Research Proposal on

TECHNOLOGY DEVELOPMENT FOR AMPHIBIOUS STRUCTURES FOR FLOOD RESILIENCE

By

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MAY 2022

Summary

Amphibious structures are the type of structures that will float along with the flood level. In the initial stage, the structure will be resting on the ground. But when the flood level goes on increasing, it is planned to lift the superstructure along with the flood level. At that time, to keep the structure in position, an arrangement of pistons is proposed which will hold the building in position and also provide some flexibility to float on the water. This will be in a stable position by using the same principle as the ship is still in a position with anchors into the water when it is not moving. The platform on which the structure lies can be treated as the water pontoons. Based on the present records, these structures can be designed to float up to a height of 2 floors which is 8 – 10 meters. This type of structure will decrease the damage to the structure as well as the lives of the people during the disaster. For testing, a model house of 1bhk house is prepared with its maximum dimension as 0.4 meters as the model testing is done in the container of size 1.2*1.2*1.0 meters. This was tested for various conditions based on our requirements. The proof of concept and feasibility of research is established at NITK from preliminary model tests. Now we propose to escalate the TRL to 6 through large model testing and standardize the technology for real field applications.

Budget Summary (Total INR 30 lakhs)

	Item	Year 1	Year 2	Year 3	Total (Rs)
1	Manpower	431520	431520	487200	1350240
2	Consumables	20000	20000	20000	60000
3	Contingency	10000	10000	10000	30000
4	Other Costs*	25000	25000	100000	150000
5	Travel	0	25000	50000	75000
6	Equipment/Model Set Up	1100000	0	0	1100000
7	Overhead Charges	72978	76728	100080	249786
	Total (Rs)	1659498	588248	767280	**3015026**

TECHNOLOGY DEVELOPMENT FOR AMPHIBIOUS STRUCTURES FOR FLOOD RESILIENCE

1. General

Floods are one of the most frequent types of natural disasters. They can be caused by water flowing over the ground as it submerges the soil. They can be caused by the overflow of inland or tidal water or during heavy rainfall in coastal areas during cyclones or tsunamis. We can see the floods mostly when the size of the waterbody changes due to seasonal variations. Floods can cause damage to homes, and businesses in the case if it is in natural condition. But when it's on the river, there may be a chance that the river can wash away the structures which are beside the riverbanks. They can also lead to a few more consequences that are long-term and are considered secondary.

Fig.1. Flood in Chennai 2015. (Source: livemint.com)

The main objective of this study is to test a model of an Amphibious structure in various conditions of floods. It aims to build a model amphibious structure with varying levels of water, to check whether the structure is capable of withstanding the various forces coming on it.
The condition of Kerala floods has been taken as for the preliminary studies to establish the proof of concept considering frequent flooding situations over the past 4 years. The flood level is considered based on the records with the maximum intensity.

2. Amphibious structure

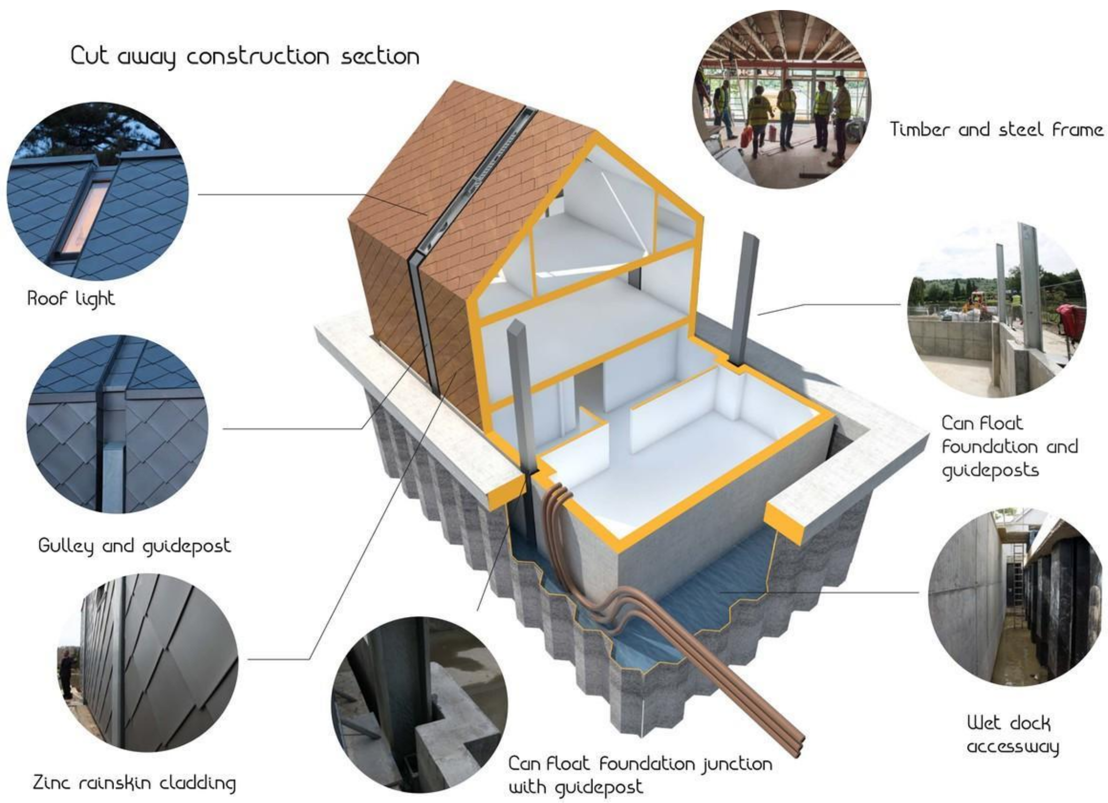

Fig. 2. Basic view of an Amphibious house (Surce: construction1.org)

An Amphibious structure is a building that rests on the ground, but whenever the water level rises due to various reasons, namely floods, it will rise along with the water level. But there must be some connection between the ground and the house when it is raised. This connection will be of the same mechanism as we see in a ship that is in the rest with anchors inside the water. For this, there must be a floating material that will facilitate the house to float during the floods.

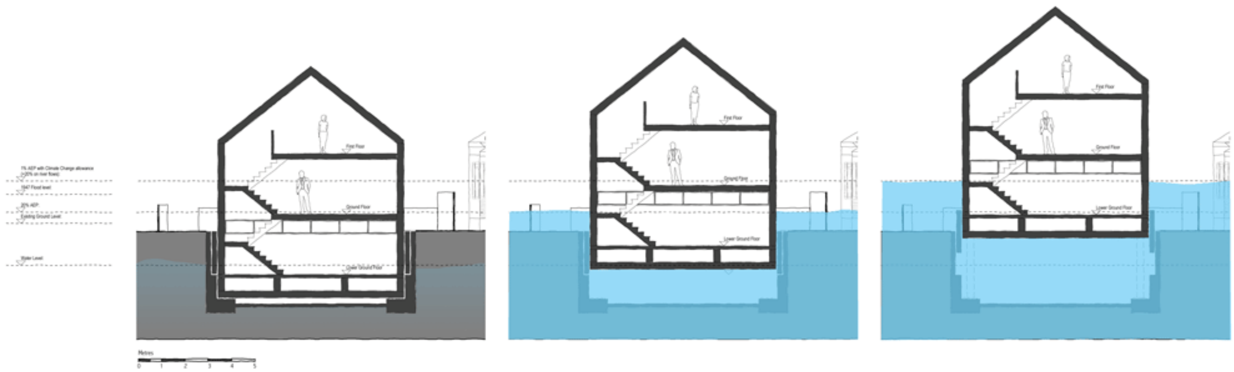

Fig. 3. Amphibious house during resting and floating position.

For these floating systems, solid Styrofoam which is encased in rubber, log floats, foam-filled steel pontoons, positive concrete, concrete ferrocement pontoons, concrete and foam, wood and foam, polyethylene shell with solid core polystyrene block molded inside, fiberglass can be used. All floating houses now are built with concrete floats. In this, the concrete works as a giant floatation block with Styrofoam inside it, and the Styrofoam is floating and the concrete is placed just like an upside-down bowl over the Styrofoam.

3 Proof of concept established at NITK

3.1 Model Tests

A model of structure was prepared based on the requirement and with the respective scale. The sub-structure of the model is prepared with the respective material based on the situation of the study area which we are considering. But when we consider the superstructure, that should be of lightweight material which may be lightweight concrete blocks, wood, steel, etc. The lightweight material is facilitated to lift the building when the flood level rises and can be arranged similarly to a pontoon platform under the superstructure.

The dimensions of the testing container are 1.2m*1.2m*1.0m. Sand can be used as the supporting soil for the model.

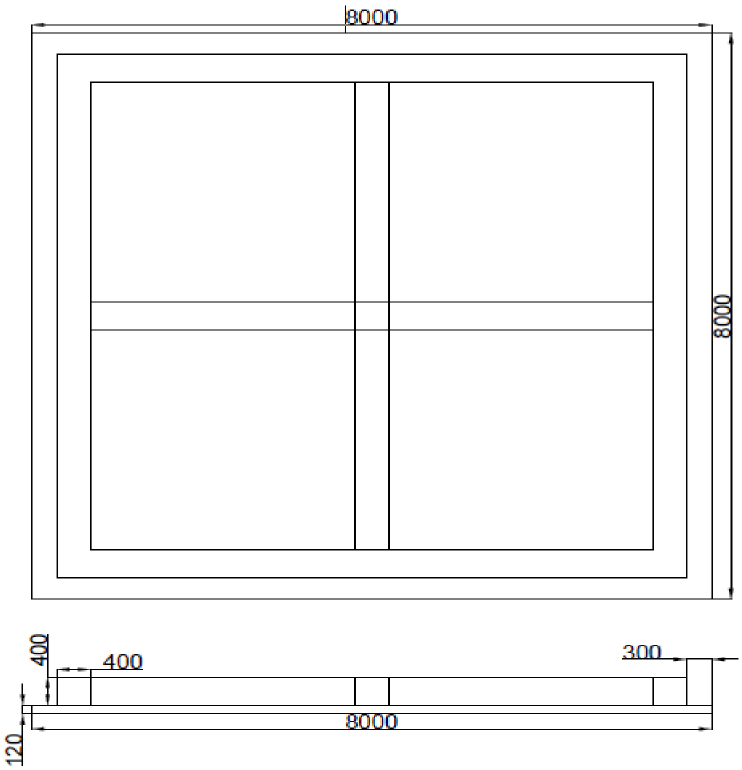

Fig. 4 (a) Approximate view of the model

As we know that one block of Styrofoam with dimensions 0.5m*1m*2m can withstand the weight of 0.9 tons, we have placed the Styrofoam by considering the weight of the model which was made with the scale of 1/20 with the prototype. From that, it is clear that the Styrofoam placed can withstand the weight of 5.716kg as the weight of the model is 5.0112kg.

During the experiment, the model is stable up to the required depth as per the record, i.e., up to 2 floors. The height of lift is recorded as 32 cm, when the scale is applied, the height of rise is 6.4 m which is approximately 2 floors.

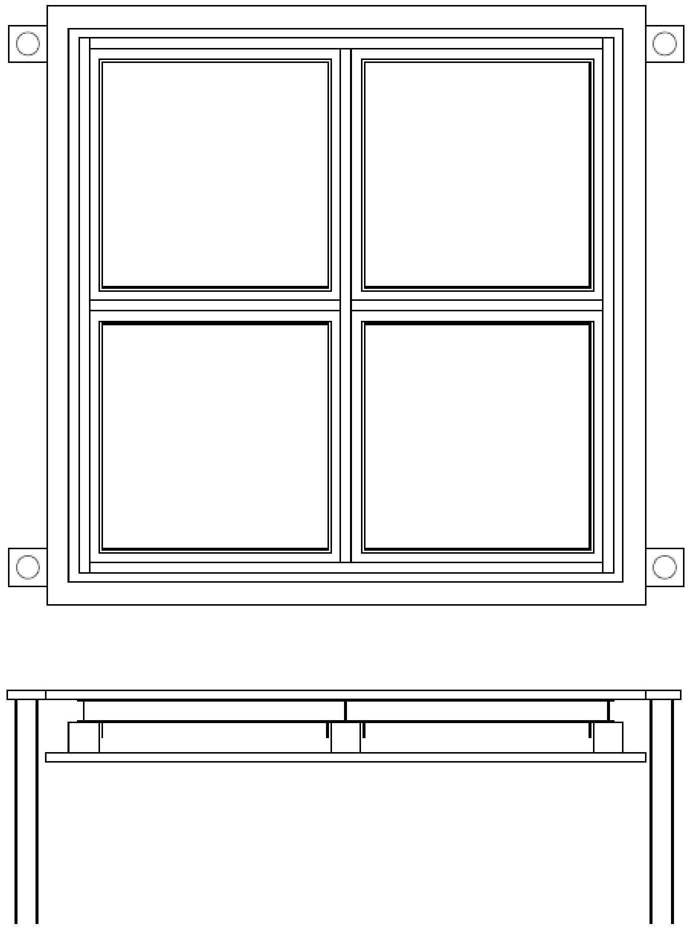

Fig. 4 (b) Model along with the floor slab

Fig. 4 (c) Model after arranging and during the test.

3.2 Simulation of the model using PLAXIS 3D:

For the simulation of the model on PLAXIS 3D, the following models will be considered as the soil can be analyzed by using the Mohr-Coulomb model and the foundation which is made of concrete can be analyzed by using the Linear Elastic model.

3.2.1 Mohr-Coulomb Model:

The linear-elastic-perfectly-plastic Mohr-Coulomb model involves five input parameters, i.e., E and ν for soil elasticity; ϕ and c for soil plasticity, and ψ as an angle of dilatancy. The Mohr-Coulomb model represents a 'first order' approximation of soil or rock behavior. It is recommended to use this model for a first analysis of the problem considered. For each layer one estimates a constant average stiffness. Due to this constant stiffness, computations tend to be relatively fast and one obtains the first impression of deformations. Besides the model parameters mentioned above, the initial soil conditions play an essential role in most soil deformation problems. Initial horizontal soil stresses have to be generated by selecting proper K_0-values.

3.2.2 Linear Elastic Model:

Soil behavior is highly non-linear and irreversible. The linear elastic model is insufficient to capture the essential features of soil. The use of linear elastic model may, however, be considered to model strong massive structures in the soil or bedrock layers. Stress states in the linear elastic model are not limited in any way, which means that the model shows infinite strength. Be careful using this model for materials that are loaded up to their material strength.

4 Expected Outcomes

The construction of Amphibious structures will be good for the locations where there are frequent floods. The technology developed from this proposal will be patented and communicated to Government and non Government agencies, Industries, and builders for putting the knowledge into practice. The technology transfer will be done on a non-profit-oriented basis to create resilient infrastructure in the country in line with the Disaster Risk Reduction policies of the Indian Government and the Sustainable Development Goal envisaged by the United Nations.

The hydrostatic and hydrodynamic behaviors of the structure considering various forces expected in the building with varying depth and wave action will be considered in the technology development. Hence the proposed technology can be employed in all states facing the flood disasters like Kerala, Karnataka, Maharashtra, Assam, Bihar, UP, and others