A study on bamboo as the alternative material for floating PV system structure

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Abstract. This paper presents the study of bamboo as an alternative material for structure of floating PV system. Bamboo is selected as it is used for traditional floating house structure by Indonesian people. Additionally, bamboo is a fast growing vegetation and it can be found easily here. To investigate its potential, the study includes the characteristics of bamboo material such as its the physics and mechanics, the application of bamboo as a structure material and subsequently the component of PV structure to analyse the feasibility of bamboo material as the floating PV structure. In the analysis, the following aspects are studied: floatation system, configuration and mooring configuration.

1 Introduction

It is acknowledged that floating PV system now has been widely used. The main reason is the lack of land for PV system utilization. Therefore, sea, lake or river now become the location for the PV system. The significant advantage is the temperature increase of the PV cell can be smaller. [1]. Essentially, floating PV system can be used as energy not only for generating electricity for buildings but also for an aquaculture. Indonesia is an archipelagic country, whereas the sea area of Indonesia region is around 70% [2]. There are a lot of aquacultures built by the netizen, not only on the sea but also on the river.

Generally, in every aquaculture uses a machine called “aerator”. Aerator is an equipment for providing oxygen and to neutralised water so that the growing of fish can be improved. The current energy source for the aerator is diesel, because it is difficult to get local grid electricity, so the farmers use diesel or use long wire to connect the aerator with electricity from the nearest building. The use of diesel not only expensive but also need to be provided regularly from the nearest land. Therefore, floating PV system for an aquaculture, especially off shore, is potential.

Floating PV systems is constructed by a floating structure. Floating PV system contain a structure and a floater. The materials for structure can be metals and PVC. And as for the floater, usually the materials are polyester and polycotton. However, in the PV system, it is also possible to use only PVC pipes, since the material has cavity. This cavity causes a buoyant force.

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In relation to the Sustainable Development Goals (SDG), one of the principles is "affordable and clean energy". The aim of this research is essentially to provide affordable material structure for floating PV system to be used for local aquaculture. Bamboo is selected as it has cavity and also a fast-growing material that is easily found in Indonesia. Furthermore, bamboo does not any special treatment during its growing process [3].

In this study, the research also studies the local wisdom of its local building that is located on river. As Indonesia is an archipelago, the sea area as well as the river area is also used as the house location. The traditional house used local materials for the floating house. One of the materials is bamboo beside wood [4]. Figure 1 shows the bamboo material as the floating structure. The picture shows a traditional of Kalimantan housing type, namely Rumah Lanting or Lanting House.

Fig. 1. Lanting House, Kalimantan [3].

This type of house is analysed to know the bamboo is constructed become a floating structure. The analysis uses the diagram of floating PV structure by [6]

In the end of this study, an initial concept for the floating PV structure is created. This concept has been applied.

2 Literature Review

2.1 Floating PV structure

The floating PV system, in general can be illustrated at Figure 2. The general components are the mooring, floater, structure, and the construction or material [5].

Figure 3 shows the component of floating structure for PV system. It can be seen that materials are form ferrous, polymers, Cementitious or combination. As for the system, it can be a floatation tanks or buoyancy tubes. The configuration can be an interconnecting float to rafts or interconnecting frames between buoyancy tanks or tubes. Also, a flexible membrane between floatation tubes. This study will be analysed using this diagram to assess the reliability of bamboo material usage as a PV floating structure [5].

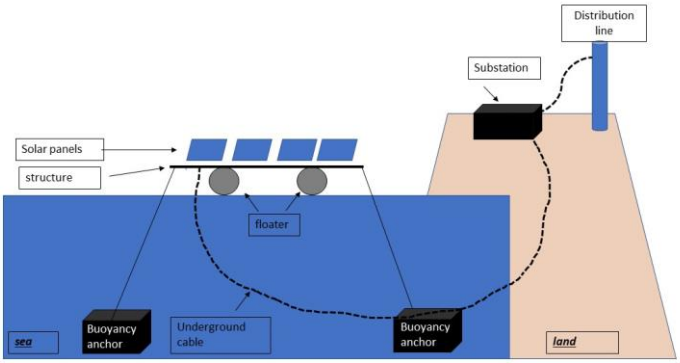

Fig. 2. Floating PV System.

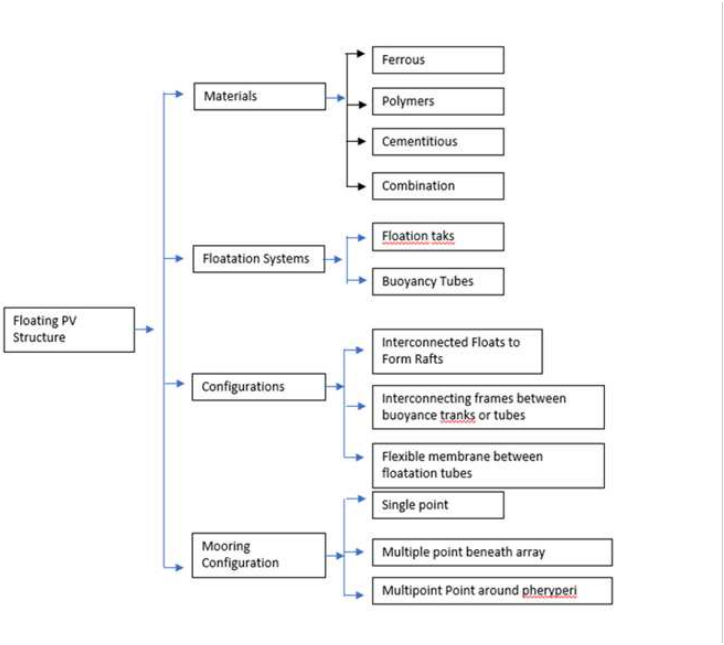

Fig. 3. Floating PV structure [6].

2.2 The characteristics of bamboo

Based on the study of Rini (2018) [7], Petung bamboo or Dendrocalamus was chosen as the main material. The anatomical structure of Petung bamboo is a vascular bundle network, consisting of mexilem and phloem vessels surrounded by fiber bundles (40%), between the vessels there is parenchyma (50%). Fiber length is 3.947 mm, diameter is 33.84 microns, lumen diameter is 29.10 microns and fiber wall thickness is 2.37 microns. The water content is very influential on the amount of retention and penetration of preservatives that enter the bamboo. The greater the moisture content in bamboo, the greater its retention and

penetration. The largest retention of CCB preservatives was at the base with an average of 13.62 kg/m , then followed by the middle 11.47 kg/m and the tip 9.12 kg/m . Penetration of preservatives on all three parts of the bamboo is 100%. The un-treated bamboo samples are very susceptible to marine borers, especially at the base, followed by the middle and tip. Samples of bamboo preserved with 3% CCB through a modified process can survive at sea for up to 6 months. The base of the preserved bamboo is more resistant than the middle and ends. The organisms that attacked the bamboo test samples were sp. and Boucherie Teredo Martesia striata. Based on the results of data analysis, the following conclusions can be drawn: 1. The bamboo stem parts (segments and nodes) have no effect on the physical properties of petung bamboo 2. The axial position of bamboo has a significant effect on the physical properties of petung bamboo namely fresh water content and fresh specific gravity 3. The interaction between the stem parts and the axial position of the bamboo did not affect the physical properties of petung bamboo.

Fig. 4. Petung Bamboo (Dendrocalamus).

2.3 The physics and mechanics of bamboo

The average shrinkage in the longitudinal direction is 0.4%, while the thickness shrinkage value is very high, namely 12.22%. Shrinkage of bamboo in this study was measured on the bamboo segments. The results showed that in the longitudinal direction bamboo had a high shrinkage value at the base, decreased in the middle and slightly increased at the ends. While in thickness shrinkage, the base has the lowest thickness shrinkage then increases to the middle and drops back to the tip of the stem. Based on the results of the analysis of variance, it shows that the axial position of the bamboo culms has no effect on the shrinkage of bamboo from fresh to kiln dry conditions, both for longitudinal shrinkage and thickness shrinkage. This shows that even though there is a difference in the value of depreciation in the axial direction, it is still considered to have no effect [8].

2.4 The standard requirement of bamboo for the usage of building structure

Bamboo has been known by the community since our ancestors existed and has been used as a material. Indonesian bamboo plants are found in the lowlands to the mountains with an altitude of about 300 m above sea level and generally grow in open places and the area is free from standing water. Bamboo has good properties to be utilized, including strong stems, resilient, straight, flat, hard, easy to split, easy to shape and easy to work with and light. In addition, bamboo is also relatively inexpensive compared to other building materials because it has a lot of potential and is easy to find in all regions in Indonesia. There are around 60 species. Some of the advantages of bamboo when used for building components: ˙ It is a renewable material (3-5 years after it can be cut down), ˙ It is cheap and easy to work on because it does not require educated personnel, only simple equipment is

enough for construction activities. ˙ Has high tensile strength (some types of bamboo exceed the tensile strength of medium quality steel), light weight, has the shape of a segmented pipe so it is flexible enough to be used as a frame building component. The construction period is quite short so the construction costs are reduced inexpensive. The downside is that in its use it sometimes encounters some limitations. As a building material, the factors that greatly affect bamboo easily attacked by destructive organisms such as pollen, termites and fungi [9].

3 Methodology

To facilitate the objective of the study, a traditional floating house that use bamboo as its floating structure will be analysed using the floating PV Structure diagram (Fig 3). The aspects include analysis on the material, floatation system, configuration and mooring configuration. The selected floating house is called "Lanting House" that originated from Kalimantan, Indonesia.

4 Analysis

Lanting House (Figure 1) is a traditional raft house with a floating raft foundation consisting of an arrangement of three large wooden trees or of bamboo tree. The Lanting house is always rocking with the waves from boats going back and forth on the river. There are many Lanting houses along the rivers in Kalimantan. Lanting houses are also found along the Musi River in Palembang, South Sumatra, as raft houses [10].Based on the Floating PV classification, it can be analysed in Figure 5.

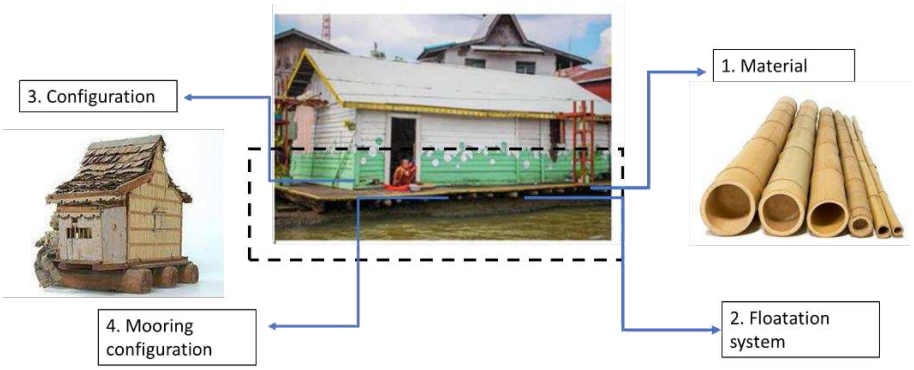

Fig. 5. The analysis.

1. Material

It can be seen from Figure 1, the Bamboo Petung or Dendrocalamus is kind of material that has cavity and has the specific gravity between 0,5-0,9 g/cm3 or less than the water specific gravity [11]. Therefore, this material can float over water.

2. Floatation system.

Based on the Lanting house foundation typology, the floatation systems of the house can be included as the buoyancy tubes.

3. Configuration

Figure 4 shows the configuration of the foundation. It is clear that the configuration use interconnected floats to form rafts.

4. Mooring configuration

Lanting House use a single mooring. The rope is attached to a peg fixed on the edge of the land.

5 Conclusion

Floating PV system using bamboo material has been studied, and based on the analysis it is possible to use bamboo as the structure for a floating PV system. An initial concept was done by adapting the typology foundation of Lanting House. Below is the concept of a simple floating structure made of bamboo has been constructed (Figure 6).

Fig. 6. The initial concept of simple Floating PV Structure made of bamboo.

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