Inundation Simulations due to Storm Surge and High Discharge in Saga Lowland and Coastal Area of Ariake Sea

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1. Introduction

Storm surge is a phenomenon in which ocean water surface elevations rise as a result of high winds and decreases in atmospheric pressure during tropical storms and typhoon. Storm surge by typhoon is the one of the frequent disasters in Japan which can cause significant flooding in coastal communities. Lives and properties located along the coastlines of typhoon-prone regions are at great risk during large storm events because of high water levels, which have the potential of inundating vast areas. Many of the risks posed by storm surge along coastal areas, which is also a residential area, industry, agriculture, etc., with the exposure of a combination of storm surge and river flooding. River flooding by high discharge is also a disaster that could cause inundation in the coastal area.

This study aims to get an overview the area of inundation when the two disasters, storm surge and high river discharge simultaneously occurred in the Coastal area of Ariake sea and Saga lowland to evaluate for the future disaster management.

2. Study area and disaster

The Ariake Sea, which is surrounded by Fukuoka, Saga, Nagasaki and Kumamoto Prefectures, is the biggest bay in Kyushu island (Figure 1). Inner Ariake Bay, where a lot of rivers flowing in such as Chikugo River, Kase River, Rokkaku River, Yabe River and Shiota River consists of muddy tidal flats mostly. Its tidal range is remarkably big, and the maximum tide level difference is as much as 7 m at the innermost part.

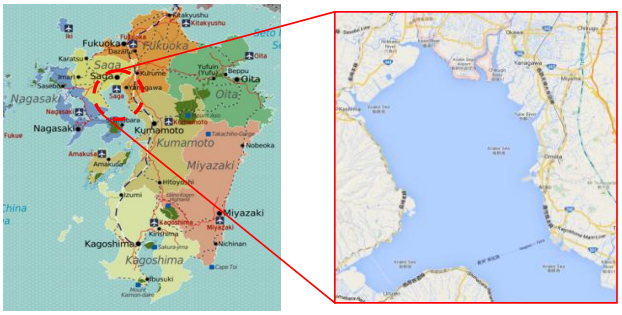

Figure 1: Study Areas

The Ariake sea is the area of typhoon track area that can cause storm surge and this area empties into the large rivers such as Chikugo river, Kase river and Rokkaku river. Near this coastal area there are settlements, airport, agriculture, industrial and office buildings and other public facilities. However, the Japanese government has built coastal dyke along the shorelines and river within this areas with the maximum elevation of 7.5m.

Studied disasters is the two ones that have occurred in this area. The first disaster is Storm Surge by Typhoon Pat that occurred in August, 31 to September, 1, 1985 and the second disasters is River flooding by high discharge of Chikugo, Kase and Rokkaku Rivers in July 14 - 15, 2012.

3. Methodology

This study utilized a two dimensional hydrodynamic model, MIKE 21 Flow Model Flexible Mesh (MIKE 21 FM) developed by DHI (Denmark Hydraulic Institute) in the frame of MIKE ZERO packages. The MIKE 21 FM is applicable to the simulation of hydraulic and related phenomena in lakes, estuaries, bays, coastal areas and seas. This software is used to create simulation of several typhoons that ever crossed Ariake Sea and high discharge condition simultaneously occurred on same time to determine the areas with water level higher than the height of the existing dyke that could caused inundation. This study considered transects are 11 measurement lines, i.e. 1) Shiroishi, 2) Rokkaku Estuary, 3) Kase Estuary, 4) Higashiyoka, 5) Saga Airport, 6) Chikugo Estuary, 7) Ohamma, 8) Rokkaku River, 9) Kase River, 10) Chikugo River_1 and 11) Chikugo River_2 shown in the Figure 2.

Figure 2: Measurement Lines

In the numerical simulations, the following data are taken as input data; bathymetrical data, topographical data, wind data (speed and direction), some of the water level at stations, discharge data and time step of simulation. Bathymetrical data are obtained from the Ariake project of Saga University. Topographic data are obtained from 50 m DEM of Japan supplied by Geospatial Information Authority of Japan. Wind data in the form of wind speed and wind direction provided by Meteorological Agency taken same time with water level and tide on August, 31, 1985 to September, 1, 1985 in some station. The discharge data are provided by MLIT taken from discharge data on July 14, 2012 to July 15, 2012 at some stations of Chikugo, Kase and Rokkaku Rivers. The simulation was taken from August 31, 1985 at 00:00:00 to September 1, 1985 at 00:00:00 when the Typhoon PAT passed through the Ariake Sea area. The model calculation was established by the computational mesh with open boundary to input time series data of tide and discharge at Ariake Sea and at the Chikugo, Kase and Rokkaku Rivers in the Saga Lowland as shown in the Figure 3.

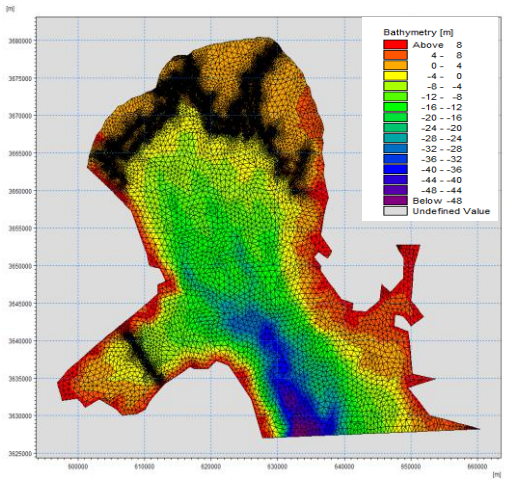

Figure 3: Computational mesh with bathymetry

4. Result and Discussion

Table 1 shows the maximum water lever at each line. The simulations results on the 11 specified location indicates that the maximum water level above 6.5 m. In some locations that were obtained near shoreline, the water level does not exceed the height of the existing coastal dykes of 7.5 m high. In the measurement location on the Chikugo river obtained that the water levels exceed 7.5 m level, so that the water overflowed on both sides causing inundation of the surrounding area, as shown in Table 1 and Figure 4.

Table 1 **:** Maximum water level of each measurement line

No	Lines Name	Maximum Water level (m)	No	Lines Name	Maximum Water level (m)
1	Shiroishi	6.6691 m	7	Ohamma	6.5076 m
2	Rokkaku Estuary	6.7015 m	8	Rokkaku river	6.7098 m
3	Kase Estuary	6.7029 m	9	Kase river	6.8521 m
4	Higashiyoka	6.5419 m	10	Chikugo river1	**7.7509 m**
5	Saga Airport	6.5231 m	11	Chikugo river2	**8.2760 m**
6	Chikugo Estuary	6.6843 m			

Figure 4 shows, inundation processes caused by high discharge and high tide by the storm surge in the coastal area of Ariake Sea. In the case that two disasters, the high discharge by torrential rain and the storm surge occur at the same time, instantaneous inundations were seen in the case of only high discharge disaster. However, the water level does not reach to a normal level and continues to fluctuate for a long time like the typhoon.

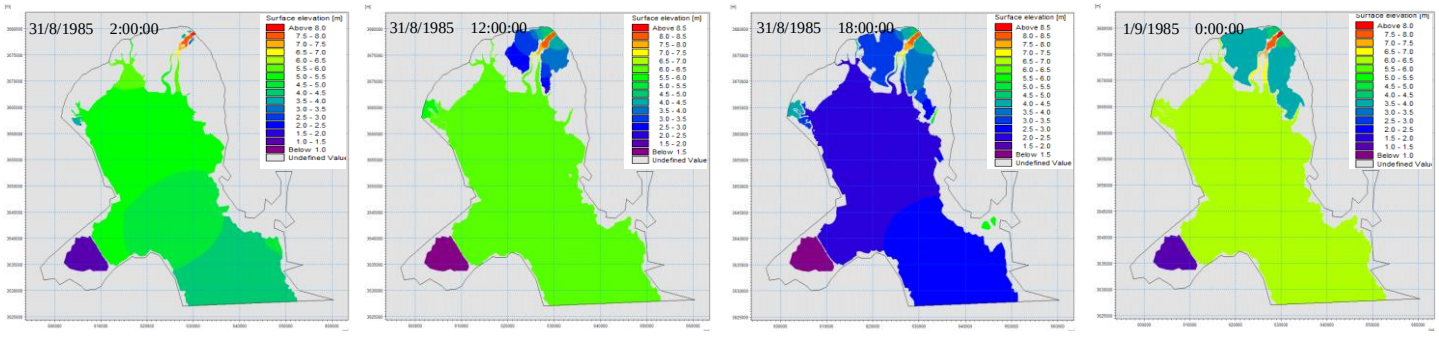

Figure 4**:** Simulation result of Inundation area

5. Conclusion

(1). There is no occurrence where the water level exceed the elevation of existing coastal dyke, which means no seawater inundation happens in the coastal area of Ariake Sea.

(2). High tide due to storm surge with high discharge by torrential rain at the same time can cause inundation near the river mouth of Chikugo.

6. References

(1). A.K.T. Dundu, A storm surge analysis in the Ariake Sea for the coastal hazard management in Saga lowland, Dissertation, Saga University, 2012.

(2). DHI, MIKE 21 Flow Model FM, Hydrodynamic Module, 2009.