THE EFFECT OF RIVER SLOPE ON TSUNAMI PROPGATION ASCENDING RIVERS

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1. INTRODUCTION

When a tsunami propagates into a river, the tsunami height is decreased with the propagation distance increase along the river. The decreasing tsunami height is deeply related to the river slope. The tsunami intrusion distance is also affected greatly by the slope. This natural phenomenon can be seen in the rivers during the 2011 Tohoku Tsunami. According to the tsunami height dissipation in rivers, Abe et al. (2012) carried out the numerical simulation and the water level data analysis to investigate the effects of tsunami propagation ascending rivers. Kayane et al. (2012) proposed an empirical dissipation coefficient of tsunami height. However, data availability was not sufficient in the previous study. It may cause an uncertain dissipation coefficient. In this study, main purpose is to improve empirical dissipation coefficient function for more efficient and practical use. The empirical function has been completed by analyzing added data.

2. STUDY AREA AND DATA COLLECTION

Study area is main rivers located in Iwate Prefecture, Miyagi Prefecture and Fukushima Prefecture in Tohoku District, Japan. To make the improved dissipation function, the river slope and tsunami intrusion distance were surveyed that Iwate Prefecture is eight rivers, Miyagi Prefecture is 10 rivers, and Fukushima Prefecture is 21 rivers.

3. METHOD

3.1 Tsunami intrusion distance (x_p)

Regarding to the 2011 Tohoku Tsunami, Adityawan et al. (2012) presented the relation to the river slope and the tsunami intrusion. Tsunami intrusion distance is one of the important factors to determine the tsunami height and dissipation coefficient. It is greatly influenced by river characteristics, especially river slope. To estimate the tsunami intrusion distances, total 39 rivers data have been used, and then it has been suggested that the relationship between tsunami intrusion distance and river slope is reflected in the empirical function.

3.2 Tsunami height dissipation (k)

The relationship between tsunami height at river mouth and propagation distance from river mouth can be written

$$\frac{H}{H_o} = e^{-kx} \qquad (1)$$

where, H_o is tsunami height at river mouth, H is Tsunami height at arbitrary location x from river mouth, k is the tsunami height dissipation coefficient. Tsunami height ratio(H/H_o) was assumed that tsunami height at the end of intrusion is 5%(0.05) of tsunami height at river mouth. Kayane et al. (2012) proposed the empirical dissipation coefficient function based on the assumed tsunami height ratio, Eq.(2) as

$$k = 4.73\times10^{-5}\exp(4.67\times10^{3}S) \qquad (2)$$

where, S is the river slope. It is found that the dissipation coefficient function is related to the river slope.

4. RESULTS

4.1 Relationship of the river slope and the tsunami intrusion distance

According to the river slope, the difference of tsunami intrusion distance is obviously shown in Fig. 1. The intrusion distance is definitely related to the slope without the location of rivers. As the result, the function of the intrusion distance can be found by using power series function for the river slope, Eq. (3) can be written as

$$x_p = 48.4S^{-0.71} \qquad (3)$$

where, x_p is the tsunami intrusion distance. If the river slope is given, this formula can be used to assess the tsunami intrusion distance in the real field data. A river case affected by river structure such as floodgate, weir, etc. was excluded in the fitting function that was only considered the case of without the structure in the river.

4.2 Function of tsunami height dissipation coefficient

The dissipation coefficient can be obtained from the relationship between the river slope and the tsunami intrusion distance. Using Eq. (1) and Eq. (3) as tsunami intrusion function, the coefficient function for the tsunami height dissipation can be expressed as

$$k = 6.19\times10^{-2}S^{0.71} \qquad (4)$$

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Compared with the previous study, this dissipation function can be used in the wide range of the river slope. Fig. 2 shows that the previous dissipation function has the limited range of river slope, whereas the improved function in this study can consider to the stiff river slope.

5. CONCLUSION

Tsunami intrusion distance and tsunami height dissipation in rivers have been evaluated that the influence of the river slope can be seen in the data from the three prefectures. Based on the rivers data analysis, the empirical functions of the tsunami intrusion distance and the dissipation coefficient has been successfully completed. Furthermore, the improved functions of dissipation coefficient and intrusion distance may be applied to real field data more effectively.

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REFERENCES

Abe, T., Yoshikawa, Y., Yasuda, H. and Hirai, Y.: Tsunami propagation up rivers in Hokkaido caused by 2011 Tohoku Pacific Coast Earthquake, *Journal of Japan Society of Civil Engineering Ser.B1(Hydraulic Engineering)*, Vol. 68, No. 4, 2012,pp.I_1525-I_1530. (in Japanese)

Adityawan, M.B., Roh, M., Tanaka, H. and Farid, M.: The effect of river mouth morphological features on tsunami intrusion, *Proceedings of the International Conference on Disaster Management*, Vol. 8, 2012, pp.75-83.

Kayane, K., Tanaka, H. and Adityawan, M.B.: Influence of river bed slope for tsunami propagation into rivers, *Journal of Japan Society of Civil Engineering Ser.B2(Coastal Engineering)*, Vol. 68, No. 2, 2012, pp.I_176-I_180. (in Japanese)

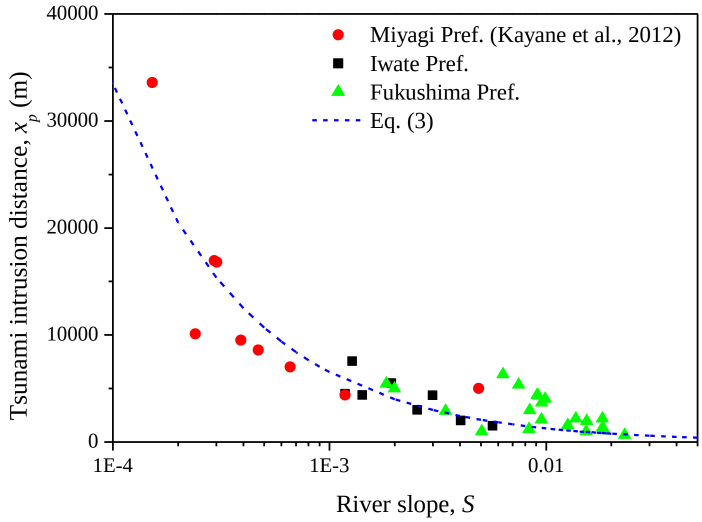

Fig. 1 Relation between tsunami intrusion distance and river slope

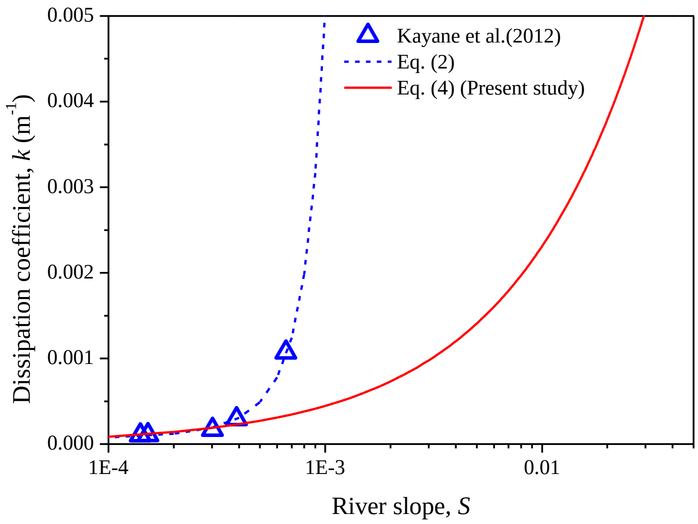

Fig. 2 Empirical function of dissipation coefficient depending on river slope