

NUMERICAL STUDY ON TSUNAMI PROPAGATION INTO RIVERS

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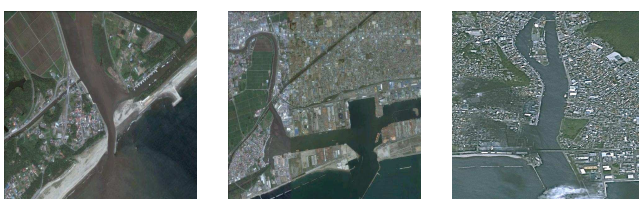
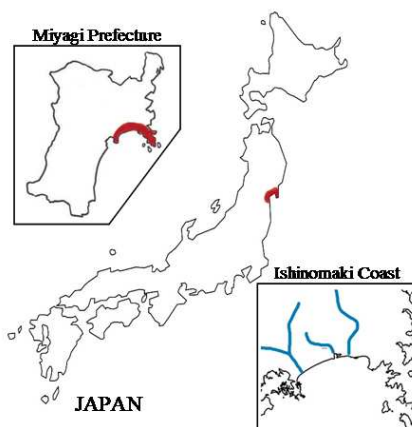
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1. INTRODUCTION

When tsunami is generated by ocean earthquake, the long wave propagated along the ocean to the coastal area. Generally, tsunami wave is accompanied with various phenomena such as the inundation into land and near coastal region, sometimes erosion and coastline changing occurred by tsunami overtopping on sand beach and lagoon. Also tsunami wave can also propagate further into river upstream. In that case, approaching the tsunami wave into rivers, it can threaten to people and social infrastructure, etc. So, the possibilities for the tsunami disaster like that always exist near the coast area and in upstream land.

In this study, we have focused on the tsunami wave propagation into rivers. It is well known that river mouth morphology is important factor in this process. Thus, the main objective is to understand the tsunami behavior into rivers and to evaluate the effect of river mouth morphology by using numerical model.

The field observation data of Ishinomaki Coast in Tohoku District of Japan is applied to the field data analysis of tsunami event that caused by the 2010 Chilean Earthquake. At that time, most rivers and near the coast were observed the fluctuation of water surface and some measurement station shown the phase lag due to tsunami wave. Additionally, the maximum tsunami height reached of over 1 m at the rivers station, also tsunami distance was expected a several tens kilometers.



Naruse-Yoshida Rivers

Jo River

Old Kitakami River

Fig. 1 : Location of study area

2. FIELD DATA COLLECTION AND ANALYSIS

2.1 Study area

Study area is located in the eastern part of Miyagi Prefecture as shown in **Fig.1**. This area consists of four rivers, Old Kitakami River, Jo River and Naruse-Yoshida Rivers. Each river includes a specific river mouth structure and different river scale. According to Tanaka et al. (2011), River mouth morphology can be classified into different two types; Type 1 is with non-constriction structure or located inside a port and Type 2 is with constriction structure, sandy coast or sand spit at mouth.

The classification is applied in the study area, each river belongs to Type 1 or Type 2 in accordance with the proposed method. Old Kitakami River and Jo River are classified Type 1, Naruse-Yoshida Rivers are Type 2, respectively.

2.2 Field observation data

In order to estimate the impacts of tsunami in river mouth and calculate the maximum tsunami wave height, the first measurement station water level variation data was used. First, the wave phase lag occurred in the small river or 2nd river group compared with 1st river group. In this area, Jo River is under the 2nd river group. This phenomenon is depending on river scale including the bottom condition, friction factor and river characteristic such as river slope, width, river discharge, etc. Second, wave fluctuations follow along with the tidal wave. So, the tsunami wave height can be estimated with eliminated Ayukawa tidal level. In this way, maximum tsunami wave height was determined to be 1.12 m and 0.78 m in Jo River and Old Kitakami River, which the tsunami propagation distance was expected approximately over 20 km. From the observation data, it should be noted that Type 1 can significantly affect the river upstream area and river channel than Type 2.

As a first step in this study, to verify the impact of tsunami wave in river mouth, numerical analysis has been carried out on the hypothesis that river mouth morphology is one of the most dominant factors.

3. NUMERICAL ANALYSIS

3.1 Computational condition

Vu et al. (2002) has developed the two dimensional shallow water equations model to calculate the wave motion. This model is based on the shallow water theory, and the computational geometry is composed of the ideal topography about sea, river, and land boundaries. In the sea area, a wave-absorbing zone is approached at the lateral boundaries to minimize wave reflection. The bottom friction is adapted Manning approach method. **Fig.2** shows the initial tsunami waves which are generated in the wave inlet

boundary. It was premised on the assumption of the sinusoidal waves from the observation data.

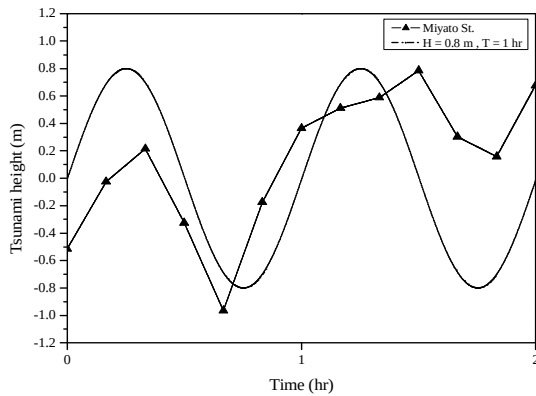


Fig. 2 : Comparison of computational wave condition and measurement data

3.2 Numerical case test results

Six different river mouth morphologies were conducted and show in **Fig.3**. Test cases were designed which is based on the real river mouth conditions. The purpose of numerical case test is to test these hypothesizes cases response to tsunami wave through the numerical experiments.

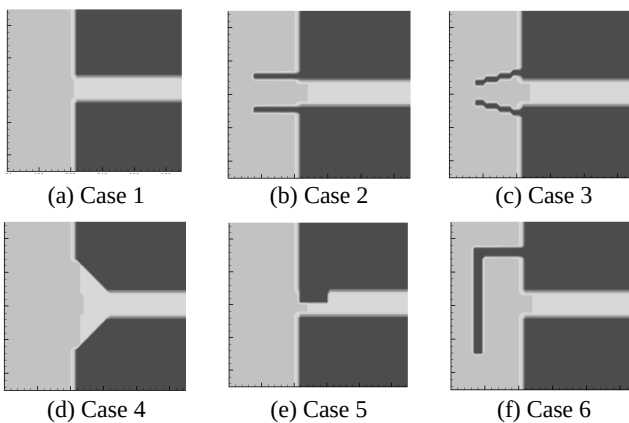


Fig. 3 : The river mouth structures of test cases

Fig. 4 is the result of the tsunami propagation model for the six experimental cases. As we mentioned before the tsunami propagation in estuaries, the deformation of the wave depends on many factors such as the shape of the estuary, river bed friction and the magnitude of that river. In which affect the shape of the estuary plays an important role because most wave energy to be dispersed. **Fig. 4** shows this point very clearly. In Type 1 river mouths, the wave energy dissipation is small so that higher wave height and spread farther upstream are obtained than compare to the estuary of Type 2 (See also **Table 1**). The wave energy as it propagates through the river entrance in Type 1 is divergent.

4. CONCLUSION

From the numerical results and field observation data, we can conclude that what kind of river mouth type is the most influential structures, also how can

change the water level variation and tsunami wave height. Although the computational model included the limited condition and numerical instability, the numerical results provided similar results about wave height and motion. For the future, in order to apply the real field using the numerical model, it is essential that this model have to modify the numerical scheme and consider the various effects.

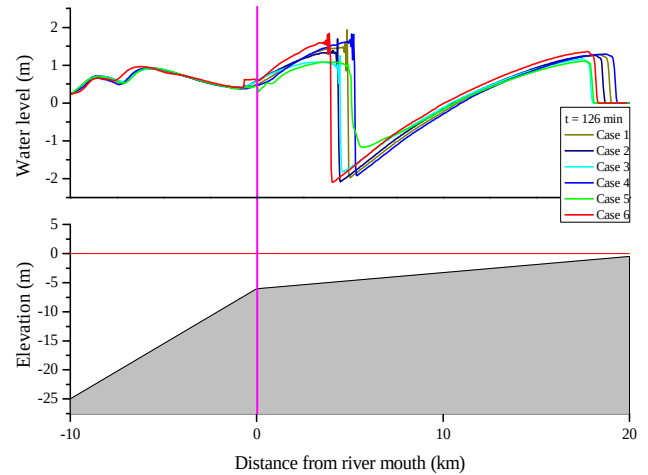


Fig. 4 : Calculated water level at stream center line

Table 1 : Summary of numerical results and classification

	Maximum wave height (1.2 km from river mouth)	Propagation time to river upstream (min)	Classification of river mouth
Case 1	1.52 m	128.2	Type 1
Case 2	1.46 m	130.1	Type 1
Case 3	1.21 m	134.4	Type 2
Case 4	1.63 m	126.4	Type 1
Case 5	1.15 m	134.2	Type 2
Case 6	1.65 m	131.3	Type 1

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