

# Analysis of floating house platform stability using polyvinyl chloride (PVC) pipe material

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**Abstract.** The high demand for land to be built on, makes the price of land more expensive. Various efforts were made to get land to build houses on, one of them was by way of coastal reclamation. The pond area initially functioned as a water catchment area, but later became new land through the reclamation process. This will have adverse impacts on the environment such as flooding due to lack of water storage. To overcome the problem of building in the coastal area without reclaiming, is using floating house. A floating house is a building structure that floats on the water surface by leaning to drowned area weight as the weight parameter which the structure could handle. This research is done to analyze the material platform. PVC pipe is used with floating force ( $F_a$ ) parameter and cost plan analysis. The structure weight analysis total result is 555,887.5 Newton. The floating force of structure platform is 648.792 Newton. The connection system is a bolt connection system that us 3 cm in diameter with an anchor of length 22 cm, and a total of 4 bolts on each connection. Cost plan analysis using PVC pipe costs IDR 379.500.000,00.

## 1 Introduction

Indonesia is a country that has a water area of 70% of the total area of Indonesia. The high demand for strategic land-to-build, makes the price of land more expensive. Various efforts were made to obtain land to build houses for shelter, one of them by way of beach reclamation or pond hoarding. The area of the pond that originally functioned as a water catchment area, then became new land, which is bad for the environment due to the occurrence of floods due to lack of recharge area [1]. Based on the description of the background, this study offers the concept of a house by building without reclamation or changing the physical form of the environment, this is done with Floating house concept. The platform material from the floating house to be discussed in this study is to use PVC Pipe (*polyvinyl chloride*).

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## 1.1 Problem formulation

There are three research questions. First, how to calculate the floating house platform foundation structure's stability by using PVC pipe material toward the structural weight laying above. Second, why is the connection system among PVC pipe materials established as a floating platform structure component. And third, how is the floating house cost plan analysis using PVC pipe material as a floating platform.

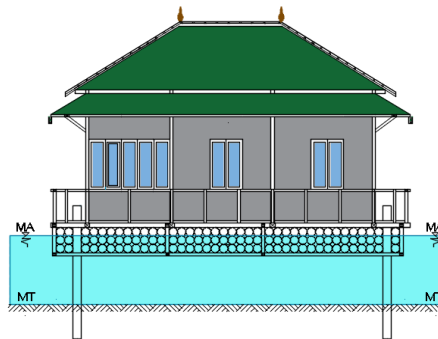
## 1.2 Research objectives

The research is conducted for specific purposes as follows. First, to find out the balance of the floating house structure using PVC pipe as floating material. Second, to find out the connection system to establish PVC pipe material as floating platform. And third, to find out the floating house cost plan analysis using PVC pipe material as floating platform.

## 2 Literature review

### 2.1 Floating house utilizing PVC pipe as foundation

Floating house PVC pipe foundation is a floating house that is designed by using PVC pipe as the foundation of its structure by connecting using anchorage and bolts to the wooden blocks (sloof), so it becomes a whole structure (platform) [2]. PVC pipe is a plastic material that has an air cavity in it so it can float on the water as in Figure 1 below.



**Fig. 1.** Floating house with PVC pipe as floating platform foundation.

### 2.2 Buoyancy force with completely submerged ( $F_a$ )

All calculation of buoyant forces on the platform assume that the entire platform is submerged in water as follows (that is with Floating House concept). [4]

$$F_a = (\pi.d^2/4).\rho.g.l \quad (1)$$

Where,

- $F_a$  : Buoyancy Force with Completely Submerged (N)
- $\rho$  : Fluid specific mass ( $\text{kg/m}^3$ )
- $d$  : *platform* diameter
- $\pi$  : 3,14
- $g$  : Specific gravity ( $\text{m/s}^2$ )
- $l$  : *platform* length (m)

### 2.3 Structural stability control

Building stability calculations can be calculated using the following formula:

$$F_a - (SF \cdot G) \tag{2}$$

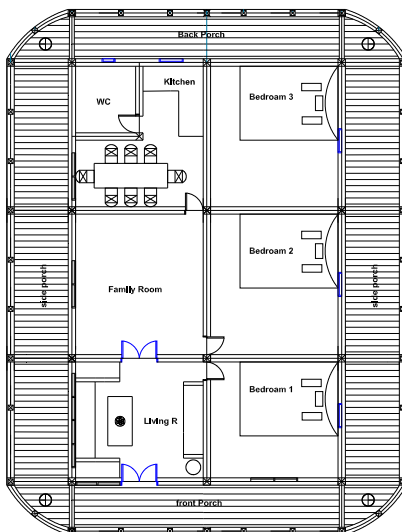
Where,

- F<sub>a</sub> : platform floating force (N)
- SF : Safety factor = 1,2
- G : Structure total weight (kg/ton/N)

## 3 Research method

### 3.1 General data

General data is information that explains the structure properties, such as type, function, and drawings. The structure data is planned (determined) by the researcher as follows: Building data is fully planned and assumed by the researcher. The Building area is 8 m x 10 m (80 m<sup>2</sup>), with 3.5 m high building (Sloof Structure - Ringblock) and 2.5 m (Structure of the horses). Types of Platform Foundation with PVC Pipe are with floating system. The floating house plan can be seen in Figure 2 below.



**Fig.2.** Floating house plan

### 3.2 Upper structure

The upper structure data is derived from structure components consisting of a few kinds of materials, detailed as follows:

#### 3.1.1 Sloof structure

- Dimension : 15 cm x 15cm
- Wood specimen : ironwood

Power classification	: 1 <sup>st</sup> class
Specific weight	: 900 kg/m <sup>3</sup>
Pulling strength parallel to fiber	: < 650 kg/cm <sup>2</sup> (absolute), 130 kg/cm <sup>2</sup> (permit) [5]
Flexural compressive strength	: < 1100 kg/cm <sup>2</sup> (absolute), 150 kg/cm <sup>2</sup> (permit) [5]

### 3.1.2 Column structure

Profile	: I. 150 mm x 150 mm x 50 mm
Steel specimen	: galvalume
Specific weight	: 7850 kg/m <sup>3</sup>
Pulling strength	: 550 MPa
Elasticity modulus	: 2,1 x 10 <sup>5</sup> MPa
Shear modulus	: 8 x 10 <sup>4</sup> MPa

### 3.1.3 Ring block structure

Profile	: I. 150 mm x 150 mm x 50 mm
Steel specimen	: galvalume
Specific weight	: 7400 kg/m <sup>3</sup>
Pulling strength	: 550 MPa
Elasticity modulus	: 200.000 MPa
Shear modulus	: 80.000 MPa

### 3.3.4 Wall

Type	: Clash Board
Thickness	: 10 cm
Weight	: 40 kg/m <sup>2</sup>

## 3.3 Bottom Structure (sub structure)

Bottom structure data is the data of the platform component that consists of several types of materials that have considerable buoyancy as follows:

### 3.3.1 PVC pipe

The PVC pipe used had a length of 6 m, diameter of 12 inch (30 cm), weight of 1.42 kg / m<sup>2</sup> and thickness of 1.1 cm.

### 3.3.2 Connector

The connector used was bolts with a diameter of 3 cm, anchors with a diameter of 2.8 cm and length of 22 cm.

## 3.4 Upper structure loading

The dead load on the floor plate was estimated to be 125 kg / m<sup>2</sup>, wall load of 140 kg / m<sup>2</sup> and roof skeleton of 5.39 kg / m<sup>2</sup>. While the planned live load includes live load on the floor plate of 100 kg / m<sup>2</sup> and live load on the beam of 80 kgf (worker + tooling). The wind load was 40 kg / m<sup>2</sup>.

### 3.5 Upper structure weight analysis

Furthermore, the load was simulated in a structural model using SAP2000 V.16 software to calculate the total weight of the structure. The total reaction forces from the weight analysis can be used as parameters to calculate the buoyant force (Fa) and the strength of the connection on the floating house platform structure. [3]

Based on the results of SAP2000 software analysis, the total weight of the upper structure was obtained as follows.

**Table 1.** Base Reaction Structure.

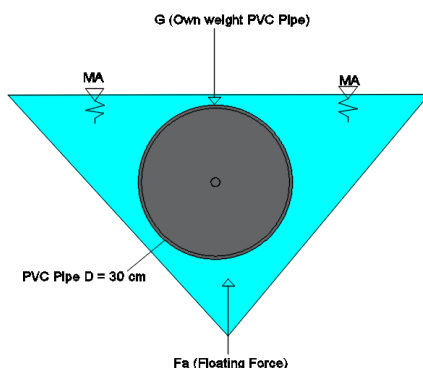
Output CaseText	Global FX Kgf	Global FY Kgf	Global FZ Kgf	Global MX Kgf-m	Global MY Kgf-m	Global MZ Kgf-m
Comb All	0,000002	-0,0000003	44557,8	289620	15524,59	0,000001
Comb All	-40	-2900,26	21610,26	140462	-32102,7	-2324,19

$$\begin{aligned}
 \text{Total structure weight caused by working load} &= 44557,8 \\
 &= 44557,8 \times 10 \\
 &= 445578 \text{ Newton}
 \end{aligned}$$

## 4 Results and discussion

### 4.1 Platform floating force analysis

Floating force analysis (Fa) is an analysis of the magnitude of the buoyant force of a platform material which will be compared with the downward force due to the weight of the floating house structure. The platform is said to be strong if the upward force (Fa) is bigger than the total weight of the structure (G).



**Fig. 3.** PVC pipe buoyant force with completely submerged.

$$\begin{aligned}
 \text{PVC pipe empty weight (G)} &= 15,9 \text{ kg} \times g \\
 &= 15,9 \times 10 = 159 \text{ Newton}
 \end{aligned}$$

$$\begin{aligned}
 \text{Buoyant force with completely submerged (L = 6 meter)} &= \pi \cdot d^2 / 4 \cdot \rho \cdot g \cdot L \rightarrow (d = \text{inner diameter}) \\
 &= (22/7) \times (0,28,9)^2 / 4 \times 1000 \times 10 \times 6 \\
 &= 3933,84 \text{ kg/pipe}
 \end{aligned}$$

$$\begin{aligned}
 \text{Total buoyant force} &= V \cdot G \\
 &= 3933,84 - 159 \\
 &= 3774,84 \text{ Newton/ pipe (upward)} \\
 \text{buoyant force for pipe 26} &= 26 \times 3774,84 \\
 &= 98145,82 \text{ Newton/layer} \\
 \text{Buoyant force with completely submerged (L = 4 meter)} &= \pi \cdot d^2 / 4 \cdot \rho \cdot g \cdot L \rightarrow (d = \text{inner diameter}) \\
 &= (22/7) \times (0,28,9)^2 / 4 \times 1000 \times 10 \times 4 \\
 &= 2622,56 \text{ kg/pipe} \\
 \text{Total buoyant force} &= V \cdot G \\
 &= 2622,56 - 159 \\
 &= 2453,56 \text{ Newton/ pipe (upward)} \\
 \text{Buoyant force Pipe 26} &= 26 \times 2453,56 \\
 &= 64052,54 \text{ Newton/layer} \\
 \text{Subtotal: } 98145,82 + 64052,54 &= 162198,4 \text{ Newton/layer} \\
 \text{4-layer platform PVC pipe} &= 162198,4 \times 4 \\
 &= 648793
 \end{aligned}$$

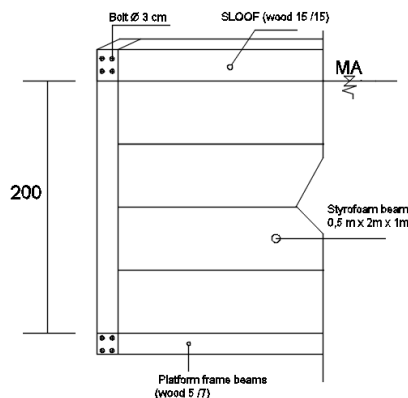
### 4.2 Structure balance analysis

The structure is said to be balanced if the buoyant force (Fa) is equal to the total weight of the structure of the house (G) and is said to be efficient if the weight of the structure is greater than the total weight of the structure of the house (G). [5]

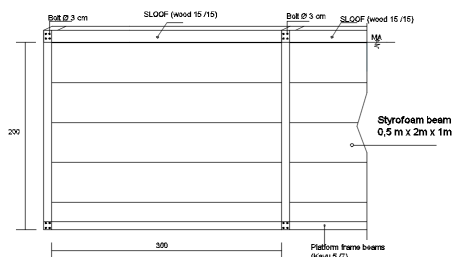
$$\begin{aligned}
 \text{Floating house Structure total weight (G)} &= 463.239,6 \text{ Newton} \\
 \text{SF (safety factor)} &= 1,2 \\
 \text{Buoyant force (Fa)} &= 648793 \text{ Newton} \\
 \text{Fa} - (\text{G} \times 1,2) &= 648793 - (463.239,6 \times 1,2) \\
 &= 92905,9 \text{ Newton} > 0 \rightarrow \text{Ok}
 \end{aligned}$$

### 4.3 Platform connection analysis

The platform structure is connected using a bolt connector. The specifications and number of bolts are made equal for all platform material types, the connection model of the three materials is as follows [6];



**Fig. 4.** Model of PVC pipe connection platform (cross-section).



**Fig. 5.** Model of PVC pipe connection platform (long section).

**Table 2.** Recapitulation of Pipe PVC Platform Budget Plan.

No	SPECIFIC WORK	PRICE
I	Preparation	2.360.000
II	Platform PVC Pipe (PVC Pipe 12 inch)	266.840.000
III	Sloof work	6.300.000
IV	Floor work	4.975.000
V	Column work	4.830.000
VI	Ring block work	4.790.000
VII	Wall work	13.510.000
VIII	Doors and Windows work	12.970.000
IX	Framework	12.630.000
X	Roof work	7.488.000
XI	Sanitation work	5.340.000
XII	Mechanical Electrical work	2.060.000
XIII	Finishing	1.000.000
Total		IDR 345.093.000,00
As a whole		IDR 345.000.000,00
Tax 10 %		IDR 34.500.000,00
Total Price		IDR 379.500.000,00

## 5 Conclusion and perspective

Based on the results of the analysis, it can be concluded that the total weight of the upper structure and platform structure (G) is equal to 555,887.5 Newton with a safety factor of 1.2. The force of the buoyant force (Fa) of the plate structure made of PVC Pipe material is 648,793 Newton. The connection system on the framework of the floating house platform is a bolt connection system, that is 3 cm in diameter with an anchor length of 22 cm and with a total of 4 bolts on each connection. The connection between the resin materials can use the glue to then be arranged and made one with the framework of the platform. Budget Cost Plan Analysis using PVC Pipe Materials requires a fee of IDR 379,500,000.00.

To increase the buoyancy of the platform material, the width and height of the platform can be enlarged. In order to increase the durability of the platform material PVC pipe uses

rubber coating as a barrier between the materials so it is not easy to break from the friction of working forces. It needs a scaled prototype of material proposed by the researcher. Thanks to the master program in Civil Engineering, Faculty of Engineering Sultan Agung Islamic University Semarang, Rotterdam University of Applied Sciences and all parties for the participation, support and good cooperation.

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