Floating Houses Technology as Alternative Living on The Water

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Floating Houses Technology as Alternative Living on The Water

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Abstract. Increasing population has resulted in increased housing needs, but currently the available land for housing is decreasing. In addition, climate change has resulted in rising sea levels. With these three problems, it is necessary to develop a place to live with limited land and utilize the potential of Indonesian waters. The efforts that have been made by the current government by building settlements vertically, but have not been able to meet the needs of the residence. One type of house that can be developed by utilizing the potential of the waters is floating houses. A floating house is a residential building that is built on water by applying floating structures, materials, and shapes to suit the construction site. The floating house will function properly with proper planning, especially in the selection of technology at the bottom, floats, and the stability of the building above the water. Besides technology, other things that need to be taken into consideration are the selection of materials and the selection of the type of structure that will be applied. This technological innovation is expected to be able to meet the needs of residences that can utilize the territorial waters.

1. BACKGROUND

Experts argue that increasing concentrations of greenhouse gases in the atmosphere can cause climate change to warm up dramatically. Impact The global warming of the Coastal / City Region is a decrease in land area due to sea level rise and excessive evaporation of sea water which results in flooding which reduces the land area. Most cities in Indonesia are located on the coast, with characteristics of high growth rates. Changes in population density due to increasing population will increase the demand for land for settlement needs [1] and [2].

Reduced land area due to flooding as a result of global warming, so that building technology is needed that easily adjusts the height position when there is a flood, with minimal risk that can cause material loss to residents, namely the development of floating houses[3], [4], and [5]. Technological advances have led to various innovations in the construction of houses and public facilities on water. Currently the innovation of floating houses is recommended to be the right solution to meet housing needs.

2. PURPOSE OF RESEARCH

The purpose of this research is to get floating house technology that is able to accommodate more occupants with a structure that meets building safety and stability standards. Research on floating house technology is certainly related to the selection of structures and materials that will be applied to the building.

3. RESEARCH METHOD

This research is a theoretical study that can be developed in a floating house. The method used is to dialogue the theory to apply floating house technology that can meet more occupant capacity with

quality that meets the occupancy requirements and the structure of floating houses that are able to support more residential capacity so that it functions better. The theory used to support this writing is a combined theory of several experts according to the field of study. The choice of theory in this writing by considering the relationship that is relevant to the problem of floating home technology as an alternative to residential houses on water.

4. RESULT AND DISCUSSION

4.1. Definition of Floating houses

The floating house as a reflection of the waterfront architecture has many different terms and terms based on its location and structural system, some of the concepts put forward, among others, by the Chaichongsrak in Denpaiboon "define it as a shop house that can float in water, move and can be used for life and sleeping floating houses is a building that floats in water, can move and can be used as a place to live, while Denpaiboon has its own definition that is a floating house with another name raft house is a traditional architectural style building that uses a raft structure and is located in water [6] , and (Iskandar & Yuliandani, 2001) Floating buildings use aquatic areas such as lakes, seas, beaches, rivers, and their parts and are not on land or land with floating type and amphibian structures [8]. or a raft house, it can be concluded that a floating house or raft house is a residential building that is built on water by applying floating structures, materials, and shapes that correspond to the construction site. Based on the explanation above, it can be explained with the following picture:

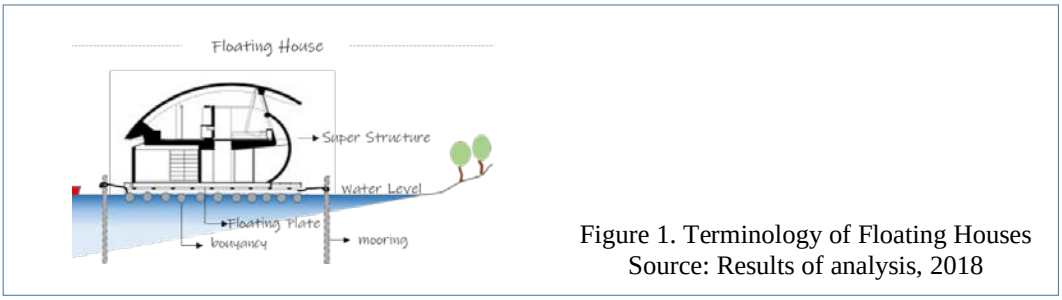

Figure 1. Terminology of Floating Houses
Source: Results of analysis, 2018

The floating house is above the water with the position of the building following the water level. It needs the principle of balance so that the building is not tilted, and needs a fastening pole so that the house does not move following the flow of water.

4.2. The Principle of Floating

Understanding Archimedes Law (flotation law) is when an object is partially or completely immersed in water, then the object will get a compressive force that points upwards which is equal to the weight of the water that is moved by the part of the immersed object. The period of the object does not change, the reduction in the weight of the object is caused by the upward force of the water that is moved by the part of the object that is in the water (force of buoyancy), with the direction of work the style is directed upwards; while the line of work is in line with the work line of gravity.

Balance will be achieved if the amount of buoyancy force is equal to the weight of the water transferred by the part of the object that is in the water or if the object floats with half the volume of the image [9] and [10]. The principle of balance applies to floating houses, the condition of the buoy is caused by the balance of enforcement of vertical forces, and will experience movement or shaking by lateral forces of attraction due to pressure of river water flow or flooding. Water surface is dynamic, whose conditions are strongly influenced by the flow of the generator which causes horizontal and vertical thrust.

4.3. Building Stability Based On Building Expenses

The workload on floating buildings is divided into dead and live loads. Dead load is a burden that will not change (very much) from time to time and the burden of life is a burden that changes in different circumstances. Dead load above the floating structure includes cargo from buildings, facilities and

infrastructure. More weight above the floating structure results in a greater load. This static load needs to be well distributed to prevent rotation and tilt of the float structure. The dead weight of the platform and upper structure depends on the design of the building. In addition to dead load, the platform is also subject to a live load. Life burden is a burden that changes in different situations. Some examples of living loads in floating houses are storage loads, traffic loads, population loads, wave loads, wind loads, water pressure and buoyancy[11].

In planning low-rise floating buildings, it is important to know that the total area available for floating buildings is estimated to be 50% of the floating structure. In planning high-rise floating buildings, it is important to know about the number of occupants who will live in one flat / apartment, the number of floors, floor to floor height, and the total height of the structure of the floating structure will be tilted if the eccentric strength is large (dead weight of the building), so the building is placed in center of the floating structure.

The more central the buoyancy shifts and shifts with a certain rotation, the higher the center shift, so the more stable the buoyancy structure is. Rectangular float structure is more stable than other shapes such as cylinders or triangular shapes. This is because when the float element rotates, the rectangular shape replaces most of the water[12]. The ratio of width to depth largely determines the shape of the float element.

4.4. Floating Houses Structure

Floating house, is the concept of a residence or stop by using floating structure media. The concept of a floating structure or often called a 'Floating Structure' is used as a substitute for land in the construction of a building. Besides being an alternative prearrangement of the area besides reclamation, because the structure is able to float on water [13]. The structure of a traditional floating house consists of a bottom structure of round wood, a bamboo raft and on the upper part is a traditional low-rise stage house. The use of the lower structure of the raft and low mast models aims to anticipate catastrophic winds so that the house is not easily thrown by the wind and carried away by the flow of water. In addition, the use of a single fastening pole that makes the house float rotates up to 360 degrees every day, because it follows the wind direction[14]. In some regions of Indonesia, which have typologies of floating houses with lower structures of wood, bamboo rafts, and used drums, and the main structure of wooden houses are very vulnerable to high winds and water currents. [15] dan [4].

4.4.1. Floating Structure

In the era of the emergence of floating houses in other countries the structure of floating houses in the form of wooden boats, but with advances in technology and increasingly limited building materials made from wood, in some countries, for example the Netherlands, New Zealand and other countries use a combination of structural steel and reinforced concrete structures. Just reinforced, and specifically in the Netherlands at this time many floating polystyrene buoyancy structures have been developed into hollow concrete blocks [5]. This is considered safer and economical compared to the use of old designs that use steel and concrete structures. An alternative development of Polystyrene foam float material in the Netherlands because architects think that the use of steel and concrete as floats can damage the environment.

This floating system is based on a polystyrene foam core (EPS, Expended Poly Styrene) with a surrounding concrete shell. EPS is a lightweight material that provides exceptional buoyancy and can be used in shallower waters. This floating system development contributes to the formation of large floating residences in the cities of Seattle and Vancouver[11].

The floating structure called the floating plate is where the building mass is attached. Part of this floating plate is a cover layer, frame plate and float. This floating plate shape will affect the buoy configuration used. Configure the float illustration in the following picture:

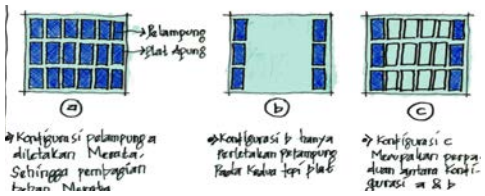

Figure 2. Configuring The Buoy
Source: Results of Analysis, 2018

The floating structures developed include; pontoon, eps foam, drums, etc.[16] and [8]. Examples the development of the structure of floating houses in Indonesia, nowadays wood and metal drums have been replaced by HDPE Floating Cube made of HDPE plastic which has proven to be strong and reliable 20 years without damage.

4.4.2. Mooring System

Each floating structure requires a mooring system that is sufficiently rigid and strong to limit the movement of the structure to external forces from wind, currents, waves or others such as the movement of ice if there is a winter. There are many belay systems in the form of temporary / temporary or permanent systems. Distribution of types of belay can also be in the form of mooring from inside or outside. Basically, the type of mooring there are several variations as follows[18]:

1. One mooring system with truss (*Attached Mooring System).*
   Basically, the mooring is done by tethering a special part of mooring line to the floating structure. Additions can be in the form of turrets placed on the inside (mounted inside end) or outside (mounted with the addition of a structure at the end). This system is caused by waves. This mooring system uses truss that is tied to one side of the building. This mooring system is more suitable for use on large-scale floating buildings.

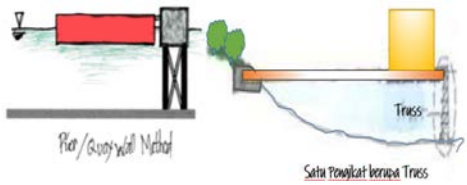

Figure 3. Attached Mooring System
Source: Results Of Analysis, 2018

2. The mooring system with piles
   This mooring system uses piles to keep the building in position. This system uses the principle of stake. Whereas to maintain the position of the building, the configuration of the supporting pole is also a consideration in this mooring system.

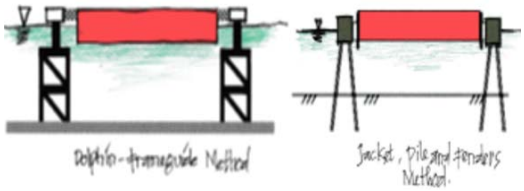

Figure 4. Pile Mooring System
Source: Results Of Analysis, 2018

3. The mooring system with a cable (Spread Mooring System)
   This type anchors the floating structure with a fixed heading direction. In this configuration is not needed swivel component. This configuration is only suitable for a location that is relatively quiet and has a change in the direction of loading that tends to be constant / not large. In general, locations such as the Malaka Strait or the Java Sea Coast may be suitable for this configuration.

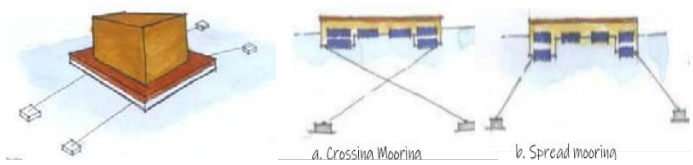

Figure 5. Spread Mooring System and Type Of Cable Configuration
Source: Results Of Analysis, 2018

There are two types of cable configurations in this mooring system, including crosses and crosses. a configuration a is more suitable for use in environments with calm water conditions because the cable only functions to maintain the position of the building.

4.5. Construction System

Construction systems in small-scale floating buildings generally use lightweight construction systems. The use of building materials is well considered to be able to withstand environmental conditions and not damage the environment. Whereas, for the floating building construction system, the mass of the construction process is carried out in the factory by building modules and assembled on the site.

4.6. Floating Houses Technology Application

Based on the theory regarding the stability of the floating house structure system, the factors that influence the selection of the structure type of floating houses used for residence include; structure that is able to provide stable conditions for waves and wind forces that work around it, relatively low prices, high durability / low maintenance, low weight, high buoyancy capacity, and easy to build shape.

For stability of buildings other than building dimensions, another factor that must be considered is the higher the building, the greater the dimension of the floating plate. In addition, the most suitable configuration of building plans is a long rectangular shape. That's because when the float element rotates, the rectangular shape replaces most of the water. The mooring system used is a wire mooring system because this system has more economic value than other systems and ease of construction. While the flexibility of the building is calculated based on the type of building lock that can be in the form of a mooring system with the installation of stakes with a sea flex anchoring system that has the highest flexibility. In addition, this system has been certified and has been used in many buildings on the water.

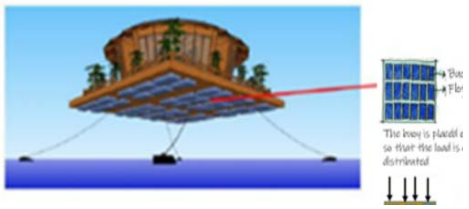

Figure 6. The Mooring System and Illustration of Floating Plate Configuration
Source: [19] and Results of Analysis, 2018

The float plate used is a square floating plate with a parallel float configuration on the edge. The square shape is chosen because this form has ease in the construction process, especially the mass of floating buildings is a mass with a large number. While the float configuration on the edge of the plate can save construction costs.

4.7. Construction System and Material

In the selection of this material, materials that are environmentally friendly are sought so as not to cause damage to the environment and surrounding habitats. Material selection based on parts of the building structure is explained as follows;

a. A binding floating structure based on air conditions can use cables and anchors.
b. Basic structure / foundation as buoy using concrete materials, composite panels of Rexwall, EPF (Expanded Polystyrene Foam), Platform, Steel, HDPE Floating Cube and concrete pontoons. The selection of this material is carried out on the ability to withstand structural loads. Middle structure,

building frame made of wood, steel and concrete blocks. Wall materials from lightweight concrete, wooden planks, plywood, and glass.

c. Upper structure, roof truss of wood, mild steel and for cover made of concrete, and Zincalum. Selection of materials for basic structures and materials, resistant to local climate, able to provide comfort for residents and easy maintenance.

5. CONCLUSIONS

The conclusion of the theoretical dialect of this floating house is as follows:

1. Looking at the development of science and technology in the field of architecture, Floating building is one solution to problems in meeting housing needs.
2. The use of appropriate technology and structures is the main thing that must be considered in designing floating buildings.
3. The things that need to be considered in the planning of a floating house are the use of components of the shape of a floating building to be symmetrical and using constructions with light weight, floating shapes and plate materials do not damage the environment, mooring the system must pay attention to changes in water on the site, and inter circulation building so as to facilitate users.

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REFERENCES

[1] W. Hantoro, ‘Effects of Sea and Beach Characteristics on the Development of Coastal Cities’, 2002.
[2] National Population and Family Planning Agency (BKKBN), Bumi Increasingly Increased Earth Population’, Jakarta, 2011.
[3] Koen Olthuis, *Building on Water to Combat Urban Congestion and Climate Change*. 2007.
[4] Puspitasari, Kadri, Indartoyo, and L. Kusumawati, ‘Microclimate and architectural tectonic: vernacular floating house resilience in Seberang Ulu 1, Palembang’, in *The 4th International Seminar on Sustainable Urban Development*, 2017, pp. 1–6.
[5] A. Ambica and K. Venkatraman, ‘Floating Architecture : A Design on Hydrophilic Floating House for Fluctuating Water Level’, vol. 8, no. November, 2015.
[6] C. Denpaiboon, M. Tohiguchi, H. Matsuda, and S. Hashimoto, ‘Typology and Life Style Analysis of the Raft House (Ruan Pae) in Riverine Settlements in Thailand’, vol. 1, pp. 173–180, 2000.
[7] S. Syamsiar and Irhamna, Banjar Traditional Architecture of South Kalimantan. Banjarmasin: Association of Indonesian Architects of South Kalimantan, 2001.
[8] Wijanarka, ‘Maritime Architecture: Water Based Architecture, Solution to development in the Indonesian Archipelago’, *Workshop Continuing Profesional Development (CPD)* Architectural Expert Organized by the Directorate General of Construction of the Ministry *PUPR*, Jakarta, 2016.
[9] R. Riski, ‘Archimedes' Law (Law of Floating)’, 2009.
[10] 212BC Archimedes of Syracuse, ‘Archimedes principle’, 2008.
[11] K.K.M. Ko, ‘Realising a floating city Appendix’, Delft University of Technology, Netherlands, 2015.
[12] Winkelen, ‘How high can you float’, Delft University of Technology, 2007.
[13] Frick.H, Ecological Architecture. The concept of ecological architecture in tropical climates, greening of ecological cities and cities, and renewable energy. Yogyakarta: Kanisius, 2006.
[14] N. Naing, ‘Creating a Better Living Condition at the Floating House in Lake Tempe’, 2008.
[15] N. dan Naing and H. Halim, ‘Structure System of Floating House at Tempe Lake in South Sulawesi’, *J.* Settlement., vol. Vol. 8 No., 2013.
[16] M. Khamdevi, ‘Floating Architecture Approach’, *IPLBI*, 2014.
[17] R. Didik, ‘Floating Houses’, 2018.
[18] C. M. W. E. Watanabe and T. U. A. T. Moan, ‘Very Large Floating Structures: Applications, Analysis And Design’, Singapore, 2004.
[19] Marina Housing, ‘Marina Housing Floating Concept and Projects’, 2009.