Development of the tidal flat and eelgrass (AMAMO) field creation system with the effective use of the dredged cohesive material.

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Abstract: The number of tidal flats is rapidly shrinking by the reclamation accompanying land development etc., and the movement toward artificial tidal flat creation has taken place in various places. On the other hand, dredged cohesive soil such as sludge has been, in great volume, accumulated on the seabed. Therefore, the demand to dredge such soil and to utilize it as artificial tidal flat material strongly arises.

In fact, everywhere in the country, there were a number of AMAMO fields along the shoreline functioning as "the marine cradle" in which marine lives grew. However, as the result of pollution and reclamation caused by population concentration, factory construction, and etc. accompanying high economic growth, the AMAMO fields had almost disappeared. Thus, the demand to regenerate the AMAMO fields once disappeared and to regain the rich sea comes to be heard from people.

The technology developed in order to respond to such a demand is "the tidal flat and AMAMO field creation system with the effective use of the dredged cohesive material". This system consists of two technologies.

One of them is the tidal flat creation method which uses the biodegradable sheet. Although it was problematic to secure a predetermined slope and to execute sand covering work due to the dredge ground being soft with high water content, the problem has been overcome through the indoor and site experiments. In short, maintenance of an artificial tidal flat was realized by combined use of a sand covering method which used partition embankment for slope protection and the biodegradable sheet made from corn element.

The other technology is the AMAMO sowing method, In this method, the "AMAMO sheet" in which the AMAMO seeds are inserted in coconut mat or biodegradable nonwoven fabric and lozenge wire net is laid on the seabed, and the sprout and growth of AMAMO is promoted. This method considers environment using the biodegaradable nonwoven fabric and the coconut mat which is plant fiber, prevents the outflow of an AMAMO seed or seedling with high probability, reduces the diver works, and further makes significant cost cut possible.

Keywords: sludge, dredging, artificial tidal flat, AMAMO field, regeneration

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INTRODUCTION

The number of tidal flats is rapidly shrinking due to reclamation associated with land development, and movements in favor of artificial tidal flat creation have arisen in various localities. At the same time, large volumes of cohesive soil requiring dredging, such as sludge, have accumulated on the seabed. As such, public opinion solidly favors dredging such soil and utilizing it in the creation of artificial tidal flats.

In the past, AMAMO fields were a common feature along the entire shoreline of Japan, functioning as a “marine cradle” in which marine life developed and thrived. However, growing population densities and factory construction during Japan’s period of high economic growth increased pollution and reclamation activities to a point where AMAMO fields nearly disappeared. People now often speak of their desire to regenerate the lost AMAMO fields and regain the rich sea life that once surrounded the coasts.

In response to such desires, we have developed a system for creating tidal flats and AMAMO fields that effectively utilizes dredged cohesive material.

MOVEMENTS SURROUNDING TIDAL FLATS AND AMAMO FIELDS

Disappearance of Tidal Flats and Demand for Their Regeneration

The shoreline of Japan has changed considerably due to reclamation by drainage or filling, and the amount of tidal flats has decreased accordingly.

According to the National Survey on the Natural Environment by the Ministry of the Environment, approximately 3,900 ha of tidal flats disappeared in the 10 years from 1982 to 1991. This area corresponds to eight percent of the current total area of tidal flats (51,500 ha). These tidal flats function as the habitat for various marine life forms including Manila clams, crabs, sandworms, and gobioids, maintain a variety of ecosystems, and provide an important water purification function for rivers and the sea. Tidal flats are among the most valuable ecosystems on Earth, but many disappeared during the high economic growth period. Now, artificial tidal flats are being created in significant numbers in an attempt to revive the marine environment.

However, conventional tidal flat construction methods have problems including a shortage of sand, which is the primary material needed for tidal flats, and environmental destruction due to sand extraction. At the same time, finding landfill sites for the dredged sludge generated in dredging projects is also a significant problem. Thus, there is now demand for a technique for regenerating tidal flats using dredged sludge, which to this point has been regarded as useless.

Disappearance of AMAMO Fields and Demand for Their Regeneration

Large numbers of AMAMO fields were once found all along the shoreline of the country, functioning as a “marine cradle” in which marine life developed and thrived.

According to the National Survey on the Natural Environment by the Ministry of the Environment, approximately 2,100 ha of AMAMO fields disappeared in the 10 years from 1982 to 1991. This area corresponds to 4 percent of the current total area of AMAMO fields (49,500 ha).

AMAMO fields absorb excess nutrients in seawater and serve as a filter for the seawater that passes through them, and thus play an important role in keeping the sea clean. However, growing population densities and factory construction during Japan’s period of high economic growth increased pollution and reclamation activities to a point where AMAMO fields nearly disappeared.

Over the past few years citizens, enterprises, and the government have started to collaborate on regenerating the lost AMAMO fields, though only a few at a time. There is a need to develop a method for integrating diverse bodies (citizens, NPOs, and private enterprises) with local governments to promote AMAMO field regeneration projects in local communities.

DEVELOPMENT OF A TIDAL FLAT AND AMAMO FIELD CREATION SYSTEM EFFECTIVELY UTILIZING DREDGED COHESIVE MATERIAL

In response to public demand for the regeneration of lost tidal flats and AMAMO fields, we have developed a system for creating tidal flats and AMAMO fields that effectively utilizes dredged cohesive material.

This system utilizes 2 technologies.

Tidal flat creation method	AMAMO sheet method
Although it was initially problematic to secure a predetermined slope and to execute the sand covering work because the dredge ground was soft due to a high water content, the problem has been overcome through indoor and on-site experiments. Maintenance of an artificial tidal flat was realized through combined use of a sand covering method using partition embankment for slope protection and a biodegradable sheet made from corn-based polylactide.	This is a technology for promoting the sprouting and growth of AMAMO by laying an "AMAMO sheet" on the seabed. AMAMO seeds are inserted into the AMAMO sheet, made from coconut mat, biodegradable nonwoven fabric, and lozenge wire net. This method is environmentally friendly as it uses biodegradable nonwoven fabric and coconut mat, which is plant fiber. It is highly effective in preventing outflow of AMAMO seeds or seedlings and reduces diver work, and can thus significantly reduce the cost of creating an AMAMO field.

The Tidal Flat Creation System, which Effectively Utilizes Dredged Cohesive Material

(1) Overview

The number of tidal flats is rapidly shrinking due to reclamation associated with land development, and movements in favor of artificial tidal flat creation have arisen in various localities.

At the same time, large volumes of cohesive soil requiring dredging, such as sludge, have accumulated on the seabed. As such, public opinion solidly favors dredging such soil and utilizing it in the creation of artificial tidal flats. When creating tidal flats, the surface is covered with sand in the final stage with a view toward supporting biodiversity. However, when the material used to create the tidal flat is soft, appropriate construction is sometimes not possible because the sand sinks into the soft base.

To solve the problem of using soft dredged cohesive soil as the tidal flat material and the problem of sand sinking in when covering the soft cohesive soil with sand, we have developed a technique based on a biodegradable sheet that makes sand covering possible (ECOFLAT construction method).

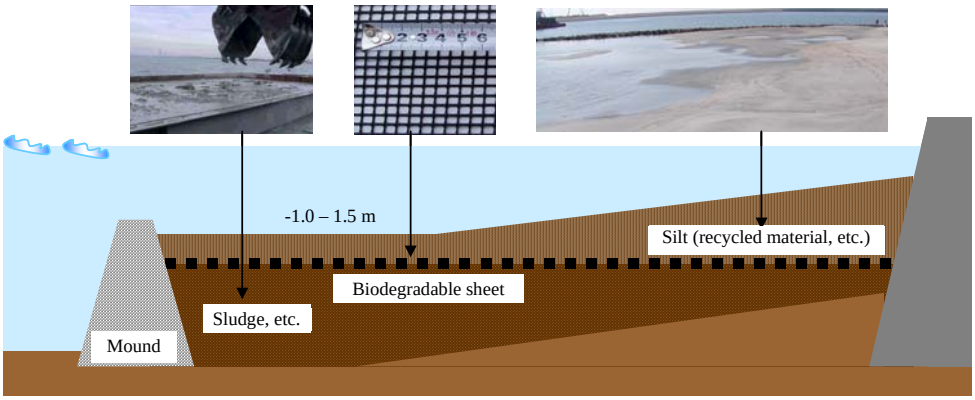


Figure 1. Schematic diagram of cross-section of ECOFLAT construction method.

ECOFLAT is an abbreviation for Man-Made Tidal Flat with Eco-Net. It has the following features.

1) It enables prompt sand covering when constructing artificial tidal flats using soft dredged soil (water content of 100 percent to 200 percent) as the filling material.

2) The biodegradable sheet used is made from polylactide extracted from corn and is expected to reduce environmental load as it is decomposed into water and carbon dioxide in 4 to 5 years by the soil fungi living in the installed area.

3) The material is meshed in order to provide large frictional resistance on the basement. Additionally, this structure permits living things to move into the soil.

4) The same design method can be applied using either ordinary sheet construction or geotextile construction.

(2) Patents

Patent application No. 2004-33800 Creation method of artificial tidal flats and artificial shallows

(3) Case example

As part of the Hannan Second District Environmental Improvement Project, which the Ports of Osaka Prefecture is promoting, an artificial tidal flat was constructed using dredged cohesive soil from July 2002 to February 2004. The construction used the dredged soil generated in the pier construction of the Sakai LNG Center of Kansai Electric Power Co.

The initial plan was to add the dredged cohesive soil between the existing revetment and the submerged breakwater and then cover over the soil with sand to promote regeneration of the natural environment. However, it was found that the soft dredge could not secure the required slope necessary for the intertidal zone. At the same time, it was discovered that the covering sand layer sank into the cohesive soil.

The dredged soil used in the construction was inhomogeneous soft cohesive soil containing 100 percent to 200 percent water, and construction was done at a depth of 8 to 11 m. In the construction, we combined the results of centrifuge model tests and numerical simulations in the laboratory with experiments and survey activities at the site. We also introduced new construction techniques including sand covering in conjunction with a biodegradable sheet made of polylactide, which was used for the first time in a large-scale sea construction. In this manner, we solved the issues related to tidal flat creation.

Polylactide is made from plants such as corn, and as such is expected to decompose into water and carbon dioxide 4 to 5 years after construction of the tidal flat.

With these efforts, we solved the problems of securing the required area for the intertidal zone and the required thickness of the cover sand. The construction increased the tidal flat area in Osaka Bay and thereby contributed to the revitalization of the Osaka Bay marine environment.

Further, development of this method has led to the establishment of techniques for constructing artificial tidal flats that effectively utilize the soft cohesive soil generated in large amounts in the dredging used to maintain coastal routes and anchorages.

Site of case example


Condition of dredged soil


Condition after filling with dredged soil


Condition after installing the sheet Photograph of ECOFLAT construction method


Condition after installing the sheet


Condition of the cover sand


Completed tidal flat

Photograph 1. Construction conditions using the ECOFLAT construction method.

(4) Effects of artificial tidal flat regeneration

In the artificial tidal flat completed, birds, gobioids, crabs, and other living things have started to make their habitats. It is beginning to fulfill its full function as a tidal flat.

The polylactide used is made from plants such as corn, and is expected to decompose into water and carbon dioxide in 4 to 5 years. If compounds such as polyethylene were used, there would be concerns that nondegradable plastic would remain in the environment. However, the present construction method does not leave unwanted materials in the environment as it uses a biodegradable sheet. In addition, it effectively uses a large amount of dredged soil, traditionally regarded as an industrial waste, which also makes it more eco-friendly from a broader perspective.

(5) Awards

The ECOFLAT construction method received the Technology Award of the Kansai Branch of the Japan Society of Civil Engineers and the Technology Award of the Kansai Branch of the Japanese Geotechnical Society in 2004.

AMAMO Field Regeneration Technique

(1) Overview

Conventional AMAMO field construction methods relied on manual work performed by divers, making large-scale construction difficult and relatively costly.

We set as our goal a low-cost mechanized construction method, and have developed an AMAMO field construction method in which AMAMO seeds are inserted into an "AMAMO sheet" consisting of coconut mat, biodegradable nonwoven fabric, and lozenge wire net. The seeding sheet is deployed by being cast into the sea from a ship to extend the AMAMO fields (referred to as the AMAMO sheet method). It is an efficient, economic, eco-friendly AMAMO field construction method.

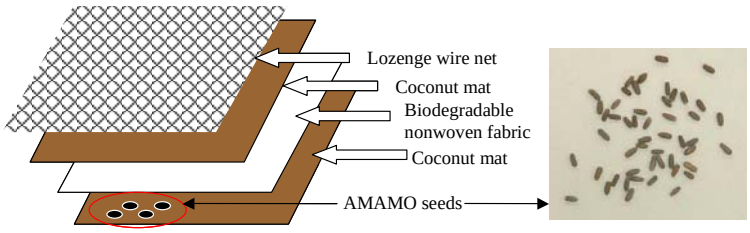


Figure 2. Structure of AMAMO sheet.

This method has the following advantages.

1) It is a seeding method that is highly effective in preventing the outflow of AMAMO seeds and seedlings.

2) It is a mechanized construction method also suitable for large-scale constructions. In small-scale constructions, it is also suitable for resident participation (cooperation work) in the activity.

3) It involves little diver work, allowing for a significant reduction in cost.

4) The main materials constituting the AMAMO sheet are a biodegradable nonwoven fabric (made of rayon) and lozenge wire net (made of raw iron). Both of these materials decompose with time, making this an eco-friendly construction method.

(2) Patents

Patent No. 3183829: Name of invention: Seeding sheet and seeding method

Patent Application Heisei 10-61874: Name of invention: Seeds

Patent Application Heisei 10-181976: Name of invention: Seeding sheet and seeding sheet for constructing artificial seaweed beds

(3) Case examples of AMAMO field regeneration

We started developing this method for AMAMO field construction 10 years ago as a technology for contributing to the conservation and revitalization of the sea environment. In 2001, we succeeded in commercializing the "AMAMO sheet method." Since then, we have worked on AMAMO field regeneration in various areas of Japan using the AMAMO sheet.

Major construction sites include the sea site adjacent to Yokohama in Mutsu Bay in Tohoku, Nojima Coast and Sea Park in Yokohama Bay, and shallows adjacent to the Bayside Marina in Kanto, the sea site adjacent to Osaka Bay Rinku Town in Kansai, Yamaguchi Bay in Seto Inland Sea, Nakaumi in San-in, and Hakata Bay in Kyushu.

As indicated in the features of the AMAMO sheet, it is classified into large-scale, small-scale, and resident-participation types. Representative case examples of these types are indicated below.

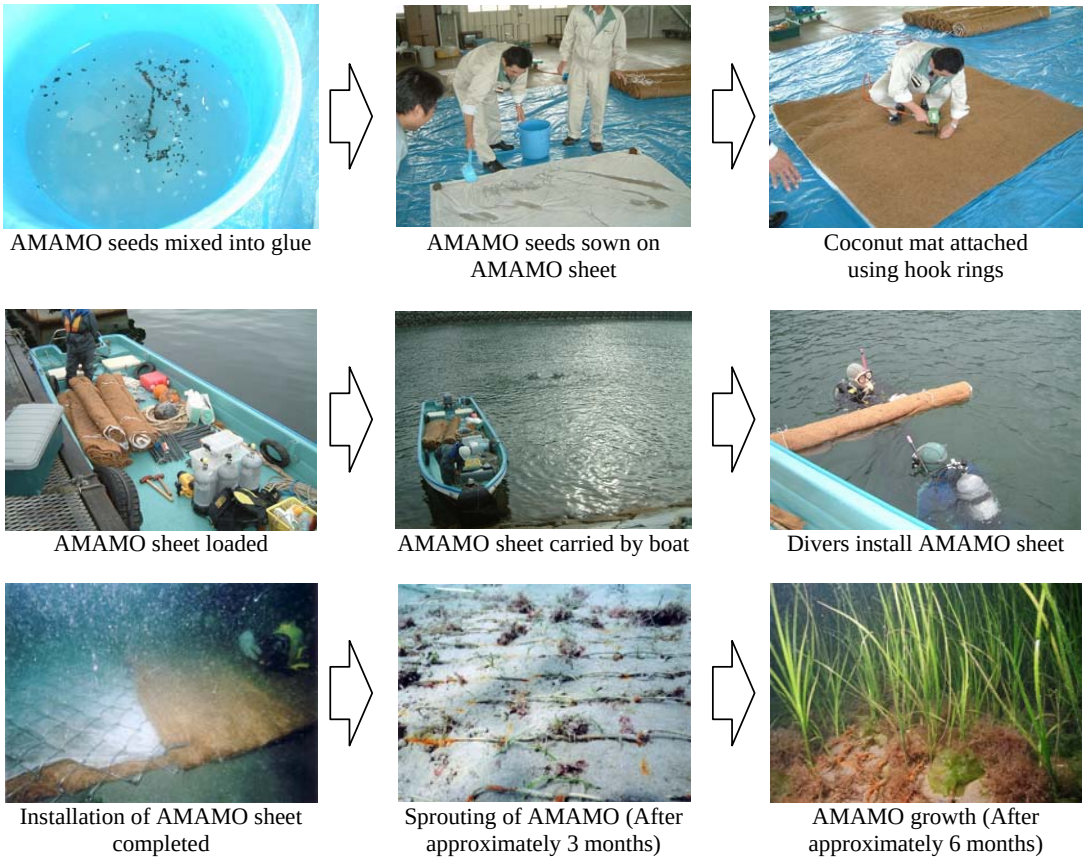
♦ Case example of large-scale AMAMO field regeneration

[2 m x 12.5 m = 25 m^2 per unit; Oi-cho Coast (Fukui Prefecture); Construction area: 1,200 m^2]

Photograph 2. Large-scale AMAMO field regeneration.

♦ Case example of small-scale AMAMO field regeneration

[2 m x 2 m = 4 m^2 per unit; Kawanoe Coast (Ehime Prefecture); Construction area: 24 m^2]



Photograph 3. Small-scale AMAMO field regeneration.

♦ Case example of resident-participating AMAMO field regeneration

[1 m x 5 m = 5 m^2 per unit; Shallows adjacent to Bayside Marina (Kanagawa Prefecture); Construction area: 50 m^2]

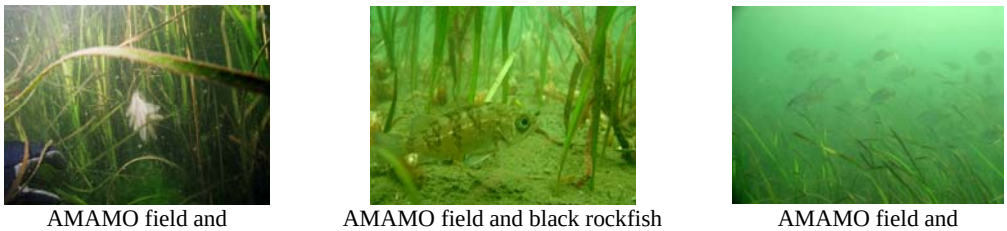
AMAMO seeds mixed into glue | AMAMO seeds sown on AMAMO sheet | AMAMO sheet rolled

AMAMO sheet ready | Divers install AMAMO sheet | AMAMO growth (After approximately 6 months)

Photograph 4. Resident-participation AMAMO field regeneration.

(3) Effects of AMAMO field regeneration

The AMAMO field is expected to form an ecosystem within 2 to 3 years after the AMAMO sheet is installed. It will serve as a spawning site for bigfin reefsquid and cuttlefish, a place for pipefish, bobtail squid, skeleton shrimp, and lawn shrimp to mature, a feeding site of black rockfish, surfperch, sea bream, and octopi, and is expected to improve the habitat of marine clams such as the Manila clam.



AMAMO field and eggs of bigfin reefsquid | AMAMO field and black rockfish | AMAMO field and school of black rockfish

Photograph 5. AMAMO field and marine life.

(4) Awards

The current AMAMO field regeneration technology received the 8th Infrastructure Technology Development Award in 2006.

In the past this award has been given to hardware technologies and software technologies that were highly technical in nature, as indicated by names such as “xx construction method,” “xx system,” and “xx technology.” In contrast, our winning technology this year was recognized as unique compared to those of past award winners in that its efforts in the arena of social action were highly evaluated in addition to its technical aspects.

SUMMARY

The shoreline of Japan has changed significantly due to reclamation by drainage or filling. As a result, the number of tidal flats has shrunk, and the number of AMAMO fields, which function as “marine cradles” in which marine life develops and thrives, has also drastically decreased.

The 21st century is sometimes referred to as the era of environmental awareness. We believe that regeneration of the lost tidal flats and AMAMO fields will lead to revitalization of the sea environment, and consequently to the revitalization of the global environment.

The “ECOFLAT construction method,” which is a method for constructing tidal flats in conjunction with biodegradable sheets, and the “AMAMO sheet method,” which installs AMAMO sheets containing AMAMO seeds inserted into coconut mat, biodegradable nonwoven fabric, and lozenge wire net, are elemental technologies which have acquired recognition for their uniqueness.

We have succeeded in formulating these two technologies as systems, which we refer to as the tidal flat and AMAMO field creation system effectively utilizing dredged cohesive material, and are engaged in groundbreaking new business activities related to the system.

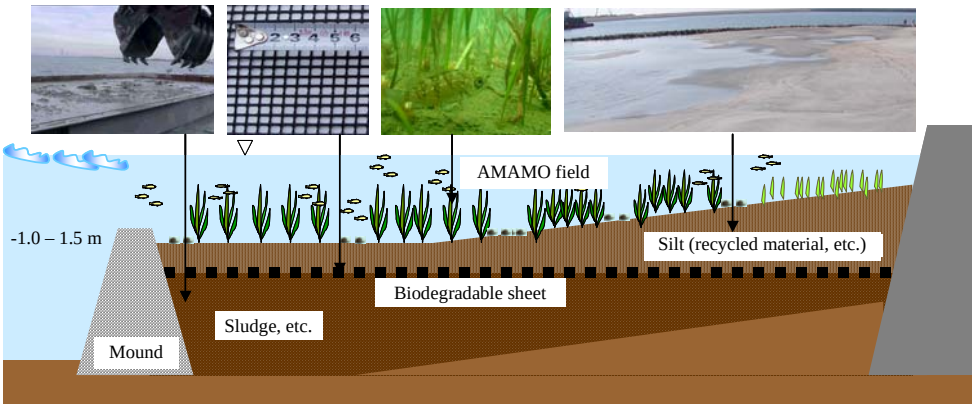


Figure 3. Schematic diagram of cross-section of the tidal flat and AMAMO field creation system effectively utilizing dredged cohesive material.

We will continue to make use of this eco-friendly tidal flat and AMAMO field creation system effectively utilizing dredged cohesive material and will aggressively proceed with business activities in the tidal flat and AMAMO field regeneration business.

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