INTERACTION OF WAVE AND COASTAL STRUCTURE IN SENDAI PORT

Tohoku University Student member ○Sompratana RITPHRING
Tohoku University Fellow member Hitoshi TANAKA

１. INTRODUCTION

The Sendai Port is located on the north part of Sendai Coast where there is the severe erosion and seems to be progressing. In this area, the most prevailing incoming wave bring about the moving longshore current and sediment from south to north direction for overall area. In addition, there is the breakwater which was constructed in 1967 at the Sendai Port located around 2 km apart in the north that is possible to generate the reflected wave and drive the longshore sediment transport to the opposite direction, north to south direction, which can influence to the morphological change in the vicinity of harbor breakwater. It was reported that the severe local erosion are found at up-drift side of breakwater with the maximum shoreline change 300 m from 1967 to 1998 [1]. This study aim to calculate wave and current field in Sendai port in the real case condition and in case of without breakwater in order to clarify the influence of wave and structure interaction since the reflected wave from breakwater has mainly effect on morphological change in this area.

２. STUDY AREA

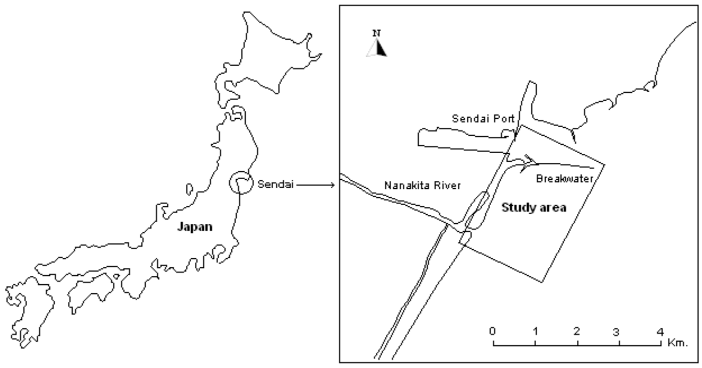


Figure 1 Study area

Study area located at the end of sandy beach in the north part of Sendai Coast, northeast of Japan, as can be seen from Fig.1. In this area, the most prevailing incoming wave in the Sendai Bay is from ESE or SE direction. Wave height in this area is around 0.8-1 m and wave period is around 7-8 seconds obtained from the observation point at water depth 20 m near tip of harbor breakwater at Sendai Port.

３. METHODOLOGY

The numerical simulation is done based on the two dimensional Boussinesq equations with enhanced liner dispersion characteristics in a depth integrated flux-formation [2] as derived by the following equations.

$$\frac{\partial \eta}{\partial t}+\frac{\partial P}{\partial x}+\frac{\partial Q}{\partial y}=0 \quad (1)$$

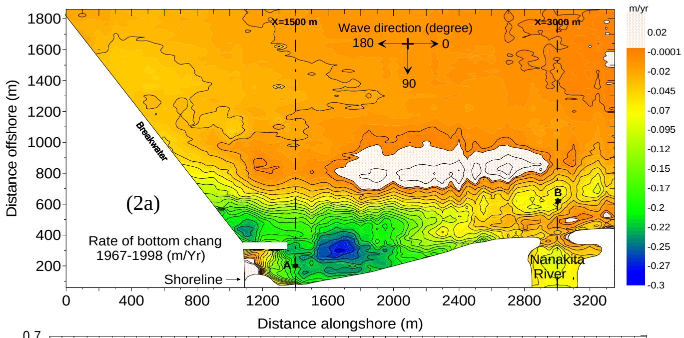
$$\frac{\partial P}{\partial t}+\frac{\partial}{dx}\left(\frac{P^2}{d}\right)+\frac{\partial}{dy}\left(\frac{PQ}{d}\right)+\frac{\partial R_{xx}}{\partial x}+\frac{\partial R_{xy}}{\partial y}+gd\frac{\partial \eta}{\partial x}+\psi_x+\frac{\tau_x}{\rho}=0 \quad (2)$$

$$\frac{\partial Q}{\partial t}+\frac{\partial}{dx}\left(\frac{Q^2}{d}\right)+\frac{\partial}{dy}\left(\frac{PQ}{d}\right)+\frac{\partial R_{yy}}{\partial y}+\frac{\partial R_{xy}}{\partial x}+gd\frac{\partial \eta}{\partial y}+\psi_y+\frac{\tau_y}{\rho}=0 \quad (3)$$

Equations 1 to 3 show the continuity, momentum in X direction and Y direction respectively. The terms denoted R_{xx}, R_{xy}, R_{yy} account for the excess momentum originating from the nonuniform velocity distribution due to the presence of the roller. The term ψ_x and ψ_y are dispersive Boussinesq terms. Here P and Q are the depth-integrated velocities (the volume flux) in the Cartesian coordinate system (x, y), d=h+η is the instantaneous depth when h is water depth and η is the surface elevation. Subscripts x and y denote partial differentiation which respect to space.

４. RESULTS

Four cases of incoming wave angles - 80, 90, 100, and 120 degrees - are selected to be modeled for calculating wave height and current in case of with/without structure. Figure 2b and 2c show wave height at the observation points as can be seen the locations in Fig.2a. The interaction of incident and reflected wave influenced to wave stirring increase considerably in the up-drift side of harbor breakwater. The perpendicular wave, 90 degree, result in high reflected wave in the nearby structure with wave height around 0.55 m and the differential of wave height between with and without structure is 0.2 m , while 120 degree of wave direction bring less effect which illustrated in Fig.2b. Wave height at point A is much higher than B in all directions correspond to the trend of bottom elevation change as shown in Fig.2a; furthermore, the differential of wave height between with and without structure cases can be distinguished clearly.



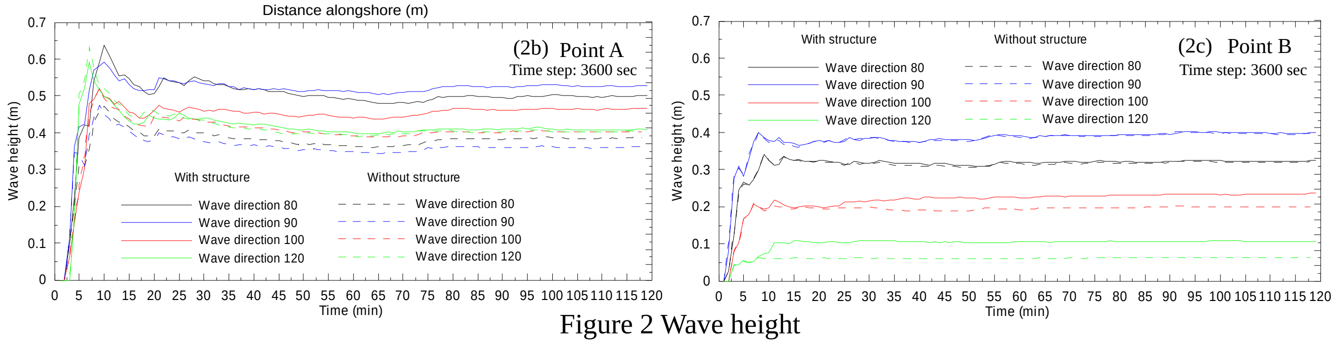


Figure 2 Wave height

Moreover, the interaction of incoming and reflected wave drift current nearby breakwater change the direction from positive (right to left in Fig.2a) to opposite direction as seen the mean velocity in X direction (alongshore) from Fig.3a which show the sampling sections in Fig.2a. In this section the maximum velocity is around 0.035 m/s occurred when wave come from 80 degree wave direction in case of without structure. On the other hand, Fig.3b, there is no change of direction at the location in front of Nanakita River mouth that located 2 km away from breakwater; however, the velocity is increased by reflected wave.

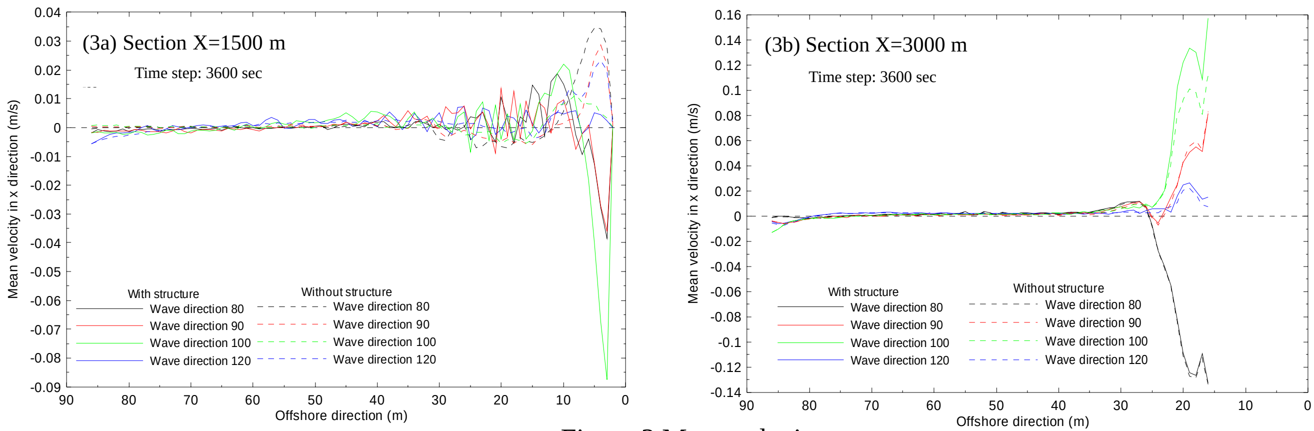


Figure 3 Mean velocity

５．CONCLUSIONS

The interaction of incident and reflected wave influence the increasing of wave height and velocity especially nearby up-drift side of breakwater cause severe erosion around this area. Moreover, the sediment move to the opposite direction because current is changed direction by this reflected phenomena. The perpendicular incoming wave, 90 degree, makes obviously differential of wave height and velocity in case of with/without structure.

ACKNOWLEDGEMENTS

The authors wish to express grateful thanks to Shiogama Port and Airport Office for providing topographic survey data of Sendai Coast.

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