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HYBRID HOUSING - A NOVEL FLOOD MITIGATION STRATEGY FOR REBUILDING KERALA

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ABSTRACT

Kerala had recently faced the most severe flood, where 1/6th of the total population was directly struck down. Henceforth, it is crucial to search for a more effective flood mitigation approaches in the flood prone areas of Kerala. The concept of this design for the flood prone areas with the strategy of automated flood defense mechanism is based on the theory of buoyancy. Hybrid housing system is an eco-friendly, adaptive flood risk reduction strategy that works in synchrony with a flood prone regions natural cycles of flooding, rather than attempting to obstruct them. A Hybrid house using GFRG panel of dimension 6.4m x 6.2m x 3m is designed. Stability analysis of the structure is carried out manually for the safety of the structure. ETABS software is used for the designing of columns in the pit system and the remaining design is carried out manually. This paper highlights the possibility of adopting Hybrid housing system over selected flood hit region in Kerala.

KEYWORDS: Hybrid house, concrete pontoons, EPS blocks, GFRG.

1. INTRODUCTION

Beginning on 15 august 2018, Kerala had faced the worst flooding in nearly a century. The Indian government had declared it a level 3 calamity where millions were evacuated, hundreds died. Every year Kerala is battered by the monsoon, but this year Kerala has seen 37% more rain than would be expected, with more than 2,300 mm of rain across the region since the beginning of June, and over 700 mm in August alone, flooding hundreds of villages and prompting the authorities to suspend flights in and out of the region. The release of the gates of 34 reservoirs resulted in the rise of water dangerously. Due to the rise in water level thousands of homes have been destroyed or damaged across the state. Even the flood water have started to recede people are yet to come to terms with the extent of damage caused to lives and properties. Now Kerala is working to rebuild infrastructures, and this should also ensure that the structures especially near the flood prone areas should be equipped with flood risk reduction strategy.

Why hybrid houses?

The concept of floating house exists for decades. Elevated or floating houses were used in the flood prone areas as a flood risk reduction strategy. In elevated houses, the house is elevated to a desired flood protection elevation but, in the case of floating house, the house will be floating in water throughout the year.

Fig 1.1 Elevated house

Fig 1.2 Floating house

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As the house is elevated to a certain height in elevated houses, it creates a certain sort of discomfort to the elderly people to reach the house and also affect the aesthetic beauty. Here the supporting columns are directly subjected to flooding and wind, hence it will be at a greater risk of damage. Whereas in a floating house, the house will be in water for the whole year there is a higher chance of corrosion of materials if it is not maintained properly. Maintenance of the floating part of the house and accessibility of the house from outside will be difficult since it is submerged in water throughout. Most of the difficulties faced by elevated and floating houses can be reduced by adopting hybrid house.

Fig 1.3 Hybrid house

2. AIM AND OBJECTIVES

This paper aims in providing an eco friendly housing system designed based on Buoyancy principle that remains operational during flood and occupy back on ground when flood water recede.

Hence the present study was conducted with a view to address the following objectives:

- To explore how important Hybrid architecture is.
- To bring necessary changes to the existing concept so that it suits with our climate and requirements.
- To design a 'Hybrid Housing' system suitable for all the year round the flood affected area with GFRG panels.
- To check the stability analysis of the above designed house.

3. METHODOLOGY

Principle of hybrid housing

Archimedes Principle states that the buoyant force on a submersed object is equal to the weight of the fluid that is displaced by the object. The hybrid houses are designed such that the load of the structure is equal or less than the uplift force of water which helps in floating the house on water. Since the house is anchored down with the help of vertical guide post, the house can only rise or fall as per the need. The density of EPS block is 5.5 kg/m^{3}which is lesser than that of water, which makes it float. The forces developed because of buoyancy can result in an uplift force which helps the house to remain on water surface.

Hybrid foundation

The design consists of sub-structure which include mounting platform, pontoons and pit system. The pit system provided beneath the house is based on the design considerations which help in the stability of house during floating by decreasing turbulence under the house during flood. The pit provides place for pavement, connection of the lateral system to pavement and space for main columns. The pit height equals to pontoon's height in addition to 1.25m service height. The soil in flood prone area will have high moisture content with higher chance to slide and have less bearing capacity; hence an internal concrete wall with raft foundation is provided in the pit. The mounting platform which is designed based on normal loading during dry season and water loading and weights during wet season. The main column provided beneath the slab support entire downward load during dry season. The number of main column and their spacing depends on total load. The pontoon consists of Expanded Poly-Styrene block (EPS) and GFRG hollow block. The EPS blocks are placed on to these hollow blocks which

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are supported by a supporting frame with four legs. The height of this leg provides necessary freeboard. The number and pattern for the positioning of concrete pontoons is designed based on the total load exerting on the

mounting platform. The pre-cast and interlocked pontoon which is made of EPS block provides buoyancy for the whole system.

Superstructure

The super structure made of Glass Fiber Reinforced Gypsum (GFRG) panel. GFRG panels used in the construction of house helps in speedy completion, does not require plastering and require less built up area for same carpet area. Plinth beams are cast around the floor where the wall is to be erected. The entire super structure is based on prefabricated panels. The wall panels and roof panels are fixed using mechanical means. In this house all the pipes, ducts, and wires of water, electricity and sewage disposal are made flexible and designed to remain functional even when the house rises several meters. The house is anchored using four vertical guidance posts that are installed not far from the corners of the house. The steel posts are provided with roller fenders, which ensure smooth vertical movement of house.

The plan given below can be constructed in an area of 440 sq ft. The Hybrid house is built as a load bearing structure with GFRG as walls. The use of GFRG instead of brick walls will reduce the dead load of the Hybrid house, thus it allows higher live load.

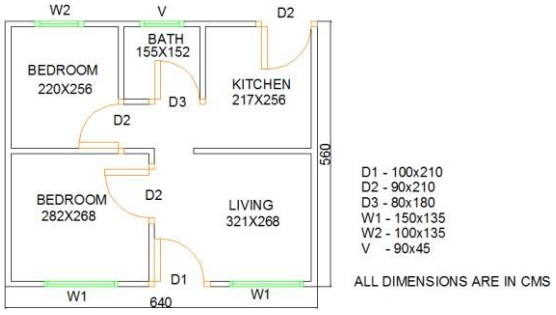

Fig. 3.1 Plan of Hybrid House

Stability analysis

During flood there is a possibility of tilting of the house, hence details of stability analysis was made with the light of fluid mechanics. In the present study a middle class family of four members in flood prone area is selected and for design consideration their average body weights for each person is taken as 60kg i.e. the total is 240kg and house area of 440sq.ft.

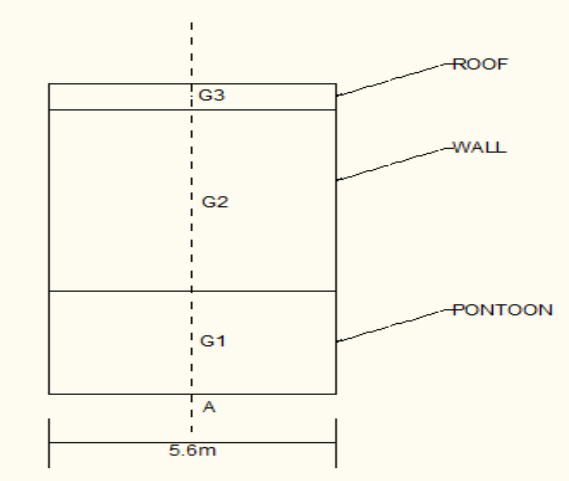

Fig 3.2 Stability Analysis

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For design purpose weights are considered as below: Weight of pontoon (W1) =385.17 KN
Weight of super structure (W2) =153.67KN Weight of roofing (W3) =67.94KN
Total weights 606.79 KN By Archimedes principle,
Buoyant force on a submersed object = Weight of the fluid that is displaced by the object
606.79= 10*(2.1*3.1*4)*H
Therefore, H = 2.33m
Distance of common Centre of buoyancy from the base of pontoon, AB = H/2 = 1.17m
Centre of gravity of the whole structure, A.G= W1 Y1 + W2 Y2 + W3 Y3 / W1+W2+W3
= (385.17 ∗1.375)+(153.67∗4.25)+(67.94∗5.95) / 385.17 +153.67+67.94
= 2.62m
Distance between centre of buoyancy and centre of gravity, BG = AG - AB
= 2.62-1.17 = 1.45m
Therefore Meta-centric height of structure about Y-Y axis of the plan,
G.M = $\frac{I}{\forall} - BG$

$= \frac{6.8*6^3}{12} - 1.45 = \frac{}{2.75*3.1*4*2.33} 0.09m$

Since it is greater than zero we can conclude that the structure is in stable equilibrium.
Stability analysis of the Hybrid house when it floats is determined by the theory that a floating body is said to be stable if it comes back to its original position after slight disturbance. Two alternate moments may act on the floating body depending on the relative position of center of gravity (G) and center of buoyancy (B).

Designing and detailing of column and beam
The design of columns and beams provided in the pit system are done using ETABS software.

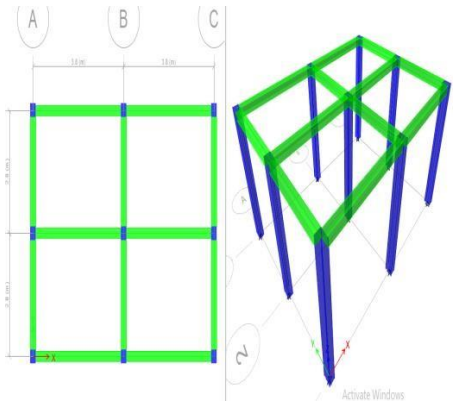

FIG 3.2 Designing of column and beam using ETABS

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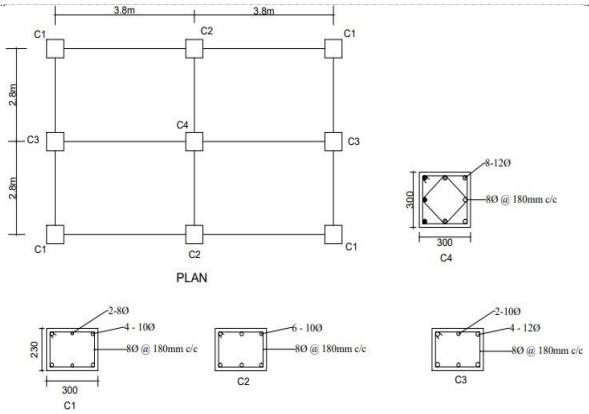

Fig 3.3 Detailing of column

4. CONCLUSION

Hybrid housing system is a sustainable flood mitigation strategy that can be safely adopted in the flood prone areas which provides a way to live safely and an innovative approach to tackle extreme flooding. When the flood water rises, it fills up the pit and will raise the superstructure which is resting on the reinforced concrete columns. As the superstructure of this housing system is of GFRG panels, it will enhance the construction much faster, easier with lesser site disturbances. Similar system is successfully functioning in New Orleans, Sausalito, Netherland, and Bangladesh, which is providing more reliable and more convenient flood protection. The concept of buoyant housing has been growing its popularity for the past decades; however this is still not introduced in our country.

As the population and urbanization are increasing day by day, the chances of again getting struck down by flood is very high. Hence it is high time for us to go with a flood risk reduction strategy. Hybrid or Amphibious foundation is a proven, low-cost flood protection strategy. Implementing Hybrid houses with GFRG walls is one of the best way in which it can be suitably adopted over flood prone areas of Kerala.

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