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Evacuation Alarm Using the Improved Magnitude Method to Damage Caused by Typhoon 9918

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ABSTRACT: In 1999, Typhoon 9918 struck Kyushu Island, which is located in Western Japan. During the strongest stage of the typhoon, the central pressure was 930 hPa and the maximum wind speed was 46.3 m/s near the center of the typhoon. Due to the significant storm surges and high and long period wind waves, the typhoon caused extensive flooding to land area and enormous damage to maritime structures. The improved Magnitude (iM) Method can be used to estimate the damage length of maritime structures that will occur along the coast before a typhoon strikes. The usefulness of a forecasting of the damage length on an announcement of storm warnings and evacuation using an iM Method for coastal residents is discussed. The result shows that this forecasting method is useful for disaster prevention management to coastal residents.

Keywords: Forecasting, Evacuation, Alarm, Vulnerability, Magnitude, Damage length

1 INTRODUCTION

The forecasting of damage length which occurs along the coastal areas is very important in the economic activities and security of fishermen, the operation of port facilities and the safety of port workers and local residents along the coastal region. Typhoon 9918, which maintained a maximum wind speed of almost 45 m/s near the center, struck the Kyushu Island in the western part of Japan. The anomalous storm surge was induced in the closed seas of the western region of the Kyushu Island by Typhoon 9918. The maximum anomaly is estimated to be about 3 m at the northern part of the Yatsushiro west coast (Figure 1). In total, 16 people were killed, 62,772 houses destroyed or damaged, and 1,883 houses were flooded. There was no forecasting system along the damage length that occurred by the typhoon passing through Kyushu Island. If an announcement of storm warning and evacuation had been provided for residents along the coastal area before the typhoon struck, these victims might have been spared.

The forecasting method based on the magnitude of a typhoon center is described. The usefulness of a forecasting system for announcements of storm warnings and evacuations using an improved Magnitude Method for coastal residents is discussed.

2 IMPROVED MAGNITUDE METHOD

The author proposed an improved Magnitude Method which is calculated based on 74 typhoons over past 25 years from 1980 to 2004. This method is proposed for forecasting the damage length of maritime structures caused by an approaching typhoon on each coast along the coastal regions in Kumamoto Prefecture (Figure 1). All typhoons passed an area delineated by a latitude of 30° N and 35° N and a longitude of 127° E and 132° E in a 25-year period. The number of typhoons passing through the delineated area is 74. The paths of typhoon are classified according to 13 types. The magnitude method is defined based on the maximum wind speed near the center and the size of the typhoon at a latitude of 30° N. The size of typhoon is defined as the radius of the area in which the wind speed is greater than 15 m/s. The maximum wind speed is classified into 10 ranks and the size is classified into 8 ranks. The magnitude is ranked from 1 to 17 as shown in Table 1. The damage length is defined as an alongshore length of damaged structures caused by a typhoon. This magnitude method utilizes an index of vulnerability of a coast for a typhoon passing along a specified path, which was derived from the damage length caused by 74 previous typhoons.

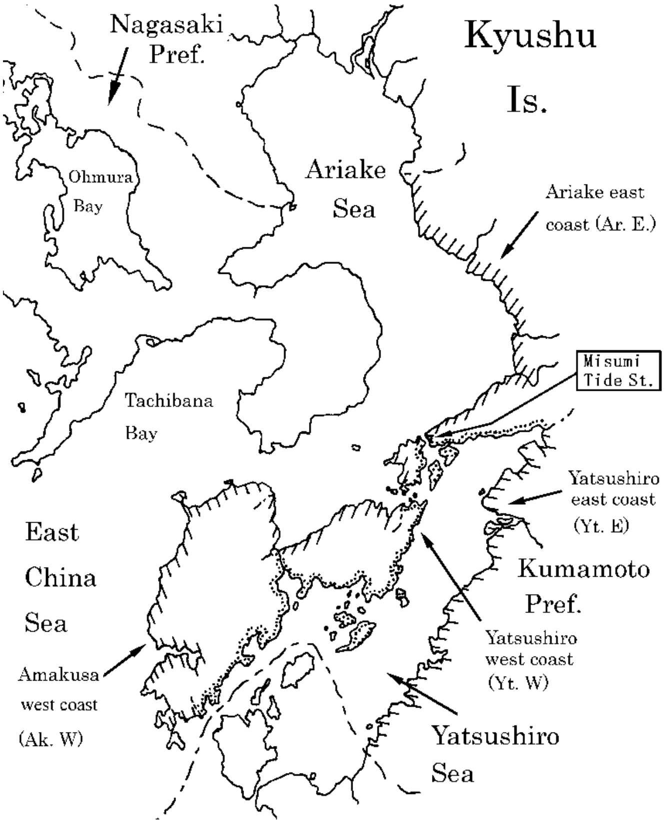

Figure 1. 4 coasts in Kumamoto Prefecture

Table 1. Magnitude of typhoon

	Size							
Intensity	1(~200km)	2(200km~)	3(300km~)	4(400km~)	5(500km~)	6(600km~)	7(700km~)	8(800km~)
D (17m/s~)	1	2	3	4	5	6	7	8
C (25m/s~)	2	3	4	5	6	7	8	9
CC (29m/s~)	3	4	5	6	7	8	9	10
B (33m/s~)	4	5	6	7	8	9	10	11
BB (37m/s~)	5	6	7	8	9	10	11	12
BBB (41m/s~)	6	7	8	9	10	11	12	13
A (44m/s~)	7	8	9	10	11	12	13	14
AA (47m/s~)	8	9	10	11	12	13	14	15
AAA (50m/s~)	9	10	11	12	13	14	15	16
AAAA (54m/s~)	10	11	12	13	14	15	16	17

This paper has tried to estimate the damage length of maritime structures that will occur along the coast before a typhoon strikes based on the magnitude of a typhoon at a latitude of 30° N. The index of vulnerability of each coast depends on the sensitivity values of the coast. The damage length of maritime structures for each coast is estimated using the magnitude of a typhoon at a latitude of 30° N and the vulnerability of the coast to the typhoon.

In Figure 2, the six numbers, 1 to 6, are termed as a "sensitivity value" for typhoon Magnitude based on the damage length. The maximum sensitivity values shown in Table 2 are defined as the vulnerability index for each typhoon path number on the individual coast. The total length of damage induced by a coming typhoon for a coast can be estimated as follows: comparing the path of Typhoon 9918 with the historical paths given in the Figure, which is not shown here, the path of Typhoon 9918 is determined (Figure 3). Based on the Table 2, the maximum sensitivity value for the western coast of the Yatsushiro Sea is 6 for the typhoon in path No. 8. This coast is the most vulnerable for typhoon in path No. 8. Based on the Table 1, if a typhoon with a maximum wind speed of 46.3 m/s and a radius 601 km at a latitude of 30° N takes the same path No. 8 with typhoon 9918, the magnitude value is 12.

The smoothed damage length (Ls) is obtained from Equation, which is shown in Figure 2, for the vulnerability value 6 and the magnitude of 12. Thus, the total damage length (Ld) caused by Typhoon 9918 for each coast is estimated by Equation (1).

$$Ls=(Ld/Lt) \quad (1)$$

where Ls is the smoothed damage length and Lt is the total damage length by all typhoons for this particular coast.

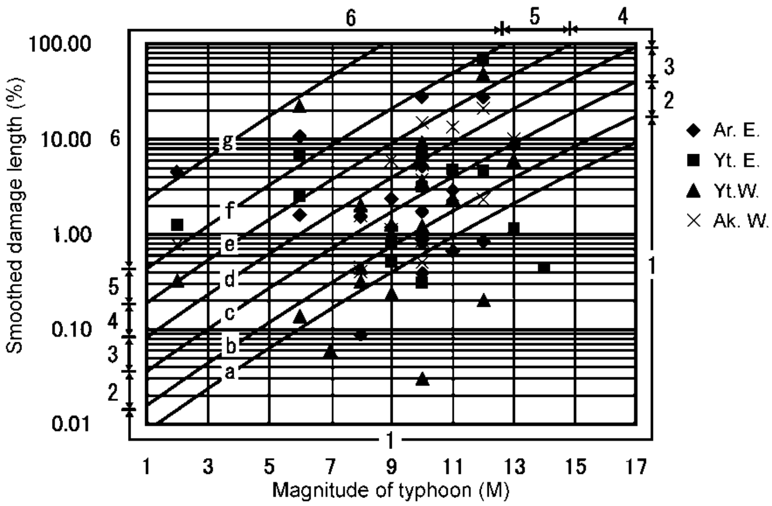

Figure 2. Magnitude of typhoon and smoothed damage length

Table 2. Maximum sensitivity values

Path No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Ar. E. (Closed)	1	3	5	4	3	4	1	6	0	2	6	0	0
Yt. E. (Closed)	0	1	4	5	3	6	0	5	0	3	6	0	0
Yt. W. (Closed)	1	3	4	5	1	1	0	6	1	2	8	0	0
Ak. W. (Open)	4	5	3	4	3	2	2	6	0	4	9	0	0

3 WARNING TIME AND INFORMATION FOR EVACUATION

As shown in Figure 1, Typhoon 9918 struck Kyushu Island, which is located in Western Japan. The Figure 2 shows the storm area where the wind speed exceeded 25 m/s as forecasted by the JMA. The dotted circle in the inset shows the area where the wind speed exceeded 15 m/s. The long-dashed circle is the 70% probability circle for the location of the center of Typhoon 9918 at 09:00 on 24th September, 1999.

Assuming that Typhoon 9918 comes from the south of Kyushu Island, it is equivalent to the forecast at 9 hours before a typhoon makes landfall as shown in the Figure 3. This time is equivalent to 21:00 of the 23rd. This means that the Kumamoto coast enters the storm area 4 hours before. In this case, except for what can be procured from convenience stores, disaster prevention measures against a coming typhoon are difficult for residents after 21:00. In fact, 12 people died in Matsuai town in Uki City as a result of this situation. The storm tide reached the highest sea level, 3 m, at about 06:00 of the 24th. In other words, the disaster was caused by the attack of the typhoon in the morning before dawn. If the forecasting of damage was earlier, this method would become more valuable. Despite this affair, the forecasting method shows an effectiveness to evacuate and save human life from a storm disaster.

On the other hand, if the allowable range of the prediction error is magnified, it is possible to forecast the magnitude and the direction of the typhoon movement at a latitude of 30° N using the recent forecasting technology of JMA when a typhoon is located at around a latitude of 28° N. This latitude is equivalent to the prediction at 19 hours before a typhoon makes landfall. This time is equivalent to 11:00 of the 23rd. This means that the Kumamoto coast enters the storm area 14 hours before. After passing through at a latitude of 28° N, the forecasting accuracy is dependent on paying careful attention to the movement and change in the magnitude of a typhoon. In other words, it is possible to predict the risk to a coast using the vulnerability index 14 hours before Kumamoto Prefecture enters the strong wind area of 25 m/s.

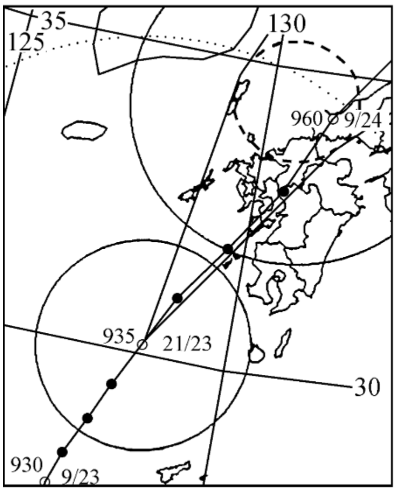

Figure 3. Track of Typhoon 9918

Thus, the forecasting of damage length before a typhoon approaches the coasts of Kumamoto Prefecture gives a sufficient evacuation time for disaster prevention measures for the coastal residents, for people who are involved in the fishery and for port administrative staff involved in the prevention of coastal hazards.

4 REGRET FOR PAST DISASTER

By the attack of the typhoon 9918 and typhoon 8513, severely strong storm surges occurred in the Ariake and Yatsushiro Seas during high tide. A major disaster occurred among coastal residents and fishing parties is concerned. When these two typhoons were approaching, there was no method for forecasting the damage level that would occur at each coast before the typhoon struck. From the weather forecasting of Typhoon 8513, which was given by JMA, residents considered that Typhoon 8513 would not attack with a strong wind. As a result, they had been off guard. There were 31 casualties due to this typhoon, many of them from the rollover of fishing boats on the Ariake Sea. This improved Magnitude (iM) Method is intended for the prediction of damage of coastal structures due to typhoons. It is considered that the information is beneficial for those who conduct evacuations.

5 CONCLUSIONS

The iM Method is performed using the media information of weather forecasting. The media information obtained from television or internet is the data of the maximum wind speed and size of the typhoon and its path. By applying these meteorological data to the Figure 2 and Tables 1 and 2, the data indicating the vulnerability as a risk of coast can be obtained. The need for countermeasures and evacuation is determined on the basis of this risk data. Therefore, it can be easily used among the general population. The establishment of a forecasting system of coastal damage caused by a typhoon passing is very useful for the mitigation of disaster. An iM Method may be used for the purpose of coastal management in disaster prevention works. Furthermore, it is useful for announcements of storm warnings and evacuations for residents along coastlines.

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