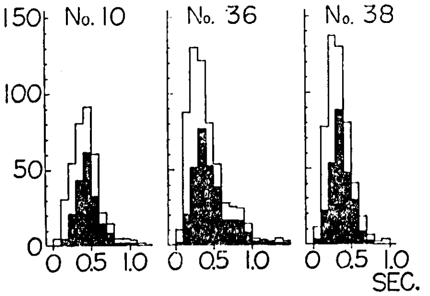

Fig. 1. Frequency histograms whose class interval is 0.1 sec.
White column: Histograms due to all waves.
Black column: Histograms due to larger waves.

The ratio of the value of station S to that of station H is computed with regard to each of these factors and predominant periods. The product is worked out of this ratio and the corresponding characteristic ratios of the respective stations in the Kawasaki and Turumi areas due to station S with the results shown in Table I–a. By this the standard is transfered from station S to station H. The figures in each column in

* H stands for Hongo.

Table I.

a. Characteristic ratios of the seismic quality of the ground.

	H	S	S-9	S-2	S-3	S-4	S-7	S-5	S-6	S-8
$S(N/2)$	1	1.01	1.96	3.06	3.56	3.67	5.28	5.17	4.32	4.13
$F(N/2)$	1	1.14	1.16	1.32	1.60	1.50	1.87	2.00	1.97	1.62
$T(N/2)$	1	1.10	0.94	1.36	1.45	1.61	1.55	1.64	1.68	2.01
$T(A)$	1	1.00	1.08	1.28	1.28	1.30	1.35	1.48	1.38	1.68
$T(W)$	1	1.18	1.18	1.62	1.53	1.65	1.62	1.70	1.68	2.17

b. Orders of characteristic ratios.

	H	S	S-9	S-2	S-3	S-4	S-7	S-5	S-6	S-8
$S(N/2)$	1	2	3	4	5	6	10	9	8	7
$F(N/2)$	1	2	3	4	6	5	8	10	9	7
$T(N/2)$	2	3	1	4	5	7	6	8	9	10
$T(A)$	1	2	3	5	4	6	7	9	8	10
$T(W)$	1	3	2	5	4	7	6	9	8	10

Table I–a have been numbered in order from small to large in Table I–b with respect to each item. Looking at Table I we find that all the characteristic ratios of stations S and S-9, representing the best seismic quality, have the values of nearly unity. This fact shows that the seismic qualities of these locations are to be ranked at the same grade as station H, or at only a slightly inferior grade.

3. Amplitude interpretations

In order to make clear the relationship between the two stations as to the summed-up amplitude, the sums of the amplitudes of all the waves that fall into the respective class intervals of periods were made out in the form

$$A_i = \sum_p a_{i,p} \ ,$$

where A_i is the summed-up amplitude of the i'th class and a_p the element amplitude in the i'th class. The summed-up amplitude A_i due to station S, denoted here as $A_{S,i}$, was divided by the value of the summed-up amplitude of the corresponding class intervals $A_{H,i}$, of station H. The running averages of these ratios were calculated as to every three numbers adjoining in order. The averaged ratios are plotted to the respective class periods as will be seen in Fig. 2. The larger circle in the figure represents the ratio where the numbers of waves in the denominator is greater than one half of the average number of waves per class. The medium circle represents the ratio where the number of waves in the denominator falls between one half and a quarter of the average number of waves per class. The smaller circle represents the ratio where the number of waves in the denominator is smaller than a quarter of the average number of waves per class. Therefore, it may be said that the smaller circles represent a value less reliable than the larger circles.

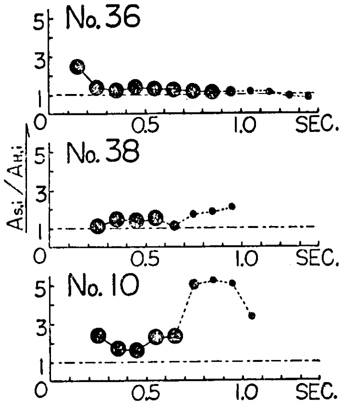

Fig. 2. Period characteristics of summed-up amplitude ratio.

Looking at Fig. 2, we notice that the amplitude ratios are only slightly bigger than unity with respect to each earthquake throughout the class intervals, and the mean value of these reliable ratios marked by the larger circles is 1.60. Though in some cases there are a few circles representing somewhat larger values than unity in the range longer than 0.6 sec., they are marked by smaller circles that show a low reliability.

In our previous paper it was noticed that the values of the maximum amplitude ratio of the stations, calculated with station S as the standard did not exceed 2 even in the stations considered to stand on very soft ground. On the other hand, referring to the studies made in the Tokyo area, it is expected that the values of the ratio of the stations which stand on very soft ground are greater than 2. It is one of the purposes of this paper to make clear whether or not station S has recorded too large a maximum amplitude in relation to its firm ground.

Now, the maximum amplitudes at two stations, S and H, were compared with those of eleven earthquakes, Nos. 9, 10, 29, 30, 36, 38, 39, 42, 43, 44 and 54. As a result of the calculation we had the mean value of the ratios of the maximum amplitudes, as

$$A_S/A_H = 1.57 \pm 0.18 ,$$

where A_S is the maximum amplitude of station S and A_H is that of H. It is noticed that this value is nearly equal to that mean value 1.60, calculated from Fig. 2.

Table II. Relation between the maximum amplitude ratio and the thickness of alluvium.

a. Station in Kawasaki and Turumi areas.

Observation station	*S*	*S*-9	*S*-2	*S*-3	*S*-4	*S*-7	*S*-5	*S*-6	*S*-8
Maximum amplitude ratio	1.57	1.05	1.38	2.18	1.62	2.24	2.50	3.09	2.80
Thickness of alluvium (m)	0	5	35	40	45	45	45	70	45

b. Stations in Tokyo area.

Observation station	Sumida	Oshima	Komatsugawa	Higashi-shinozaki
Maximum amplitude ratio	1.62	2.46	2.68	2.90
Thickness of alluvium (m)	30	45	50	66

In our previous paper, maximum amplitude ratios of the respective eight observation stations were calculated with the maximum amplitude of station *S* as the standard. In order to transfer the standard station from *S* to *H*, the figures of the maximum amplitude ratios which were already laboured out in the former paper were multiplied by the value 1.57 obtained above. The relation between these ratios and the thickness of the alluvium at each station is shown in Table II–a and in Fig. 3 with solid circles.

In the period from 1952 to 1954 Miyamura[2] carried out seismic observations at four locations in down-town Tokyo as well as at the Hongo station, using six seismometers with different periods. From his data on the maximum amplitudes and periods recorded by these seismometers, we picked up such amplitudes as were recorded by

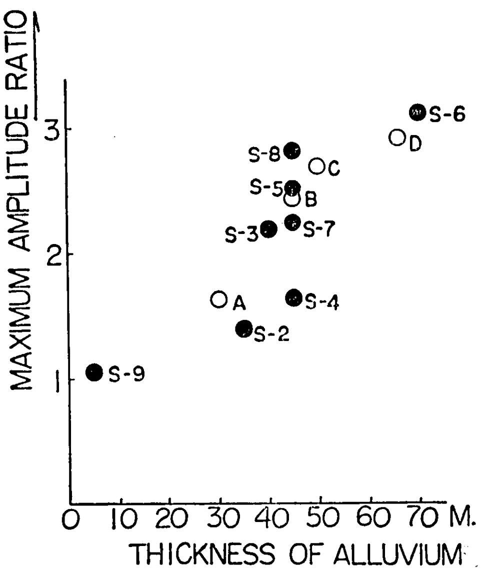

Fig. 3. Relation between the maximum amplitude ratio and the thickness of alluvium.
A: Sumida. C: Komatsugawa.
B: Oshima. D: Higashi-shinozaki.

2) S. Miyamura, *Bull. Earthq. Res. Inst.*, **33** (1955), 512.

Ishimoto tromometers having the oscillation period of one second, and we computed the ratios of the maximum amplitudes of the down-town stations to that of the up-town Hongo station. These maximum amplitude ratios of the stations too were related to the thickness of alluvium[3] at the respective stations in Table II-b and in Fig. 3, with the open circles.

In this figure we can compare the ground conditions of the stations distributed in the Kawasaki and Turumi areas with those of the Tokyo area. Looking carefully at Fig. 3, we notice that the ground conditions of the 1st group of stations in the Kawasaki and Turumi areas, including *S* and *S*-9, resemble closely in seismic quality that of station *H* standing in up-town Tokyo, those of the 2nd group, including *S*-2, *S*-3 and *S*-4, that of the Sumida station in the Tokyo area, and lastly that those of the 3rd group, *S*-5, *S*-6, *S*-7 and *S*-8, are in good accord with those of such stations as Oshima, Komatsugawa and Higashi-shinozaki, which stand in down-town Tokyo.

Kanai and others[4] made some observations of earthquakes in many buildings with the same construction but standing on the ground of different natures by means of Ishimoto tromometers having a period of one second. In their report we read that the smaller the regidity of the ground is, the larger will be the maximum amplitude of earthquake motions. This coincides well with our result.

Before discussing the maximum amplitude in this paragraph, two kinds of correction had to be made. One is the correction of the amplitude caused by the difference of dynamic magnification due to the periods proper to the respective maximum amplitudes. The other correction concerns the difference in the epicentral distances. In practising this correction it is assumed that the maximum amplitudes decrease in inverse square proportion to their epicentral distances[5] because it is the *S* wave that determines the maximum amplitude of the earthquakes with a short epicentral distance.

Before concluding this paragraph, it will be of some use to add the following facts to what has been discussed above. One is that the maximum amplitude ratio of station *S* to station *H* is smaller than unity as regards earthquakes with the epicentres off the east coast of Honsyu

3) S. OMOTE, *Bull. Earthq. Res. Inst.*, **33** (1955), 479.
4) K. KANAI, T. SUZUKI and S. YOSHIZAWA, *ibid.*, **34** (1956), 61.
5) H. KAWASUMI, *Bull. Earthq. Res. Inst.*, **30** (1952), 319.
C. TSUBOI, *Journ. Phys. Earth*, **5** (1957), 1.

Island of Japan. Another is that the maximum amplitude ratio of station S to station H is extremely large, 4.05 in the case of earthquake No. 11, with the epicentre in the vicinity of Titibu City in the western mountaineous part of the Kwanto District.

4. Conclusions

Judging from the period and amplitude interpretations studied above, the following results will be summarized.

The stations belonging to the 1st group in the previous paper, S and S–9 have a seismic quality similar to that of station H located in the up-town of Tokyo. The 2nd group including S–2, S–3 and S–4 have a seismic quality similar to that of Sumida station. The 3rd group including S–5, S–6, S–7 and S–8 have a seismic quality similar to those of Oshima, Komatsugawa and Higashi-shinozaki stations in the downtown of Tokyo.

The authors wish to express their indebtedness to Professor Takahiro Hagiwara, the Chief of the Observation Branch of their Institute, for the use of the original seismograms on which their analysis was based.

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30. 川崎鶴見地域9ヶ所で行つた地震観測とその場所の地盤特性（その2）

地震研究所 表 俊一郎
小 牧 昭 三
小 林 直 吉

我々はさきに川崎鶴見地区 9ヶ所に置かれた地震計の記録に基き，その波を解析して各々の地震計の置かれた場所の地盤特性を調べた．その際には洪積台地の上にある慶応高校に置かれた地震計の記録を基準として他の観測点の震動特性が調べられた．その時にも述べたように，一つには基準点とした慶応高校が約 30 m の崖の上にあつて，その崖縁の影響と思われる原因により振幅が少し大きく出すぎるように思われる傾向が見えること，もう一つには，本郷の記録と比較して川崎鶴見地域の地盤をすでにかなりよく調べられている東京の地盤と関連させることの為に，本郷にある本研究所に於て，川崎鶴見地域で用いたと同じ地震計で而も同じ南北成分で観測した記録の解析を行つた．本郷で観測された地震の記録について地震動の周期及び振幅の解析を行い，慶応の周期及び振幅とそれぞれ比を求めることによつて，先に慶応を基準として求めた各観測点の特性比及び最大振幅比を本郷を基準としたものに書き直した，因みに慶応の本郷に対する最大振幅比は，1.57±0.18 である．更に宮村は昭和 27 年－29 年に本郷と東京下町とに於て地震の比較観測を行つているので，その data を用いて，本郷に対する下町各点の最大振幅比を求めた．このようにして川崎鶴見地域の各観測点と東京下町の各観測点とを関連づけることができた．これらの解析結果につき考察を行い，次のような結論を得た．即ち前に第 1 群に選定された慶応及びキリンビールは本郷と同様な地盤特性を示し，第 2 群に属する東芝，味の素，市場は隅田に第 3 群の鋼管，森永，港湾，埠頭は大島，小松川 東篠崎に対応することが解つた，