An Analysis of Plastic Barrels as a Platforms Material of Floating House in Coastal Areas

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Abstract. Housing is a very basic necessity for human life, so it is needed by considering its comfort of the environment and constituent materials. For people who live on the coastal areas which have narrow land and low environmental arrangement, a floating house can be the solution. The floating house is a building that stands or floats on water by relying on the weight and area of the field that is submerged as load parameters that are able to be borne by the structure. The house can float and be placed on the edge of the beach and above the sea water front. There are various materials that can be utilized as the footing of this floating house; one of which is plastic barrels. This research aims at analyzing the level of buoyancy, the amount of materials and the cost needed for the construction of a simple floating house unit using plastic barrels as the platforms. The results showed that the buoyancy level (Fa) of plastic barrels as the platforms material is 549.814 Newton, the number of plastic barrels needed as platforms material is 232 pieces costing for IDR 358,270, 000.

1. Introduction

The development of residential areas in Indonesian coastal areas is the most important part in supporting the sustainable development and improving the welfare of the nation. Economic activities in coastal areas will be followed by growth in population which has a direct impact on the housing and settlement sectors [1]. However, there are still many resident settlements in the Indonesian coastal areas that are poorly laid out, too dense, slums and not worth living. To over come the housing problems in the coastal area, recently a new concept of floating house technology has been developed [2]. The advantage of this floating house is the flexibility to move its position or location. In addition, the house that uses a flat foundation can rotate its direction position and can also move [3]. Besides being environmentally friendly and safe from flooding, the floating house is also regarded as unique in terms of design as well as sustainable [4]. The location in this study is the northern coast of Semarang City, Indonesia. In this area breakwaters and sea walls have been built, so that the coastal area is sufficiently protected from ocean wave energy, so it is safe enough to build a floating house.

There is a wide range of materials that can be used as floating house platforms, such as bamboo, styrofoam, PVC (Polyvinyl Chloride) pipes and plastic barrels [5]. The study aims at analyzing the use of plastic barrels as a floating house platform. The analysis is carried out on a simple floating house construction, including the calculation of Buoyancy, the amount of material and costs needed. The design of the floating house is made simple that can be applied as a resident house in the coastal area by taking into consideration on the economical
design. As for the sloof structure, the column, and the beam rings use wooden material, whereas for the trestles use light steel, and the roof is using Sakura roof.

2. Literature Review

2.1. The Design of Houses in Coastal Area
Coastal housing designs in Indonesia can be divided into two types of buildings, namely raised platform and non-raised platform house [6]. The location of the building can be either on the ground directly or on the water or float. The main structure of the house can use wooden structures, concrete structures or bearing wall structure. As in the following figures (Figure 1) are the designs of houses in the coastal area [7].

![Figure 1. The Designs of Houses in Coastal Areas [6]](image)

2.2. Floating House
Floating house is a living house concept using floating structure media. The concept of floating structures is used as a substitute for land in the construction of a building, because its structure is able to float over water [8]. Floating house is a building structure that floats on water by relying on buoyancy platforms as a structure that holds the load on it by combining the footing or the platforms then some areas will be submerged as a load parameter able to borne by the structure. The floating house is a unique life mechanism on the platforms designed to float without any fear of drowning as well as the upward movement of the building according to the water level [4].

2.3. Types of Floating House Platforms
The floating house design is divided based on the type of its floating material platforms. In some countries, various materials have been developed for the footing of the floating house, including the following:

2.3.1. Floating House with Styrofoam Platforms.
Styrofoam is a material derived from polystyrene that in the process of manufacturing is using a mixture of air bubbles so that it can expand and has a light weight like foam (Figure 2). Platforms with Styrofoam materials used are styrofoams in the form of beams with a length of two meters, width one meter and a thickness of half a meter, for the number of it is based on the needs [9]. The more spacious and heavy the building, the more the styrofoam needed.
2.3.2. Floating House with Bamboo Platforms.
Bamboo is a material that has light specific weight and also cavity. Some people think that the cavity in the middle of bamboo as a weakness, but actually this is not true [10]. Bamboo does have a cavity in it, but the central cavity on bamboo is actually a characteristic of bamboo power and serves as a bracer. The bracer can strengthen the bamboo and makes the elements commonly used as structures to be lighter and less rigid (Figure 3). A bamboo also has an elastic character and is not easily broken so that its structure becomes more powerful and reliable [3].

2.3.3. House with Plastic Barrel Platforms.
The footing of the floating house design is a structure that is under the house serving to withstand the total load of the building to float the house. This floating house material is plastic barrels that have a good buoyancy, lightweight and easy to obtain as it is commonly available around us (Figure 4) [8].
3. Research Method
The research methods of this study is research and development method including the creation of a floating house design plan (Figure 5 and 6), calculation of buoyancy platforms bottom structure, calculation of upper structures, calculation of buoyancy platforms and cost calculation. In the law of Archimedes, that is all objects dipped into the fluid will get buoyancy in proportion to the weight of the fluid they move. Because the pressure at each point on the surface of the object is equivalent to the specific weight of the fluid and the depth, the total force acting on the left and right parts of the object becomes the same and can be ignored (the equilibrium of the horizontal direction force, Fx=0). Data of floating house design plan as a dwelling house that is with the area of building (11 m x 9 m) = 99 m² and floating platforms (12 m x 15 m) = 180 m² as shown below.

![Figure 5. Front View of Floating House Design Plan.](image)

![Figure 6. Side View of Floating House Design Plan.](image)
3.1. Lower Structure Load
The structure data of the type of material used in the floating house design, including:

i. Vertical Wood Beam Load
- Size: 8 x 12 cm
- Volume: 3.456 m³
- Wood Specific Weight: 1250 kg/m³
- Weight: Volume x SW = 3.456 x 1250 = 4320 kg

ii. Horizontal Wood Beam Load
- Size: 8 x 12 cm
- Volume: 3.456 m³
- Wood Specific Weight: 1250 kg/m³
- Weight: Volume x SW = 3.456 x 1250 = 4320 kg

Total load applied on the bottom structure:
Total Weight of Platforms Frame: 4320 kg + 4320 kg = 8640 kg = 86,400 Newton (downward direction)

3.2. Upper Structure Load
To calculate the weight of the upper structure in this study the SAP 2000 software application is used, which serves to help calculate the amount of load in the floating house design, which consists of roof loads, horse loads, column loads, beam ring loads, sloof, loads walls, door and window loads, and wind loads, while for calculating the load of fences and house floor plates calculated using Microsoft Excel software. Based on the SAP 2000 calculation result, totally weight of upper structure that consist of roof loads, horse loads, column loads, beam ring loads, sloof, loads walls, door and window loads, and wind loads is 20,604.7 ton. While the weight calculation of sloof, wall, column, beam ring, trestle and roof structures as following:

a. Load on floor plate
- Size of floor plate: 200 x 20 x 0.2 cm
- Volume of floor plate: 3.6 m³
- Wood Specific Weight: 1250 kg/m³
- Weight: Volume x SW = 3.6 x 1250 = 4500 kg

b. Load on fence
- Size of Wood Beam: 10 x 10 cm
- Volume of Fence: 1.787 m³
- Wood Specific Weight: 1250 kg/m³
- Weight: Volume x SW = 1.787 x 1250 = 2233.75 kg

c. Live Load
- Load of Residents: 6 People
- Weight / person: 80 kg (assumption)
- Total of Live Load: 6 x 80 kg = 480 kg

Total load applied on the upper structure is:
= 20604.7 kg + 4500 kg + 2233.75 kg + 480 kg
= 27818.45 kg = 278,184.5 Newton (downward direction)
3.3. Total Weight of the Structure
Based on the calculation result of the upper and lower structure load of the floating house design, it can be obtained that the total weight in the floating house is as follows:

\[ \text{Total weight in floating house} = \text{Total weight of upper structure} + \text{Total weight of lower structure} \]

\[ = 27818.45 + 8640 \text{ kg} \]

\[ = 36458.45 \text{ kg} = 364,584.5 \text{ (downward direction)} \]

4. Result and Discussion

4.1. Calculation of Floating Platforms with Plastic Barrels
The calculation analysis of plastic barrels floating footing is conducted to identify the power of the floating footing to be able to withstand the weight of the floating house structure, so it can be identified how many plastic barrels needed to withstand the load of the floating house, with a defined amount of structural stability of 1.5. For more details, the steps of calculation of a plastic barrels floating house foundation structure can be seen below.

a. Calculate the Weight of Empty Plastic Barrel

| Weight of Plastic Barrel (G) | 8.6 kg/pcs |
|-----------------------------|------------|
| Diameter of Plastic Barrel  | 0.58 m     |
| Height/Length of Plastic Barrel | 0.93 m   |
| Total Weight of Plastic Barrel in Newton | 8.6 kg x 10 N/kg |
|                             | 86 Newton  |

b. Calculate Buoyancy of fully submerged plastic barrel

\[ \text{Buoyancy} (\text{Fa}) \text{ of Plastic Barrel} = \pi.\text{d}^2/4.\rho.g.L \text{ (d = inner diameter)} \]

\[ = (22/7) \times (0.58)^2/4 \times 1000 \times 10 \times 0.93 \]

\[ = 2456 \text{ Newton/pcs} \]

So the total buoyancy of 1 Plastic Barrel is (Fa - G)

\[ = 2456 - 86 \text{ Newton/pcs (upward direction)} \]

\[ = 2370 \]

Total floating force of 232 Plastic Barrels

\[ = 232 \times 2370 \]

\[ = 549,814 \text{ Newton (upward direction)} \]

Based on the results of the above analysis, it can be identified that the buoyancy (Fa) is 549,814 Newton (upwards). By using plastic barrel foundation material as many as 232 pieces, the footing system is made one layer with the arrangement as Figure 7.
c. Stability structure control on floating footing after lied with floating house

Total Weight of Floating House Structure = 364,585 Newton (downward direction)
SF (Safety Figure) = 1.5
Upward Buoyancy (Fa) = 549,814 Newton (upward)
Stability Control (Fa/G > 1.5) = 549,814 / 364,585 = 1.5

After checking the result of structural weight calculation analysis of buoyancy with 232 plastic barrels which was 549.814 Newton (upwards), it was compared with the weight of the floating house structure which was 364.585 Newton (downward). Therefore, it was obtained the value of the structure stability control which was 1.5. Thus, it can be stated that the construction of a floating house using 232 plastic barrels is declared safe. For more details, can be seen in Figure 8.
4.2. Cost Calculation of Floating House with Plastic Barrels Platforms
The recapitulation of the floating House cost calculation using plastic barrels as the foundation of can be seen in Table 1.

Table 1. Cost Recapitulation for Plastic Barrel Materials

| No | Working Process          | Total (IDR)     |
|----|--------------------------|-----------------|
| 1  | Preparation              | 1,500,000.00    |
| 2  | Floating Platform        | 92,298,000.00   |
| 3  | Sloof                    | 18,195,000.00   |
| 4  | Column                   | 21,834,000.00   |
| 5  | Ring Beam                | 18,195,000.00   |
| 6  | Wall                     | 45,392,800.00   |
| 7  | Floor                    | 43,668,000.00   |
| 8  | Fence                    | 21,834,000.00   |
| 9  | Doors And Windows        | 16,745,000.00   |
| 10 | Light Steel Trestles     | 14,988,000.00   |
| 11 | Roof                     | 12,040,800.00   |
| 12 | Electrical Mechanical    | 3,187,500.00    |
| 13 | Sanitation               | 5,180,000.00    |
| 14 | Painting                 | 9,678,400.00    |
| 15 | Finishing                | 1,000,000.00    |
|    | Total                    | 325,736,500.00  |
|    | Rounding Off             | 325,700,000.00  |
|    | Taxes 10 %               | 32,570,000.00   |
|    | Total (IDR)              | 358,270,000.00  |

5. Conclusion
Based on the result of the calculation, it can be concluded that for making a simple floating house with the 99 m² area of dwelling house and the 180 m² area of floating footing, using plastic barrel platform materials showing buoyancy (Fa) of 549.814 Newton, the number of plastic barrel platforms needed is 232 pieces and the cost is IDR 358,270,000, estimated lifespan of the structure is 15 years.

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Acknowledgments
The author thanks The Ministry of Research and Technology of Indonesia that has funded this research and all those who participated and supported