Exploring the possibilities of Application of Amphibious Construction Technology in Coastal Districts of Odisha

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Abstract—During cyclonic events, flooding has always been a problem in the coastal districts of Odisha. Because the coastal regions of Odisha, notably the Mahanadi delta region, is in the path of a more severe cyclonic storm originating in the Bay of Bengal, there is a concentration of run-off. The severity of cyclonic rain has necessitated an immediate need to improve flood resilience in flood-prone areas. In this article we have explored the possible role of amphibious architecture, design, and construction in response to the problem of Odisha's coastal districts to become flood resilient. Architects and urban planners have started to investigate and identify the necessity for amphibious architecture to address flood-related issues. This study examines case studies of current and projected amphibious structures, as well as the systems and components that make them up. Amphibious housing is a type of home that may be used both on land and in water to give low-flood protection to occupants. The use of a buoyant foundation provides a cost-effective and safe alternative for permanent static elevation.

Index Terms— Amphibious, Construction, Buoyant, Coastal, Flood resilient, Architecture, Structures.

1 INTRODUCTION

EVERY year, natural disasters like floods and cyclones strike Odisha's coastline region. Severe floods in the Mahanadi River system have become routine, wreaking havoc on downstream settlements, particularly the Mahanadi delta area in Odisha's coastal tract shown in Fig 1. During each storm, tidal surges rise several meters and inundate the coastal land, rendering it unfit for cultivation, killing numerous people and causing significant property damage. Ganjam, Khurda and Puri are among the districts affected as shown in Fig 2a and Fig 2b. As per Disaster resilient housing scheme by Odisha disaster management in the districts of Ganjam, Khurda, and Puri, some 30,000 disaster robust dwellings have been built under the ORDP within 5 km of the high tide line [5]. Numerous initiatives were taken into consideration to manage flood related disasters in odisha which includes Structural engineering projects such as embankment, raised platform and other temporary shelters. A policy guideline of Odisha disaster management has allocated @Rs 3,00,000/-per house for Owner Driven House Construction have been adopted. This sum would be given to each beneficiary for the construction of around 300 square feet. Other amenities such as electricity and running water are available in the house. Housing schemes such as the Pucca building should be promoted as cyclone-resistant structures. Source:(https://www.osdma.org/preparedness/disaster-resilinet-housing).

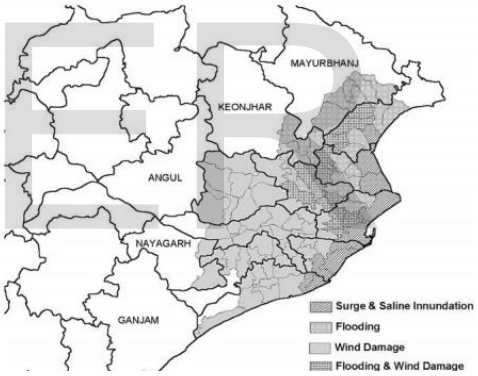

Fig 1. Source: Mitigation of Flooding and Cyclone Hazard in Orissa, India

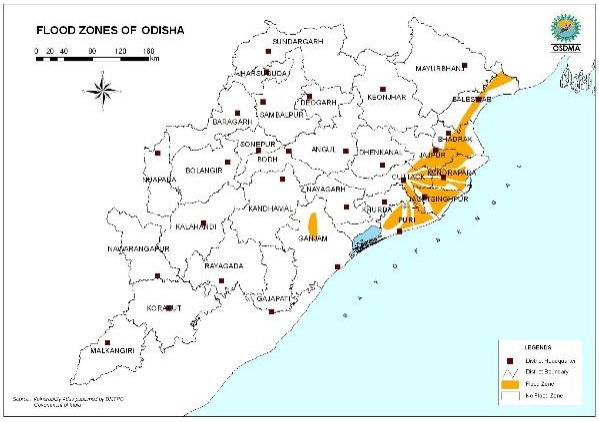

Fig 2 a. Source: https://www.osdma.org/state-hazard-map

Fig 2 b. Source: https://www.osdma.org/state-hazard-map

New strategies are required to provide resilience in flood prone areas with critical hydrologic and hydraulics study which would facilitate in restoration of structures with a medium to long term view. Amphibious architecture is a type of flood protection approach that allows a structure to float above rising floodwaters without blocking the flow of water or succumbing to flooding. An amphibious structure's initial concept is based on buoyancy. Buoyancy is the force that allows an object to float on water or another liquid. A buoyancy mechanism beneath the house displaces water as needed to create floating, and a vertical guidance system allows the rising and falling house to land in the same spot [4]. Houses are built on hollow concrete boxes that are connected to enormous steel pillars. During a flood, the boxes behave as a ship's hull, maintaining buoyancy. When the water level rises, the home rises with it, sliding over the pillar and floating above the water illustrated in Fig 3. The home will revert to its original position as the water recedes.

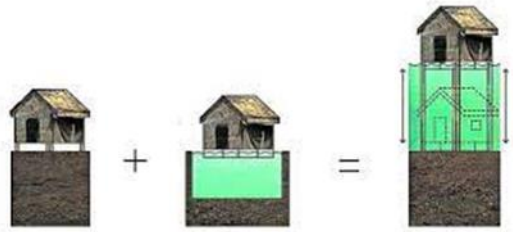

Fig.3. Source. https://edtimes.in/houses-that-float-are-what-india-needs-to-tackle-floods/

2 Case Studies

2.1 Kerala, India

Every monsoon, torrential rains, floods, and landslides wreak havoc on portions of Kerala, leaving communities unable to witness the devastating consequences of their investments. Many have resorted to novel design structures or construction methods in anticipation of these extreme weather conditions to minimize the damage. Gopalakrishnan Achari, a Vazhappilly inhabitant, is one among them. He first built a model house Fig 4. out of steel tubes and multi-wood sheets, which took him five years to complete [3]. It was erected in 2017, and the following year it was flooded. He then modified it to ensure that it is prepared for a probable flood crisis. The air tanks inserted in the house's foundation are what allow it to rise. The four steel pistons at four corners of the wall were put to keep the floating house from being washed away by floodwaters. These pistons are buried 25 feet down and are not visible from the outside or inside the home. The house is supported by the pistons' inner rods and does not contact the ground. During floods, the house, together with the air tank, will rise with the help of the piston. When the water recedes, the level will automatically return to normal.

The piston in this model reaches up to 15 feet above the ground, allowing the home to securely move up to 10 feet. The pistons' height can be modified to any level, but the piston's strength and length should be raised in proportion. So that the tank would not be visible from the outside, the basement was covered with multi-wood sheets. Aluminum sheet is used to construct the model house. The house costed approximately Rs. 1,600 per sq.ft.

Material Used for Construction of House:

Steel Tubes, Multi wood Sheets, Air Tanks, Steel pistons, Aluminum sheets.

Fig 4 Source: https://www.thebetterindia.com/204381/kerala-floods-innovation-floating-house-monsoon-sustainable-architecture-india/

2.2 Bangladesh

The people of Bangladesh have long been living with the natural calamities that ravage lives and properties and cause immense suffering to them. The most common among them is flood, which forces hundreds of thousand of people, almost every year, to leave their inundated homes and take refuge in flood shelters.

The Core Bangladesh research project, the Bangladesh University of Engineering and Technology (BUET) has brought a phenomenal technology to deal with the issues on sustainable

basis.

A riverain country, Bangladesh is a land of floods. Evacuation of individuals to safe homes to save lives and belongings poses vulnerability to the affected people. With research prototype homes were developed that may allow the people to remain with all belongings even amid a high rise of floodwater. The technology introduces floating Amphibious Houses with retrofitted floor, which is innovated with the Dutch flooding technologies, implemented within the local context. An amphibious home is built on the land and designed to float on water just in case the water level rises. The home is built using the principle of buoyancy. Buoyant foundation of the house would make it safer while it would be floating sort of boat dock, it rises and goes down with a change within the water level and anchors are used on the perimeters so that the house does not move horizontally while floating Fig 5. Expanded polystyrene is employed to construct the amphibious base. It is a lightweight cellular plastic material that consists of small spherical balls. Most house and shed are built using tin. The floating blocks of the house lift it when flooding occurs. Also, the prevailing muddy floor is retrofitted by putting a wooden floor on top of it. Reused plastic bottles and pipes are arranged in layers below the wooden floor which function as hollow vessels Fig 6. So, when the water level rises, the airtight bottles uplift the full house.

This project aims to extend the capacity and resilience for flood risk management. It had been applied in the flood affected area of ranigram village of khoshkbari in siranjganj. SHARP and Sirajganj engineering school together helped to implement the technology, to make sure community participation many local people, students and engineers took part in implementing different levels of designing and planning of the technology to make it more feasible and user friendly.

Material Used for Construction

Expanded polystyrenes, reused plastic, airtight bottles.

Fig.5
Source: https://www.preventionweb.net/experts/oped/view/75293

Fig.6
Source: https://www.preventionweb.net/experts/oped/view/75293

2.3 Port maria and Bliss Pastures, Jamaica

Field research was carried out in Jamaica to look into communities at danger of inland flooding with the purpose of constructing buoyant foundation retrofits for homes in flood-prone areas. The city of Port Maria is located on the Outram River, and many homes are located directly near to the river, putting them at significant danger of flooding, inflicting property damage and displacing residents. The problem might remain for days or weeks following the flood, when the water usually recedes within a day or two, extending the time it takes for properties to dry.

A light establishment retrofit for a house has been planned and detailed. Utilisation of cost effective, locally accessible materials and local construction practices was an essential thought in developing the buoyant foundation retrofit designs for the chosen houses. The assembly comprises of a few components, for example, expanded polystyrene underneath the current floor and compressed wood primary substrate that builds up the current design and supports the buoyancy blocks Fig 7 [2]. There is a low-cost vertical framework, easily accessible lumber utility poles to restricts any horizontal movement of the houses as it rises, floats, and descends. To guarantee that the existing construction has sufficient strength to withstand the added forces associated with buoyancy, the floor outlining structure are strengthened by joining pieces of water-safe pressed wood placed opposite to the floor joists.

The previous retrofit configuration utilized sealed, recycled 5-gallon cooking oil containers to give buoyancy. The jugs themselves were a cheap and readily available material for buoyancy, the material and work needed to make the wire boxes to contain the containers and join them under the house were discovered to be expensive. Finally, these were substituted with expanded polystyrene (EPS) when exploration established that EPS would be altogether more affordable than reused containers after the expense of work was considered in, as the utilization of EPS would simplify the development process. This result in a 65 % decrease in the expense of the buoyancy components. Development expenses of the land and/or water capable retrofits, which incorporate both work and materials are assessed Rs 3.2 Lakh for the port maria houses.

Material Used for Construction

Expanded polystyrene, compressed wood primary, lumber, recycled 5-gallon cooking oil container.

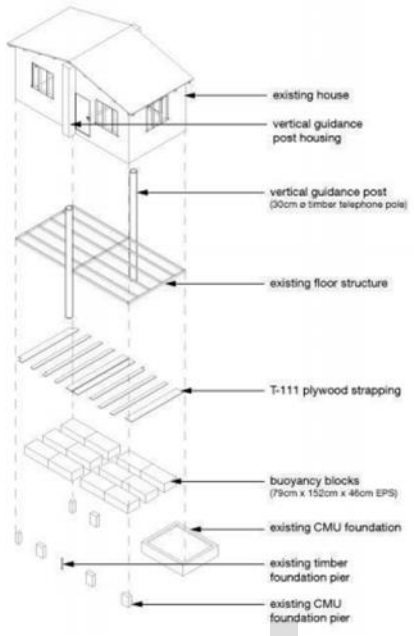

Fig 7

3 Conclusion

The potential of amphibious technology has been evaluated in this research. The study demonstrates how to incorporate this technology into new and existing structures to improve water retention capacity. This novel technology allows for an adaptive and cost-effective flood protection strategy enabling locals to survive in adverse environmental condition. This method will allow marginalized communities to stay on their land. People of Coastal district of Odisha are facing complicated difficulties during flood which has affected its residents "quality of life". This proposal is a contribution to raising quality of life of people living in flood prone area of Odisha by designing and building amphibious houses so as to promote the resilience and adaptability in terms of dealing with flood.

Amphibious houses designed in Kerala and Jamaica cost approximately 40 to 60 percent more that the ordinary house built for flood effected residence of Odisha. Instead of having short term solution, a long-term vision should be adopted as this area is stricken by natural calamities like cyclones and floods every year. The local stakeholder, R&D team and local authority can participate in design and planning of Amphibious houses which prove financialy feasible in long term and efficient in sustaining the vagaries of nature.

Amphibious technology may catalyze this transformation process as it is multifunctional and its symbolic value will provide incentives for landowner and the local government to implement this technology. Further detailed research is needed to customize the design and construction technology as per the local geographical and socio-economic context.

REFERENCES

[1] P. Chittibabu, S. K Dubei, J.B. Macnabb, T. S Murty, A.D. Rao, U.C. Mohanty and P.C. Sinha, "Mitigation of Flooding and Cyclone Hazard in Orissa", *India for Atmospheric Sciences Natural Hazards*, 31: 455–485, 2004. (c) 2004 Kluwer Academic Publishers. Printed in the Netherlands.

[2] Buoyant Foundation Project https://www.buoyantfoundation.org/

[3] R.N.Wangchuk ",Kerala Man Design Affordable Floating House that can Withstand Floods"https://www.thebetterindia.com/204381/kerala-floods-innovation-floating-house-monsoon-sustainable-architecture-india/

[4] E. English, K. Ntasha and S. Turner, "Thriving with water: Developments in amphibious architecture in north America", E3S Web of Conferences e3sconf/201, DOI: 10.1051/ 6 FLOODrisk 2016 - 3rd European Conference on Flood Risk Management

[5] D. Beura, "Floods in mahandi river, Odisha, India: Its cause and management", IJEAS ISSN:23 Volume -2, Issue-2, February 2015

[6] P. Sharma, "Analytical research on ferrocement: Design, strength and servicibility aspects", https://www.academia.edu/19598796/ANALYTICAL_RESEARCH_ON_FERROCEMENT_DESIGN_STRENGTH_AND_SERVICIBILITY_ASPECTS

[7] I. S. Igwe and T.J. Ajoko, "Analysis and design of steel Floating Pontoon for use as jetty in the coastal Region of Nigeria", EJERS, European Journal of Engineering Research and Science, Vol 5, Issue 9 Sep 2020

[8] S. bhattachrjee and N. Mukherjee, "Floating Houses: A design for flood resilience innovations in Bangladesh", research gate, published on July 2017, PLEA 2017 EDINBURGH design to thrive.

[9] N.H.R. Sulong, S.A.S. Mustapa and M.K.A. RashidApplication of expanded polystyrene (EPS)in buildings and constructionsJanuary 2019: Journal of Applied Polymer Science 136(3) ,11jan 2019

[10] E. English, "Amphibious foundations and the buoyant foundation project: Innovative strategies for flood-Resilient housing", Paper presented at the International Conference on Urban Flood Management sponsored by UNESCO- IHP and COST Action C22, "Road Map Towards a Flood Resilient Urban Environment", November 25-27, 2009, Paris, France

[11] P. Nilubon, W. Veerbeek and C. Zevenbergen," Amphibious Archtecture and design: A catalyst of Opportunistic Adaptation? -Case Stuy Bangkok", *Urban planning and Architecture Design for Sustainable Development*, UPADSD 14-16 October 2015

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