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A STUDY ON THE SETTLEMENT REDUCTION OF ARTIFICIAL REEF USING GEOSYNTHETICS

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ABSTRACT

An artificial reef project for marine resource recovery business has been actively promoted to increase fish catching and restore marine ecosystems. Ground subsidence was usually induced by installation of artificial reefs,especially in soft deposit. This study investigated the effect of the geogrid on settlement reduction of artificial reef from a large size laboratory settlement test. The test results indicated that geogrid reinforced soil had less settlement than unreinforced soil because itsbearing capacity was increased when the geogrid was reinforced on ground surface of a large size tank.

1. INTRODUCTION

An artificial reef project for marine resource recovery business has been popular to protect marine habitants and restore marine ecosystems because productivities of fisheries, marine resources, fish activities and fishery income have been gradually reduced. From these reasons, a lot of artificial reefs has been installed on near coast. Korean government has promoted an artificial reef construction for marine resource recovery business since 1971. Figure 1 shows the construction area and cost of artificial reefs. However, settlement and scour of artificial reef frequently occurred around artificial reef due to ground properties, wave type and reef weight. Many researchers have investigated the state of settlement of artificial reefs using submergence, side scan sonar and split beam echo sounder. From these researches, it was found that some artificial reefs were partially or fully buried in various coast area (Kim et al., 2010; Kim et al., 2009; Oh, 2008; Kim et al., 2008).

This study investigated bearing capacity, settlement characteristics of artificial reef reinforced with geosynthetics (geogrid and hybrid bamboo mat).Artificial reef was installed with various reinforcement areas (unreinforcement - 0A, 1A, 2A, 3A and 5A) on soft ground. Several series of laboratory tests (bearing test andtwo dimensional wave generated water tank test) were performed to find out bearing capacity and settlement of geosynthetic-reinforced artificial reef. Laboratory experiment model of artificial reef was cube type mostly used in South Korea. Size of artificial reef model and laboratory test conditions were satisfied with Froude similitude.

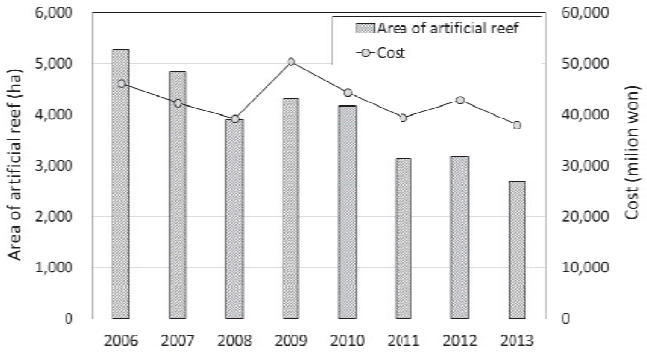


Fig. 1: Area of artificial reef and cost each years

2. MATERIALS AND EXPERIMENTAL PROGRAM

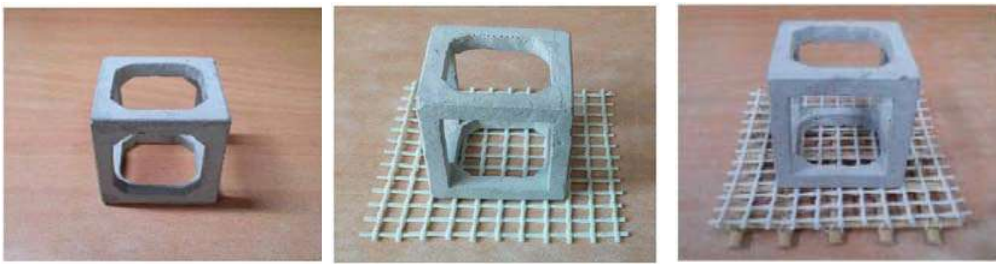
2.1 Materials

Loose sand was used for a soft soil of a seabed. Sand have 30 percent of relative density by using water pluviation method. The pluviation method is well known to make accuratly a fully saturated ground similar with real seabed condition (Vaid et al., 1999; Lee at al., 2008). Table 1 shows the physical properties of loose sand. From grain size distribution test results, the soil was classified mostly as SP (poorly-graded sand) according to the unified soil classification system (USCS).

In this study, three types of reinforcements (unreinforcedment, geogrid, hybrid bamboo mat) and five areas of reinforcement (0A, 1A, 2A, 3A and 5A) used to find out the settlement characteristics of artificial reef. Fig 2 shows three reinforced types of artificial reef.

Table 1: Properties of sand

Particle size	D_{10} [mm]	0.26
	D_{30} [mm]	0.33
	D_{60} [mm]	0.47
	Uniformity coefficient [C_u]	1.81
	Coefficient of gradation [C_c]	0.89
	USCS	SP
Standard compaction test	Optimum moisture content (w_{opt}, %)	13.1
	Maximum dry unit weight ($_{dmax}$, kN/m^3)	16.0



(a) Unreinforcement (b) Geogird – reinforced (c) Hybrid bamboo mat - reinforced

Fig. 2: Reinforced type

2.2 Experimental Program

Bearing test and two-dimensional water tank test were performed to find out settlement and scour characteristics of artificial reef according to reinforced types. Size of the penetration test mold is 150 mm in inside diameter and 175 mm in height. Penetrated velocity is 1mm/min. Table 2 shows the experimental conditions of two-dimensional water tank test. Real sea data was obtained from measurement of the southern coast of Korea. Wave generated duration time was 30 minutes, assuming that durations of typhoon and storm wave are three hours in wave field condition (Sohn, 2007; Sohn et al., 2010). All of experimental conditions follow with Froude criterion of similitude. Laboratory experiment model of artificial reef was cube type mostly used in Korea. Reinforced area sizes were as follows: unreinforcement (0A), one time (1A), double times (2A), three times (3A) and five times (5A) of the floor area of artificial reef.

3. RESULTS AND DISCUSSION

Fig. 3 shows the penetration test results with different types of reinforcement at same reinforcement area. This result shows that penetration load of artificial reef reinforced with hybrid bamboo mat was higher than those of unreinforced artificial reef and geogrid-reinforced artificial reef. This results indicated that reinforced hybrid bamboo mat has supported with own tensile strength and stiffness became overloaded as load increased. In addition, side of the hybrid bamboo mat was detached from the ground as the load increase. Also, it has caused the loss of friction and interlocking between soil and reinforcement.

Table 2: Wave generated water tank experimental conditions

		Real sea	Experiment	Scale
Regular wave parameters	Wave height	3.6m	9cm	1:40
	Wave period	11.13sec	1.76sec	
	Depth	15m	37.5m	
Artificial reef	Size	2m × 2m × 2m	5cm × 5cm × 5cm	
	Thickness	250mm	6.25mm	
	Weight	3.4ton	60g	

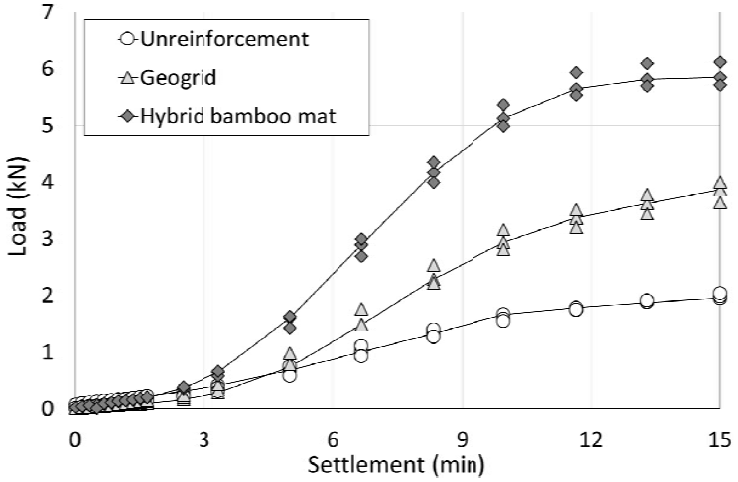


Fig. 3: Load-settlement curves with reinforced types

Settlement characteristics are most important factors to find out stability of artificial reef on seabed. Soft ground quietly vulnerable to consolidation settlement behavior when artificial reef was subjected to wave generation. Fig 4 shows the settlement reduction ratio (SRR) of artificial reef with reinforcement type and areas according to scouring around artificial reef. SRR is defined as the percentage reduction in settlement due to stabilized case relative to the unstabilized case.

$$SRR = \frac{S_{UR} - S_R}{S_{UR}} \times 100(\%)$$

Where, S_{UR} and S_R are the settlement depth of unreinforced and reinforced artificial reef, respectively. Fig. 4 shows SRR with reinforcement type and area from two-dimensional water tank test.

From this results, in case of reinforced geogrid, SRR of 1A was near approximately 15%. This results means reinforcement effect of georid 1A is similar with unreinforcement. However, in case of reinforced hybrid bamboo mat, SRR of 1A was almost 40%. Because stiffness of ground on artificial reef increased by bamboo mat. Also SRR values of both reinforcement types gradually increased as reinforced area increased. This results indicated that scour characteristics of reinforced artificial reef with geogrid and hybrid bamboo mat were more reduced and stable than unreinforced artificial reef.

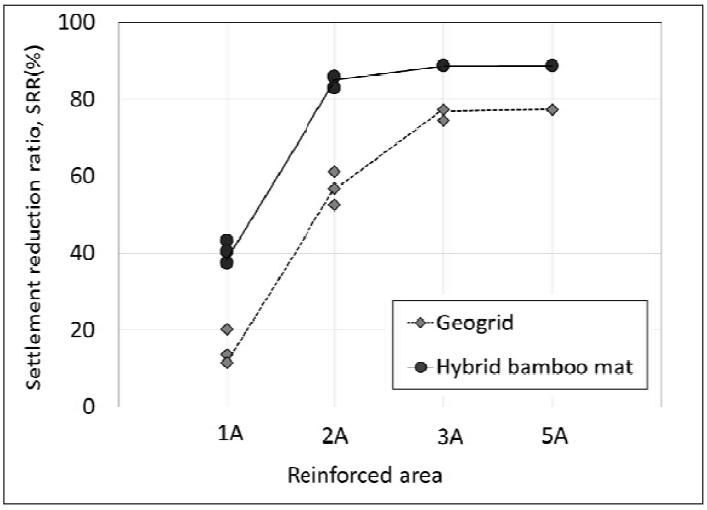


Fig. 4: SRR with reinforcement type

4. CONCLUSION

This study investigated settlement reduction characteristics of artificial reef which was unreinforcement or reinforced with geosynthetics (geogrid and hybrid bamboo mat). From this experimental test results, geosynthetic-reinforced artificial reef has less settlement depth than unreinforcement. Test results indicated that artificial reef reinforced with geosynthetics can improve stabilization of artificial reefs and it will promote fishing catching and restore marine eco systems.

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