On the Tsunami of March 4, 1952.

By

Kozo YOSHIDA, Kinjiro KAJIURA and Hisashi MIYOSHI

(Geophysical Institute, Tokyo University)

1. Introduction.

At 10^h 23^m, on March 4, 1952, northern parts of Japan were attacked by a somewhat severe earthquake. The epicenter determined by the Central Meteorological Observatory from some seismological data is located at about 42.0° N., and 144.0° E. This location lies on the continental slope to south-east of the coast of Tokachi in Hokkaido and the tsunami accompanying this earthquake struck various parts of the coasts of Hokkaido and Sanriku.

The present report is concerned with the results of the general survey on the tsunami which was carried out along some parts of these areas.

2. General Features.

Measurements of the heights of waves were made by means of hand-level and graduated scales. Tidal records at several stations on March 4 were collected. Those data which could be gathered are shown in Table 1, and in Fig. 1, of which the values are calibrated to the actual wave heights from the normal

Table 1. Data on Tsunami from Tidal Records and from Observations.

Location	Time of arrival of waves	Period (in min.)			Height (in m)		
		Time interval from crest to crest I-II, II-III, III-IV	Several hours later	Secondary undulations	Order of the highest wave	Tidal record	Observed
Miyako	11 h 08 m	18 20 22	45~50	{ 20 40~50	1st	0.7	1.3
Hachinoe	11 h 10 m	52 41 57	50	{ 10~20 50~70	4th	1.9	2.2
Kushiro	10 h 50 m	40 45 40	{ 40~50 60	20	1st~2nd	1.1	1.4
Hakodate	11 h 30 m	30 30 ?	50	{ 20 30 50	4, 7, 10 hours later	0.7	?
Mori	?	50	50	10~20	?	0.3	?
Toyoura	?	60	60	{ 10? 60?	?	0.3~0.4	?
Birao	?	25~35	50~60	?	?	?	1.8

Fig. 2. Map of Hokkaido and Sanriku, showing the fronts of long waves which start from four stations and travel reversely during the travel times of the actual tsunami.

4. Refraction Diagram.

The refraction diagram is constructed on the assumption that the waves are radiated from the point source which coincides with the epicenter of the earthquake, (Fig. 3). At first sight, the general features of waves might be explained by this diagram. Comparing, however, the heights and the travel times of observed waves with those predicted, considerable discrepancies were found between them. Perhaps these discrepancies may indicate that the method of refraction diagram is not applicable in cases when the bottom topography near the source is irregular. In such localities the energy within two orthogonals seems not to be conserved. To the west of the source, we may be able to explain the ratios of wave heights in various places by the assumption that the wave energy diverges uniformly and so it is inversely proportional to the distance of the places from the source.

Along the coasts from Biroro to Akkeshi, the bottom slope is so steep that waves cannot be predicted well by means of a usual refraction diagram. The

Fig. 3. Refraction diagram, showing bottom topography, wave fronts of every five minutes, and orthogonals of the tsunami.

greatest height of about 6 meters observed at Tokotan at the mouth of Akkeshi Bay may be partly due to the reflection at the shore, and it seems reasonable to estimate that the actual heights of waves near Akkeshi may be about 3 to 4 meters. Even after this reduction, the ratio of the actual wave height near Akkeshi to those at Biroo is large compared with the corresponding ratio predicted from the refraction diagram. This may be ascribed to some effects of reflection at the margin of the continental shelf as is shown in Fig. 4.

A rough calculation is made as follows: Let the energy computed from the actual heights be α at Biroo and $m\alpha$ at Akkeshi and those estimated from the refraction diagram be $n\beta$ and β respectively. Furthermore, we assume that a part of energy which is radiated from the source and is to reach the coast of length l_1 near Biroo, is reflected and focussed within the coast line l_2 near Akkeshi. Then the energy equations are given by

$$\begin{aligned} n\beta l_1 (1-r^2) &= l_1 \alpha && \text{for Biroo,} \\ n\beta l_1 r^2 + l_2 \beta &= l_2 m\alpha && \text{for Akkeshi,} \end{aligned}$$

where r^2 is a reflection coefficient.

Fig. 4. Map showing the source of the tsunami Illustration of the reflection of waves at the margin of the continental slope.

Put $l_2/l_1 = P$, we have

$$\beta/\alpha = \frac{1+nP}{n+P},$$

and

$$r^2 = P(mn-1)/n(mP+1).$$

A rough estimation gives $P=1/2$, $n=2$ and $m=2$. For these values we find $r^2=0.37$. If we consider the case when the wave progresses in deep water ($h_1=800$ m) against shallow water ($h_2=100$ m) at incident angle of 45° , the reflection coefficient is $r^2=0.33$ from the theory, which is in fair agreement with the present estimate.

5. Period of the Waves.

The periods of this tsunami which were recorded in tidal records indicate that they might be related to the topographic conditions near the stations. The origin of the occurrence of longer period of about 50 minutes is obscure, but it may be of particular interest that comparatively short periods of 18 minutes are recorded at Miyako. The latter may partly be ascribed to the very steep slope of bottom near this coast, and partly to the proper oscillation of the water of Miyako Bay.

6. Energy of This Tsunami.

Assuming the energy to be radiated uniformly in all directions from the

source, the total energy of main waves may be estimated to be approximately 3×10^{22} ergs from obtained data along the coasts. This is about three thousandth of the energy of this earthquake, which is estimated to be about 10^{25} ergs. According to R. Takahasi (1951), the Sanriku Tsunami in 1933 had the energy of 16×10^{22} ergs and the average energy of the Sanriku Tsunamis in the past is about 8×10^{22} ergs, so that the energy of the present tsunami may be rather small.

7. Acknowledgement.

There are so many persons who have aided our survey or provided the tidal records, that we cannot mention them here. We wish to express our sincere thanks to Prof. K. Hidaka who gave us many advantages concerning this investigation.

The expense of this survey was defrayed from the fund for the Scientific Research of the Ministry of Education.

References

- Miyabe, N. 1934. An Investigation of the Sanriku Tsunami Based on Mareogram Data. *Bull. Earthq. Res. Inst.*, Supplementary Volume 1, Part 1, pp 112-126.
- Takahasi, R. 1951. An Estimate of Future Tsunami Damage Along the Pacific Coast of Japan. *Bull. Earthq. Res. Inst.*, Vol. 29, Part 1, pp 71-95.