報告番号	※ 甲 第 11058 号

主 論 文 の 要 旨

論文題目 Study on Beach Profile Change of Gravel Beach and Countermeasure Against Beach Erosion（礫浜海岸の汀線変化機構と海岸侵食対策に関する研究）

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論 文 内 容 の 要 旨

From the past, human have gained their livelihood directly or in directly from the coastal area through many kind of economic processes such as fishing, tourism, aquaculture, etc. However, certain human activities result in many negative impacts on the natural coastal system. And a popular case is destroying natural balance of sediment system which leads to coastal erosion. And Shichirimihama beach which located in southern part of Mie Prefecture is of the area, facing to serious coastal erosion. In order to reduce the effects of erosion, variety of measures such as artificial reef, wave dissipating block have been done in recent years. However, beach is still suffering from beach erosion especially in storm season. To reduce beach erosion, artificial reefs have installed in this area. However, recent continuous shoreline retreat indicates that artificial reef did not function well as expected. This occurred because the hydrodynamic behavior around artificial reef is not fully understood yet. In order to find a more effective measure and create more stable beach, the behavior of flow field around the present artificial reef should be reassessed considering the permeability of gravel sea bed. Therefore this study aims to investigate the function of artificial reef on Shichirimihama beach through analysis of the change of shoreline position and beach topography. After that the flow field of coast in which artificial reef has been installed as countermeasure against beach erosion will be investigated by conducting numerical simulation in order to clarify the mechanism of hydrodynamic change on the swash zone as well as around artificial reef. In numerical simulation model, the permeability of sea bed is considered to clarify the mechanism of hydrodynamic change on gravel beach which has high permeability as Shichirimihama beach. In summary, this study aims to: (1) Investigate the shoreline change based on image obtained from coast based WEB camera system as well as to propose new method of shoreline detection from image. (2) Collect and analyze the change of topography in Shichirimihama beach using 3D terrestrial laser scanning system. (3) Investigate mechanism of flow field around artificial reef in consider

the effect of seabed permeability using numerical simulation. (4) Validate the present artificial reef in Shichirimihama Beach and investigate a more effective method to increase the function of present artificial reef.

The results obtained in the present study show that;

WEB camera system along with image processing is a very efficient method for collecting continuous shoreline data with an efficient operation as well as a management cost. The proposal method can extract shoreline more stable than the existing CCD method, especially in bad weather when quality of images were not good. Hence using the proposal method shoreline in rain weather or storm event can be collected. And it helps to gain more knowledge about behavior of shoreline caused by special event, which cannot collect by filed survey or satellite image. Moreover continuously data set of WEB camera system is a very efficient tool for investigate the mechanism of shoreline change for both short-term change and long-term change.

According to image processing results when wave heights larger than 6m and wave periods longer than 10s off to the coast, shoreline retreated. When wave heights smaller than 1m and wave periods smaller than 8s off to the coast, shoreline will forward at the area behind artificial reef, and stand still in the area without artificial reef. For other cases of wave conditions, shoreline behavior strongly depends on wave direction, and shoreline can be forward or retreat due to the change of wave direction.

Topography data showed that the beach width as well as beach volume decrease significant when wave approach to the coast from S, and SSW direction with wave height larger than 3m. Beach slope became steeper when moving from south to north on long-shore direction. On the area without artificial reefs, beach slope became steeper and berm was retreated about 10$\sim$20m. On the other hand, on the area behind located artificial reef, beach slope did not change dramatically.

Berm development was investigated through snapshot image data. The results indicated that berm development did not occur when wave height less than 1m. When wave height is ranged from 1.0m-2.5m, berm was formed on low area of beach face. And when wave height exceeds 3m berm was located on the top of original beach face. The results also showed that wave direction plays an importance role in term of berm location, and berm size.

From topographic change and shoreline change it can be said that under the incoming waves with wave height less than 1.3m and wave period smaller than 8s, there is no significant change of beach morphology as well as shoreline position. However when wave height is larger than 2m and wave period larger than 8s, berm development has begun and shore-

line position has changed significantly. From numerical simulation results it can be said the reason leading to such kind of differences is the change on characteristic of flow field under low energy condition and high energy condition. In the case of high energy waves, sediments on the lower part of beach face were rolled up due to strong flow field caused by wave breaking near the coastal and moved to the top of the beach, then berm occurred and shoreline retreat as consequently. Moreover topographic change and shoreline change in the area behind artificial reef was smaller in compare with the area without artificial reef. Numerical simulation results showed that in case of artificial reef, wave breaking over artificial reef reduced wave energy off to the coast, then reduced cross-shore and long-shore velocity, so reduced sediment transport in nears-shore area.

Three dimensional numerical simulation was adopted to investigate the near-shore flow field in the present of artificial reef over impermeable bed. When considering the permeability of the seabed, flow field extended to inside the permeable seabed layer, and accordingly, the difference was found in the average flow field in the vicinity of the water surface. In addition, changing on the porosity of artificial reef material also influenced the breaking point.

Wave breaking on the artificial reef crest revealed a higher average water level on the top of artificial reef, and a relatively high average water level was also formed in the area behind artificial reefs. Water level on artificial lee also increased, but decreased far from artificial reef. Onshore flow occurred when wave breaking returned to the sea through lower part artificial reef crest and through the gap between two artificial reefs.

Artificial reef plays an importance role on reducing wave energy and prevent coast from erosion. And most of study focused on function of artificial reef on beach erosion. However artificial reef is a long-term anti-erosion countermeasure, so preventing artificial reef itself from erosion is also important. Hence, for making a good design decision, the characteristic of flow field around artificial reef is also important. It means that the final design decision needs to be chosen based on the three dimensional flow field characteristic rather than the two dimension flow field characteristic. Moreover as mentioned in Chapter 4, when distance between beach and artificial reef become shorter, the flow inside permeable layer increases, then reduces the offshore direction flow and reduces offshore sediment transport amount, and it can be expected to reduce beach erosion. On the other hand, the mean flow in the gap between artificial reefs increases when the distance become smaller, therefore also the erosion at artificial reef lee increase as well. So it is required to conduct more studies to figure out a best arrangement of artificial reef which reducing beach erosion as well as artificial reef itself erosion simultaneously.