2. Artificial Floating Island (AFI) Method

2.1 Features and Function

2.1.1 AFI and its development

The Artificial Floating Island (AFI) is a floating structure on which aquatic vegetation such as reed grows. The main purpose is to create habitats, purify water, improve landscape, and preserve lakeshore by wave absorption. AFI technology was originally developed as fish spawning reef in 1950's. It is kind of new ecological method and didn't attract much attention until 1995 on the 6th ILEC Conference. After that there is a big increase of AFI application case in Japan and also other countries, such as Germany, and U.S.A. And recently it is widely recognized as Eco-technology, and installed at many lakes and ponds in Japan, investigation revealed that about 15 companies laid artificial floating islands, and the number of those so far is approximately 2,000 reaching 24,000m^2. (4)

2.1.2 Function

There are many functions of AFI concerning water environment management such as water purification, habitat for wild life, and improvement of lake shore scenery listed as follows: (26)

(1) To create habitat for fish and birds

AFI can support growth of aquatic plant and thus create a habitat and offer shelter for birds, insects, and other bio-organisms. It also provides "spawning bed" for fish. As a result, the ecological diversity is intended to restore and improve after construction of AFI.

(2) To purify water

The growth of aquatic plants densely on the AFI and the micro-organisms attached in the AFI help purify water a lot. Besides, the AFI can inhibit growth of phytoplankton due to that it occupies water surface and form a "shadowing effects".

(3) To break wave and protect littoral zone

The AFI is designed to dissipate wave and can help stabilize and protect littoral zone through reducing wave impacts and erosion, and thus advantageous to the recovery and growth of vegetation in the littoral zone.

(4) To improve landscape

The growth of different plants on floating island form a favorable landscape.

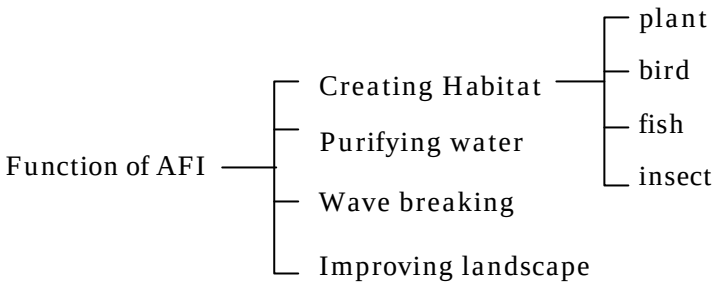


Figure2-1 Function of AFI (8)

2.1.3 Suitable installation places

The AFI creates artificial nearshore mini-ecosystem through utilization of water surface instead of occupying the shoreline space. Since the AFI uses floating platforms to support vegetation, it can move up and down with the fluctuation of water level, and also can be move from place to place. Due to its unique features, it is suitable for the following places: (8)

(1) It is effective structure for the dam lakes with violent fluctuations in the water level;

(2) It is suitable for the lakes and marshes involving difficult in the recovery of vegetation zone due to the waves,

(3) It is also possible for the ponds and marshes requiring accents in the landscapes, shores requiring the spawning site for fish and habitat for birds.

2.2 Structure of AFI

2.2.1 Structural classification

The AFI is composed of the vegetation base-AFI platform and the fixing system-anchor. According to its platform structure, the AFI is classified into two types, the dry type and the wet type. See table2-1. The Wet type with frame is the most frequently used type until now, sharing about 70% or more, dry type shares 20%, and wet type without frame shares about 10%. (10)

Table2-1 Type of the AFI

type		characteristics
Wet type: Plant can contacts directly with water and performs good water purification effects.	Mat-with-frame type	Vegetation base: usually inundated by water. Dominant plant: emergent plant, such as reed, cattail, etc. Advantages: habitat for bird resting and fish spawning, water purification, etc.
	Mat-without frame type	Vegetation base: up-part emergent out of water Dominant plant: hydrophyte plant Advantages: habitat for birds resting, natural landscape
	Floating log type	Vegetation base: contacts with water Dominant plant: water-resisting plant such ad willow Advantages: habitat for birds, ducks
	Waste tire and other type	To use wasted tire and pet bottle for plant growing. Easily making with low cost.
Dry type: Plant cannot contact with water. It Scarcely bring water purification effect, but possible to plant arbors and garden trees.	Box type	Vegetation base: doesn't contact with water Dominant plant: terrestrial tree and grass Advantages: Habitat for bird resting and fish spawning, good landscape, wave-broken
	Floater and vegetation-base separating type	Vegetation base: doesn't contact with water Dominant plants: emergent plant such as reed, cattail Advantages: habitat for birds, duck, aquatic animals

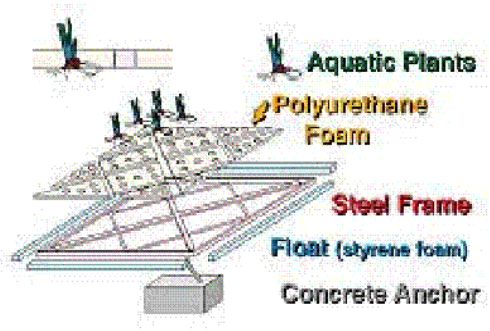
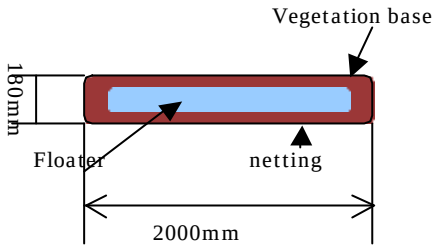


Figure 2 Structure of AFI

AFI just after installation in lake Kasumikaura

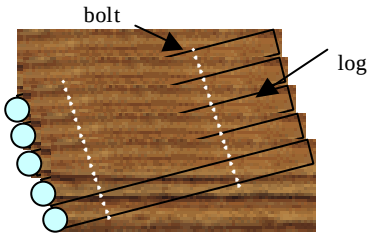
The most popular used type. FRP, stainless steel+foam polystyrene, PVC, concrete, etc are used as support for the growth of the plant. Stainless steel is utilized as frame.

Figure2-2 Wet and with frame type AFI (4)



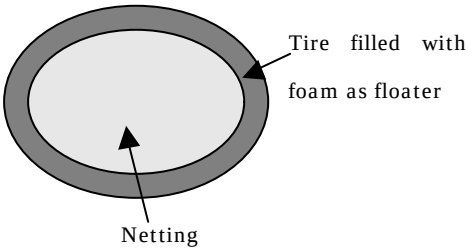
To use coconut fibers skillfully sewn together without frame, It gives a soft impression to the landscape due to absence of frame.

Figure2-3 Wet and without frame type AFI



To combine logs or plastics to be a raft shape, and plant vegetation on it.

Figure2-4 Floating log type



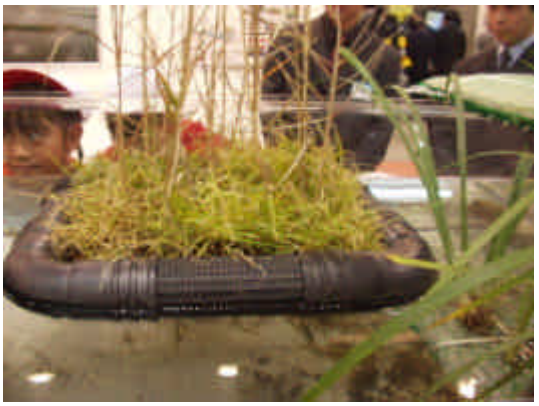
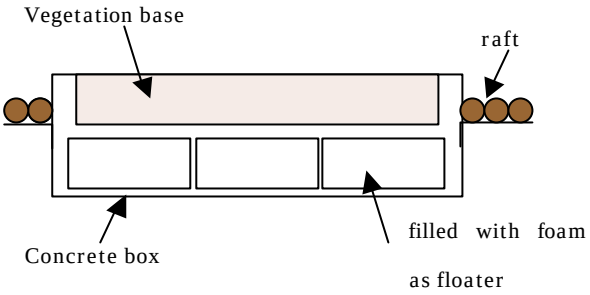
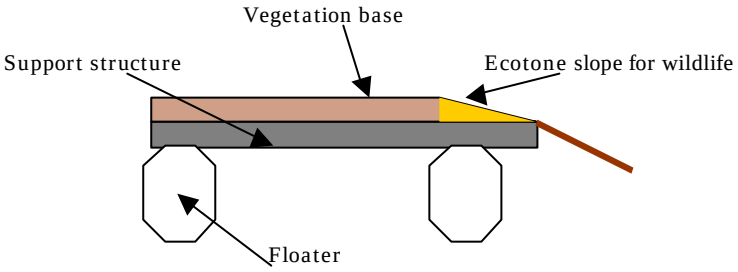


Figure2-5 Tire type [10]



To fill the foaming material in the box structure. Soil cover the structure supporting growth of the terrestrial plants.

Figure2-6 Box type [8]



The floater is separated from vegetation base and installed underneath the vegetation base.

Figure2-7 Floater and vegetation base separate Type [8]

2.2.2 Vegetation base

Coconut palm fibers are most often used as the vegetation base. Other than those in coco palm fibers, vegetation bases are often made of special foam polyurethane, fishing nets, foam polyurethane beads, and the combination of these materials in many cases.

2.2.3 Size and configuration

As the sizes, one side of a unit range from about 1 to 5 meters, but many of them have a side ranging 2 to 3 meters, transportability, workability, and durability being taken into account. The most popular configuration is four-sided.

2.3 Points for AFI Design and Installation

2.3.1 AFI plan process

The process for conducting an AFI plan is showed as follows: [8]

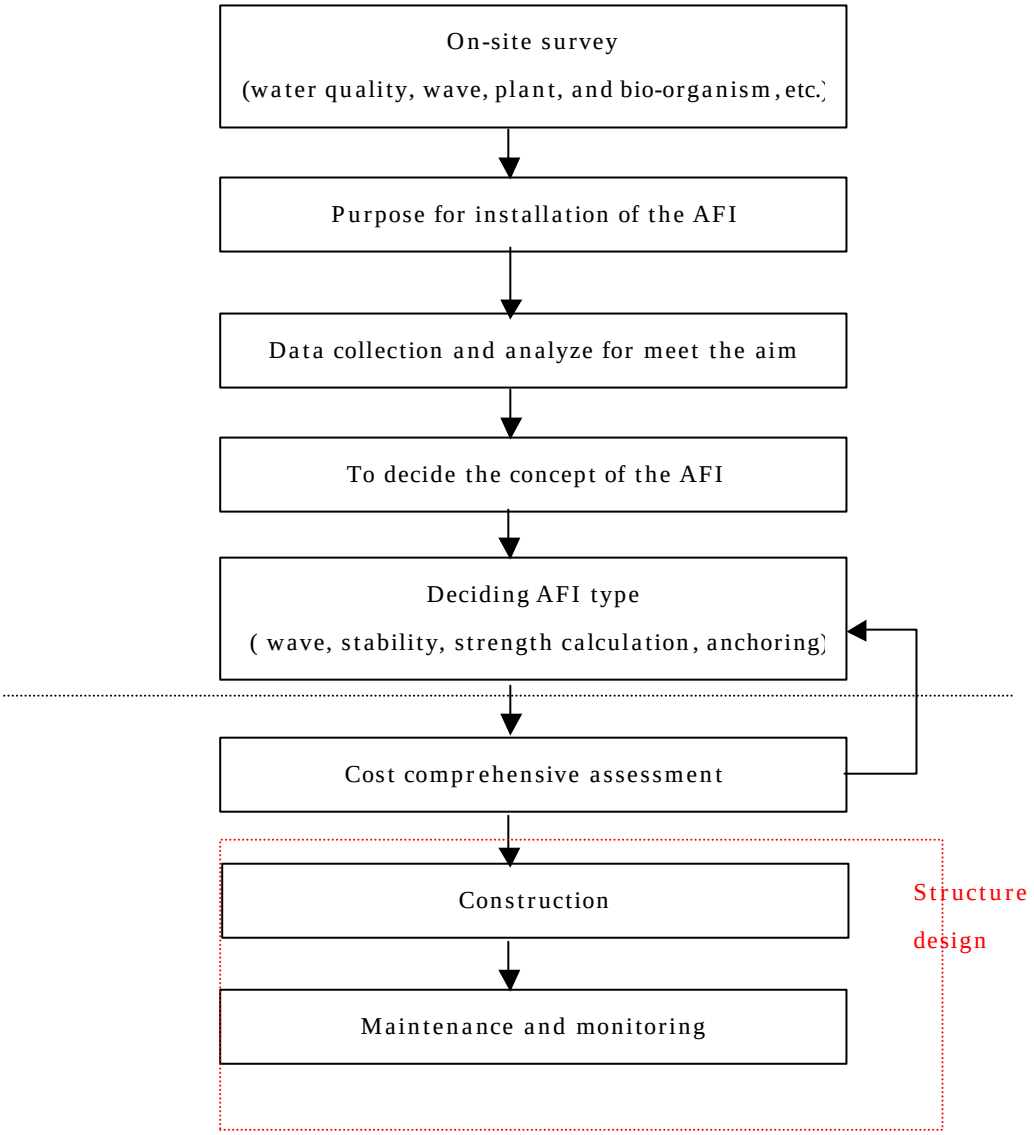


Figure 2-8 AFI design and installation process

2.3.2 Structure design

There are 5 keypoints that should be taken in good consideration including stability, durability, landscape, cost-effectiveness, and easily-construction in structure design of the AFI.

- Stability: To maintain stable and avoid destruction from strong wave, wind and conflict between units.
- Durability: To choose adaptable materials for frame and floater, and design the reasonable structure to make the AFI durable.
- Landscape: To fit the landscape of the AFI with the surrounding landscape.
- Economically: to reduce the cost for the AFI and make cost-effective.
- Construction: The connection of the units considerate easily construction, move, maintenance, etc. factors.

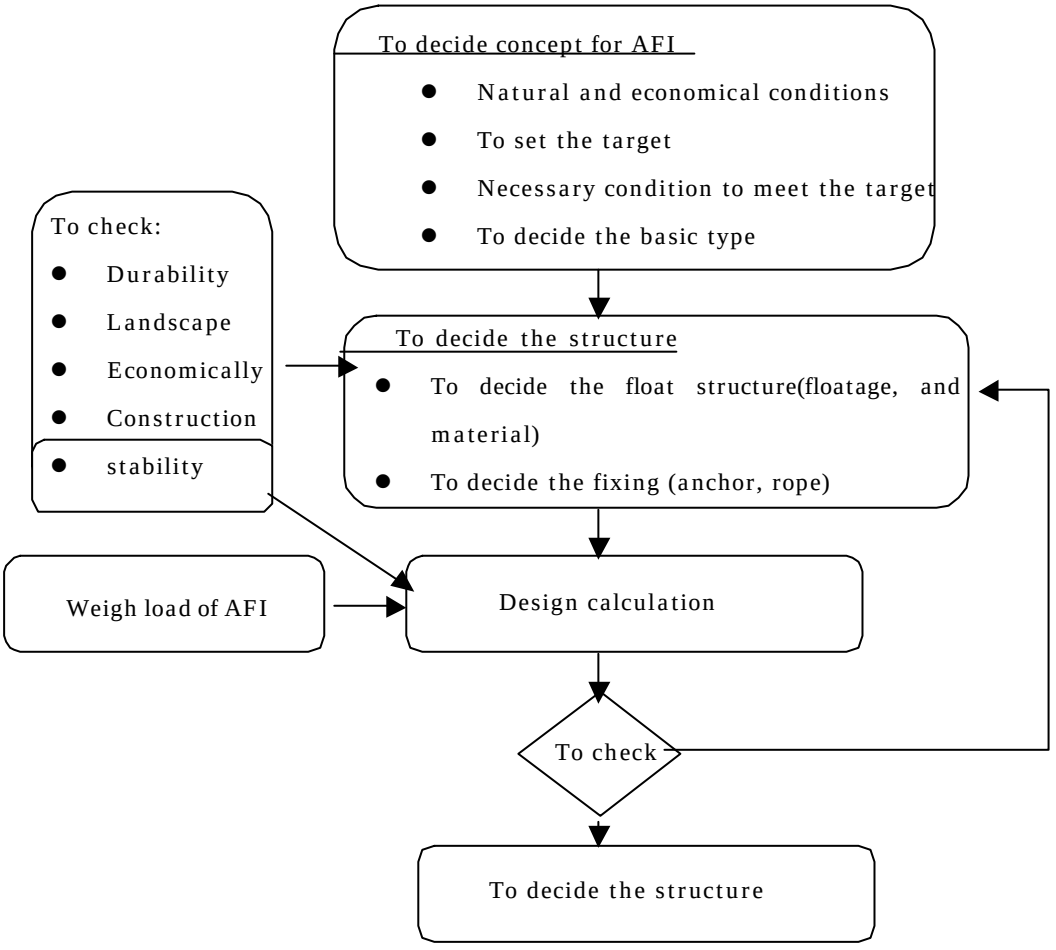


Figure 2-9 The structural design of AFI [8]

2.3.3 External force calculation

In the design step of AFI, the calculation of external force including wave force, wind force, water flow force is necessary and important for stability of the AFI. [8]

(1) wind force

The wind force is calculated according to the following formation:

$$P_1 = 1/2 \times Pa \times Va^2 \times Ca \times G \times Al$$

Pa: air density (kgf.s^2/m^4)

Va: wind velocity (m/s)

Ca: force-resistant coefficient

G: atmospheric-response coefficient

A1: projection area of the AFI on the water surface (m^2)

(2) wave force calculation

The wave force is calculated according to the following formation:

$$P2 = 1/2 \times Pw \times U^2 \times Cw \times A2$$

Pw: water density (kgf.s^2/m^4)

U: water particulate moving velocity (m/s)

Cw: water-resistant coefficient

A2: projection area of the AFI under water surface (m^2)

(3) Water flow force calculation

The water flow force is calculated according to the following formation:

$$P3 = 1/2 \times Pw \times V^2 \times Cw \times A2$$

Pw: water density (kgf.s^2/m^4)

V: water velocity (m/s)

Cw: water-resistant coefficien

A2: projection area of the AFI under water surface (m^2)

(4) Total external force

The total external force is:

$$P = P1 + P2 + P3$$

With the total external force, it is possible to check the intensity of the rope connecting float with anchor, the intensity of anchor against external force, the intensity of the floater against the force and the intensity of the rope connecting units.

2.3.4 Fixing design

There are 3 methods for fixing of AFI: gravity type, anchor type, and pole type. See figures. [8]

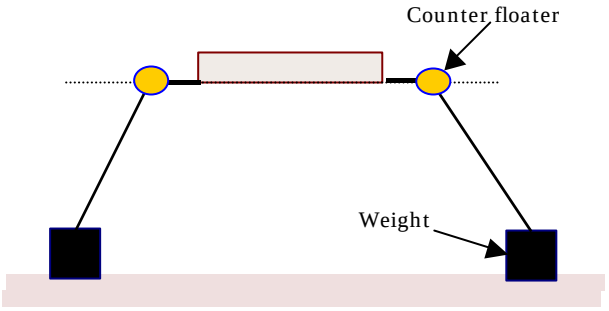


Figure2-10 Gravity type fixing

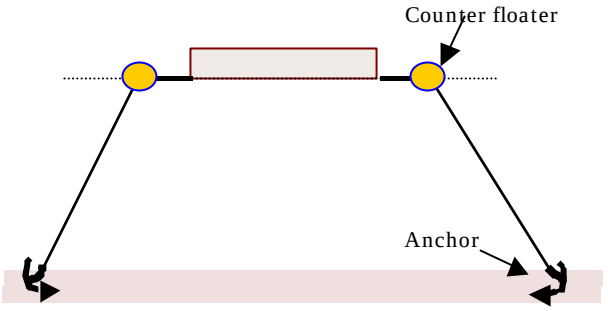


Figure2-11 Anchor type fixing

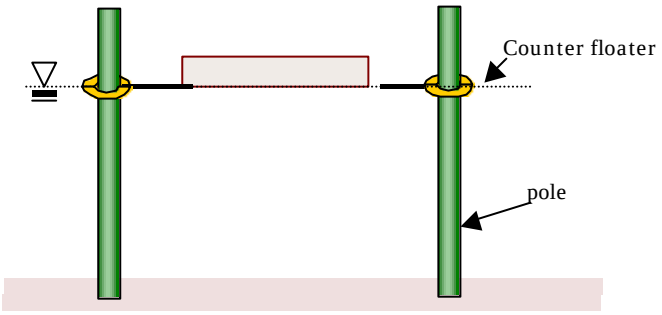


Figure2-13 Pole type fixing

Table2- 2 Fixing type and its characteristics [8]

Items	Gravity type	Anchor type	Pole type
Water depth	Possible in every depth	Water deeper, requirement higher	Water deeper, pole longer
Geology	No influence	influence	influence
Displacement with water level	Horizontal displacement	Horizontal displacement	Vertical movement
landscape	Exposure of anchor in the low level season	Anchor is fixed under water without exposure	Exposure of poles don't do good to landscape, but it may offer resting places for birds.
Economically	Heavier the weight, much cost of both material and construction	Material is expensive, but construction is less expensive than gravity type	Shallow places, cost is less than gravity and anchor type
Construction	large size machine, and complex construction	Less large machine and less complex than gravity	Large machine and difficult construction

2.4 Cost

Cost of AFI varies a lot from different structures of the AFI. Among all types of AFI, the box type is the most expensive one and cost about 250-500 thousand yen/m^2, while the wet-with-frame type is less expensive with cost of 50-100 thousand yen/m^2. Generally, the cost of AFI is high and will exceed 100 thousand yen/m^2. However, sometime, if use recycled material such as tire, the cost of AFI less than 10 thousand yen/m^2 becomes possible. [8]

2.5 Monitoring and Maintenance

2.5.1 Monitoring

After the installation of the AFI, it is necessary to conduct 3-5 years' monitoring for mastering the change of surrounding environment and evaluating effects of the AFI. Monitoring items including biological survey, water quality, wavebroken effects, etc.

2.5.2 Maintenance

Maintenance mainly includes:

(1) Check, repair and emergency measures: To examine the connecting part between different units, fixing rope, anchor, vegetation base, etc so that to keep in good condition. To repair the destroyed parts.

(2) Plant management: To remove the undesired and invaded species away from the AFI, to keep the desired and designed landscape. To mow at some interval and irrigate and fertilize.

2.6 Application case in Lake Kasumikaura

2.6.1 Introduction

The AFI case at Tsuchiura Port in Lake Kasumigaura was installed in March, 1993, by the Ministry of Construction. It belongs to the wet-with-frame type. It has a length of about 91.5m and a width of 9m, consisting of 40 segments.

Each segment has an area of 20.25m^2, with each side of 4.5X4.5m. The segment is made of steel frame with polystyrene. Sponge was filled into the frame for supporting aquatic plants. And on the sponge, there are many 10cm cuts for planting of plants. [9]

The purpose of this AFI is (1) create better landscape and habitat (2) To purify water, and (3) To protect lakeshore.

Figure2-14　AFI at Tsuchiura Port in Lake Kasumigaura [26]

Another AFI also installed at Aso town in Lake Kasumikaura. It aims at wave dissipating and protecting vegetation in the littoral zone.

Figure2-15　Wavebroken AFI in Lake Kasumikaura [26]

2.6.2 effects

On Figure2-15 case, research carried out vegetation restoration by using AFI as a breakwater. This AFI was designed to break water 50% and reduces wave height to 40 cm, which is critical wave height for vegetation growth. As a result of our experiment, vegetation area has expanded 3.4% a year.

The AFI installed in Kasumikaura proved AFI really effective in creating habitats for small fish and prawn, in increasing the biodiversity on and underneath the AFI, in purifying water quality surrounding AFI, and in dissipating wave's erosion at the

littoral vegetation. (11)

2.7 AFI case in Lake Jonuma

On 11st, April, we visited the Tatebayashi City where there is floating island under construction on Lake Jonuma which is one part of Tsuruuta River flowing through Tatebayashi Park. Sato san who is from the Seniya Oceanic Service Company and have engaged in AFI work for about 8 years explained the main structure and installation points of AFI for us.

(1) Aim of AFI on the river

One of the main purposes for installation the AFI is to purify water quality of the river which is polluted by non-point pollution from paddy field and surrounding areas. The other one is to provide habitat for birds and other animals, and also improve the landscape of the river for the river is inside the Tatebayashi park. The AFI is installed on two different sites in the Jonuma City, see the pictures in the following, Figure 2-16 shows the newly finished AFI and Figure 2-17 shows the under constructing AFI started one week ago.

(2) Structure

The AFI installed in the 2 sites both belongs to the wet without frame type—mat without frame type. The structure of the unit see Figures.

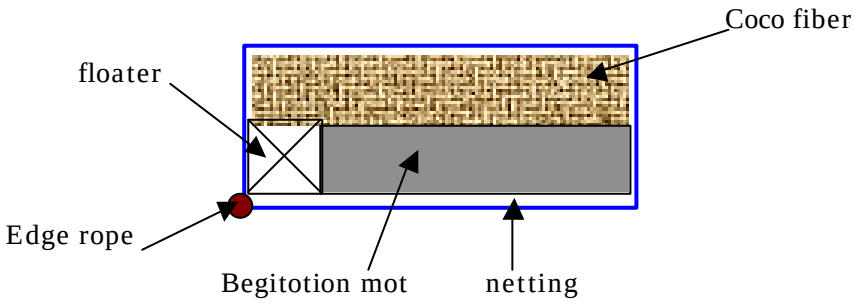


Figure 2-15 Structure of the vegetation base (6)

The unit is primarily composed of (1) the vegetation base which is made of coconut fiber imported from Indonesia. After the mat is arranged on the water, the coconut can absorb water and this keep plant untouched with water. (2) the Begitotion Mot made from polyplopirene fiber, which will provide growth of the rhizome of plant, which may provide support for the plant even after 3 or 4 year's when the coconut fiber decayed

away. (3) the floater, which is made of polyetirene foam provides sufficient floating ability for units. (4) netting covering outside of the unit encloses the different parts of unit and make it a integrate.

Each unit has an area of 4m^2 with each side of 2mX2m. Moreover, the AFI installed on two sites has 25 units with an total area of 100m^2 separatively.

(2) plants on the AFI

The primary plants on the AFI are reed, cattail, etc, which are all taken from the nearby river side. See photo. To taken plant from near area of AFI is critical so as to make sure the plant is native and adapt to local environment.

The plantation on the unit is very easy, see photo. Firstly, making some cuts on the netting, and then put the plant root into holes. In this case, 16 cuts are made in each unit for 16 pieces of plant root. Sometimes after installation, the plant may be eaten by bird or other organisms.

(3) connecting of the units

Rope made from polyetirene with diameter of 12mm are used for connecting different units. See photo. The black jointing structure made of polyocetar are used for connecting rope with mat.

(10) Layout of the AFI on the water

Layout of AFI doesnot have so many restrictions. Usually layout arrangement is decided according to the purpose of the AFI. In the 2 cases in Lake Jonuma, we just arrange the layout freely.

(11) Fixing of the AFI

In this case, we use the anchor for fixing the AFI. The installation of anchor see photo. The boat carriers the anchor near the mat a certain distance away and drop the anchor into water. The anchor can automatically grab soil and keep the AFI stable after dropped into the water. On the newly finished AFI, totally 8 anchors are installed with a weight of 55Kg each.,

Figure 2-16 Dropping of the anchor