Thailand's Floating House Project: Safe and Sustainable Living with Flooding

P. Saengpanya and A. Kintarak

***Abstract*—Thailand is suffering from the major floods in the recent years. Numbers of people were killed properties were damaged, and livelihoods were aggravated by flood water. Such destructions give a sign of adaptation to this natural disaster. In fact, flooding happens almost every year in Thailand during the monsoon season. Government sector has announced "Thailand's Water Resource Management Strategy" as a framework for all dimensions of water management. Apart from an implementation of 'Thailand's Water Resource Management Strategy', community has an option to counterpart flooding in the non-defensive way. Back in the past, Thais were conventional to living with water; majority of transportation took place in canal network, elevated houses tell a clear story of amphibious way of life. Houses in the former time were elevated against seasonal flood waters. Currently, cost effective amphibious houses are being developed as an alternative to conventional elevated house to fit more for future urbanization, sustainable living and help community enhance flood resilience in more convenient way.**

***Index Terms*—Climate change adaptation, amphibious structure, flood mitigation, disaster resilience.**

I. Background

The notable Thailand flood in 2011 has incited an awareness of village adaptation to get prepared with routine floods. In fact, flooding happens almost every year in Thailand during the monsoon season. Government sector has announced "Thailand's Water Resource Management Strategy" as a framework for all dimensions of water management [1], [2]. The idea of floating house has been delivered with an expectation of the larger scale to floating market as a prototype of future floating village that is truly protected from flooding. The villages are able to survive during flooding and lie in place on normal dry ground.

In general, a traditional Thai elevated house (Figure 1 and 2) model so called 'stilt house' for flood-prone areas has been built for such a long time. Thai residents normally intimated with seasonal flood.

After the major flood in 2011, more construction projects gear towards amphibious structure to deal with floods. The floating house project is one of them. The project is developing under the cost-effective, easy to build, easy to move, and easy to repair concept with the purpose of being one of the flood proofing options to the flood prone residents saving them from loss of properties, and most importantly, loss of life.

Fig. 1. Traditional Thai House (single type) in central region [3].

Fig. 2. Traditional Thai House (group type) in central region [3].

In general, amphibious structure is divided into three types: stilt house, boat house, and floating house. Stilt house's foundation sits in the ground under water level and is mostly built by river bank or seacoast [4].

In the past stilt house is for permanent residence in Thailand whereas modern stilt house is more like a resort. Examples of residential stilt houses are IJburg on JImeer, a lake east of Amsterdam (Fig. 3 and 4) and Redwood City,

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California (Fig. 5 and 6) [5] and example of stilt house resort is Centara Grand Resort and Spa Maldives (Fig. 7) [6].

Fig. 3. IJburg on JImeer stilt houses.

Fig. 4. IJburg on JImeer stilt houses village, Amsterdam.

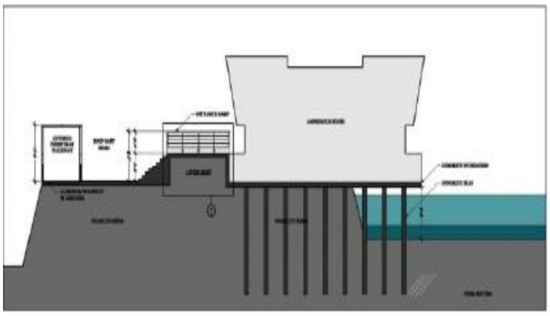

Fig. 5. Stilt House Structure at Redwood City, CA.

Fig. 6. Stilt House at Redwood City, CA.

Fig. 7. Stilt Houses in Centara Grand Resort and Spa Maldives [6].

Boat house is straightforwardly house on boat. It comes in different size from small single house to large cruise ship (Fig. 8). An example of boat house is Vietnamese boat houses (Fig. 9).

Fig. 8. Cruise ship.

Fig. 9. Vietnamese boat house [7].

Floating house is a house sits on buoyancy i.e. pontoon and raff. The project focuses on floating house type of amphibious structure. Examples of floating house type are Uthaithani raft village (Fig. 10), the floating house of the local wisdom that has been conserved in the southern Thailand (Fig. 11), [8] Floating Home Community in Redwood City, California and Toronto Float Homes, Canada (Fig. 12).

Fig. 10. Uthaithani floating house, Thailand.

Fig. 11. Floating house in Thailand.

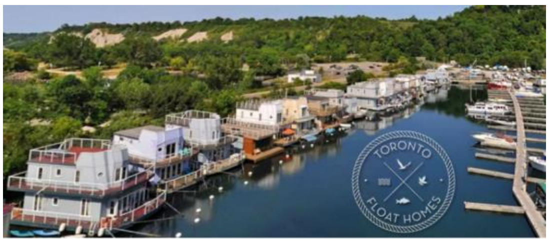

Fig. 12. Toronto float homes, Canada.

A. Well-Known Amphibious House by Factor Architecten and Dura Vermeer at Maasbommel in the Netherlands [9]-[11]

Flood resilient infrastructure development and implementation is important to Dutch culture since the Netherlands has a long history of flood damage mitigation and flood risk adaptation with 60 per cent of the country below sea level.

The concept of amphibious house is developed in the Netherlands as “Ruimte voor de River” (room for the river) program. The first amphibious houses have been developed in Maasbommel in 2015 (Fig. 13 and 14). The project is in the flood zone along the Maas River. The objective of the project was to test the amphibious house in a real environment and demonstrate an approach in comparison with the conventional flood resilient infrastructure. The project is successful in terms of residents’ satisfaction, international attention and awards, later amphibious projects of Dura Vermeer, Factor Architecten and Boiten, and mitigation measures integration potential. However, the project costs higher and is expensive for Dutch standards and only considered a recreational house that families cannot live there all year round.

Fig. 13. Amphibious houses in Maasbommel 1.

Fig. 14. Amphibious house in Maasbommel 2.

B. Amphibious House in Ban Sang Village, Ayutthaya Province, Thailand [12], [13]

In general, Thailand endures seasonal flooding during monsoon season. However, severe flooding occurred in 2011 and spread throughout the northern, north eastern and central provinces of Thailand as well as some part of the capital city of Bangkok. It was caused by three major factors: La Nina event that increased fall, topology of the region, and the land-use that locates in former flood plains and flood prone areas. After the floods, more construction projects are returning to use traditional structures such as stilts and building on barges and rafts. The Ban Sang village amphibious house project by Site-Specific Company Limited (Fig. 15 to 16), then developed in 2013. The house was tested and rose 8.5 cm. The under house drag out space was filled with water as the water level rises, and then lifted the house up.

Fig. 15. Amphibious house in ban sang village.

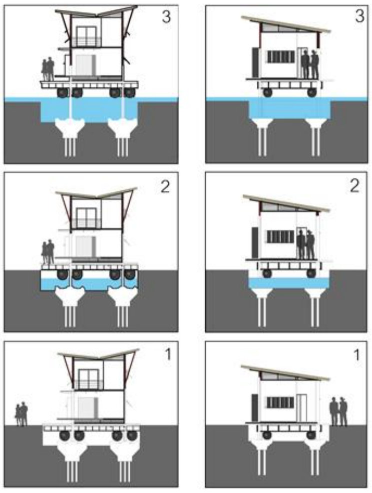

Fig. 16. Ban sang village amphibious house functions.

II. ADVANTAGES OF FLOATING HOUSE

Among all the architectural designs as a resolution for flooding, the amphibious design tends to be the most effective and the most resilience option. Turner and English stated that Global warming greatly contributes to inconsistency rise of sea level, inconsistency flood height. As a consequence, a statically design elevated house becomes inefficient to support an extreme flood event with unusual flood height. On the other hand, Amphibious house, proactive solution, enable the house to float safely accordingly to the flood level.

There are many advantages of an amphibious house. Firstly, they are cost effective and resident-friendly. An amphibious house is widely implemented in many flood sensitive area because people who affected by the flood can afford to buy the house with a certain function. This type of anti-flood design does not interfere with every life of the resident.

Secondly, as mentioned, the house can tolerate extreme flood condition because the house is fixed on the guide post and be able to float up safely. They do not disrupt overall urban landscape as elevated house does.

Finally, there are many options for floating unit from the used gallon jug to EPS. People can choose the structure from what they have which is very convenience for houses in a rural area where they are out of reach of good quality building material.

In terms of stakeholders those who advantage from floating house project are the following:

1) Government sector: providing alternative residences to flood prone areas.
2) Tourism Authority of Thailand: applying floating house know how to Thai traditional based tourism management, and floating market management.
3) Department of Water Resource: implementing floating house know how for public disaster resilience.
4) Tourism industry: applying standardized and researched floating house know how to build safe resort under low budget.
5) Real estate industry: developing commercial housing estate projects in the future.
6) Public: building well standardized and researched floating house for flood zone home or holiday house.

In conclusion, there are many advantages of using this certain type of amphibious design. People who are living in flood risk area should adopt this design in order to make sure that they are ready for unpredictable caused by Global Warming.

III. Floating House Project

Floating house project applies amphibious structure design to practice. In normal condition, the house sits on the ground. When flooding occurs the house rises up and floats on flood water. The buoyancy expanded polystyrene (EPS) frame is attached to floor structure as well as the guidance poles that work to keep the hose rise up and float safely in place [14]. The house is allowed to go only in vertical direction (Fig. 17 and 18).

A. Project Objectives

The objectives of the floating house project are to house design must be constructed with simple, already available materials, construction must be easy to perform and adjust, cost must be economical, and the whole project must be sustainable and eco-friendly.

B. Design Concept

As per the project's objectives of being simple and locally available materials, easy construction, low budget, and sustainable living, the floating house functions the same as normal building despite some key buoyancy system compositions have been equipped to push the whole house up as water rises. The house's floating system consists of vertical guidance poles, water-proof substrate strapping, and EPS blocks. Vertical guidance poles keep the house move only in vertical direction. Water-proof substrate strapping secures buoyancy assembly to floor structure EPS blocks encased in reinforce concrete provide floating to the house. Utility system is also equipped with the buoyancy blocks underneath the house where as its lines are coiled and its connections are able to disconnect when the house rises. Under dry ground situation the house is supported by its foundation piers (Fig. 18 left). Under flooding situation, the floating system lifts the house (Fig. 18 right). The components of the floating house utility line disconnect show in Fig. 19.

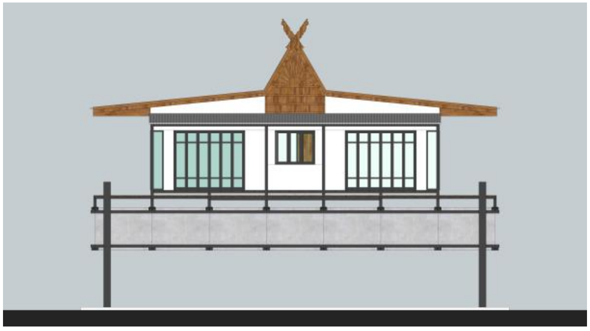

Fig. 17. Floating house model on front view.

Fig. 18. House on ground (left) and on water (right).

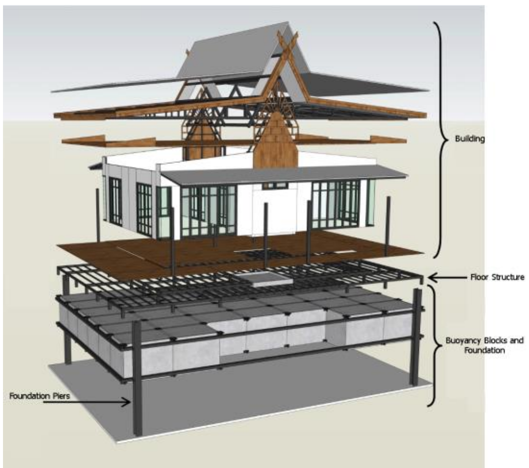

Fig. 19. Floating house compositions.

C. Primary Study and Design

The early project studied requirements of residents in floating buildings are to build with the same function as the building on ground. Floating building should be safe, strong, and preserve culture of living on water. Its buoyancy must be durable.

Design principles of foundation for floating buildings should be concerned as follows: living space and functions, floating building stability, buoyancy safety when flooding, pile foundation sitting when dry condition and all parts must be able to maintenance. So that, the project specifies the size of the floating house at 9 x14 square meters consisting of building, base, and buoyancy part or pile foundation.

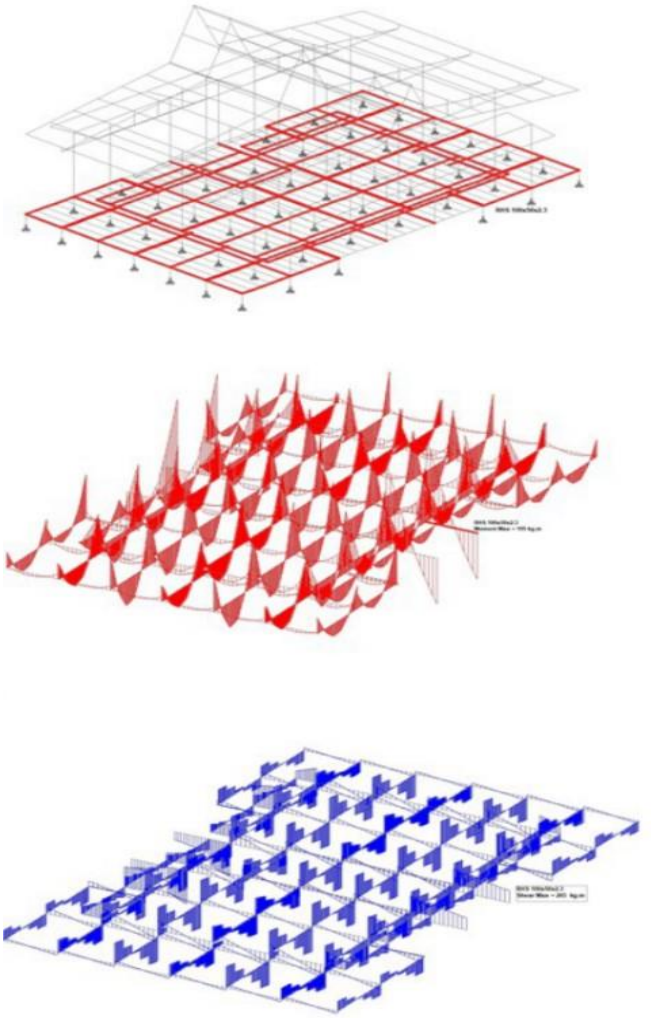

Fig. 20. Analysis of Maximum Shears, and Maximum Moments on floating house major beam elements, analysis positions (top), Bending Moment Diagram of major beams (middle), Shear Force Diagram of major beams (bottom).

Then, loads to the floating building consist of dead loan, live load, and environmental loads (Fig. 20). The static weight of the building is 620 kg/m^2 and live load is 300 kg/m^2. The buoyancy blocks should be 1.5metres height so that the buoyancy force is able to lift and float the building on water. In care of dry condition, the building has to sit on the foundation. Pile foundation should be placed into a sandy sediment layer (SM) at a depth of 16.00metres below the ground level or more. The finite element method for analysis and design shows that for the steel structure base, maximum shear in the main beam is 265kg and maximum moment is 195kg·m. At the front beam, maximum shear is 180kg and maximum moment is 182 kg·m. On sub-beam, maximum shear is 125 kg and maximum moment is 60 kg·m. Additionally, maximum axial loads on the long column C1, short column C2 are 850kg and 3,000kg respectively (Figure 21). Maximum moments of C1 and C2 are 25 kg-m and 205 kg-m respectively. The column between base structure and foundation piers C3, holds maximum deflection at the top at 23.7mm with maximum moment of 31.5 kg-m at the tip. For the buoyancy blocks, maximum positive moment is 144kg·m/m at the middle of concrete slab, maximum negative moment at the edge is -144kg-m/m. for lateral slabs maximum moment at the center of concrete slabs is 175 kg·m/m and maximum negative moment at the edge is -161 kg·m/m. For the lower slabs, maximum negative moment at the center is -55 kg·m/m and maximum positive moment is 175 kg·m/m. maximum deformation is found at the center of all slabs.

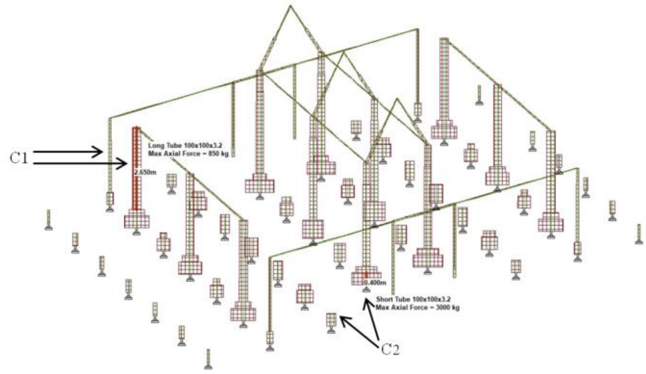

Fig. 21. Elements of column analysis.

IV. Conclusion

Although amphibious structure concept is not new in the engineering world, it is currently gaining more attention since Thailand is facing seasonal monsoon, climate change, and some parts of the country are in flood-prone areas. The project development strongly follows the key purposes of simple construction, locally available materials, low cost, and sustainable functioning. The houses are not only protecting residents' life and property, but also preserve culture and the local way of living with the water.

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