DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE

PROJECT REPORT ON

"A COMPARATIVE STUDY ON AMPHIBIOUS HOUSING SCHEME"

SUBMITTED BY

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UNDER THE GUIDANCE OF

PROF. A. A. Sangave

DEPARTMENT OF CIVIL ENGINEERING

NAGESH KARAJAGI *ORCHID* COLLEGE OF ENGINEERING AND TECHNOLOGY,

SOLAPUR-413002

(AFFILIATED TO DBATU, LONERE)

2022-2023

CERTIFICATE

This is to certify that the Project entitled **"A COMPARATIVE STUDY ON AMPHIBIOUS HOUSING SCHEME"** is completed by the following student of BE (CIVIL) class satisfactorily under my guidance:

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The project is found to be complete in partial fulfilment for the award for Degree of Bachelor in Civil Engineering from Dr. Babasaheb Ambedkar Technological University, Lonere.

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PROJECT APPROVAL SHEET

The project entitled **"A COMPARATIVE STUDY ON AMPHIBIOUS HOUSING SCHEME"** Submitted by following Students -

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Is hereby approved in partial fulfilment for the award of Degree of Bachelor of Civil Engineering of Solapur University, Solapur.

EXAMINERS

1. _______________ (INTERNAL)

2. _______________ (EXTERNAL)

DEPARTMENT OF CIVIL ENGINEERING

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I also express my Sincere Thanks to **Dr. S. B. More** Head of department of Civil Engineering, and **Dr. B. K. Sonage** Principal N.K.O.C.E.T, Solapur, for extending all the facilities required for my seminar.

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ABSTRACT

Housing is a very basic necessity for human life, so it is needed by considering its comfort of the environment and constituent materials. For people who live on the coastal areas which have narrow land and low environmental arrangement, a floating house can be the solution. The floating house is a building that stands or floats on water by relying on the weight and area of the field that is submerged as load parameters that are able to be borne by the structure. The house can float and be placed on the edge of the beach and above the sea water front. There are various materials that can be utilized as the footing of this floating house; one of which is plastic barrels. This research aims at analyzing the level of buoyancy, the amount of materials and the cost needed for the construction of a simple floating house unit using plastic barrels as the platforms. The results showed that the buoyancy level (Fa) of plastic barrels as the platforms material is 549.814 Newton, the number of plastic barrels needed as platforms materials is 232 pieces costing for IDR 358,270, 000.

India is a peninsular country three sides covered with water. It faces a heavy monsoon season that causes large scale destruction throughout the country. Perennial rivers such as Ganga, Brahmaputra, etc. Always causes flooding in north India and cyclones and heavy monsoon are the reason for flood in southern parts of India. India is the one of the vulnerable country for climatic change. It should work to provide flood proof, safe and affordable structures for all citizens.

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CHAPTER ONE
INTRODUCTION

1.1 GENERAL

The development of residential areas in Indonesian coastal areas is the most important part in supporting the sustainable development and improving the welfare of the nation. Economic activities in coastal areas will be followed by growth in population which has a direct impact on the housing and settlement sectors. However, there are still many resident settlements in the Indonesian coastal areas that are poorly laid out, too dense, slums and not worth living. To overcome the housing problems in the coastal area, recently a new concept of floating house technology has been developed.

The advantage of this floating house is the flexibility to move its position or location. In addition, the house that uses a flat foundation can rotate its direction position and can also move. Besides being environmentally friendly and safe from flooding, the floating house is also regarded as unique in terms of design as well as sustainable. The location in this study is the northern coast of Semarang City, Indonesia. In this area breakwaters and sea walls have been built, so that the coastal area is sufficiently protected from ocean wave energy, so it is safe enough to build a floating house. There is a wide range of materials that can be used as floating house platforms, such as bamboo, styro foam, PVC (Polyvinyl Chloride) pipes and plastic barrels. The study aims at analysing the use of plastic barrels as a floating house platform.

The analysis is carried out on a simple floating house construction, including the calculation of Buoyancy, the amount of material and costs needed. The design of the floating house is made simple that can be applied as a resident house in the coastal area by taking into consideration on the economical design. As for the slope structure, the column, and the beam rings use wooden material, whereas for the trestles use light steel, and the roof is using Sakura roof.

India being a peninsular country and surrounded by Arabian Sea, Bay of Bengal and Indian Ocean is quite prone to flood. As per Geological Survey of India (GSI) the major flood prone areas covers 12.5% of total country area. Flood, the most common disaster of India causes immense to country’s property and lives every year. The major flood prone areas in

India are river banks and deltas of Ravi, Yamuna, Gandak, Sutlej, Ganga, Ghaggar, Kosi, Teeste, Brahmaputra, Mahanadi, Mahananda, Damodar, Godavari, Mayurakshi, Sabarmati and their tributaries. Cyclonic storms can cause floods in Andhra Pradesh, Orissa and Tamil Nadu. The monsoon rain causes heavy rainfall and flooding in southern eastern part of country.

1.2 BUOYANT FORCE

The term buoyant force refers to the upward-directed force that a fluid exerts on an object that is partially or completely immersed in the fluid. The buoyant force arises from differences in hydrostatic pressure – the pressure exerted by a static fluid.

Buoyancy results from the differences in pressure acting on opposite sides of an object immersed in a static fluid.

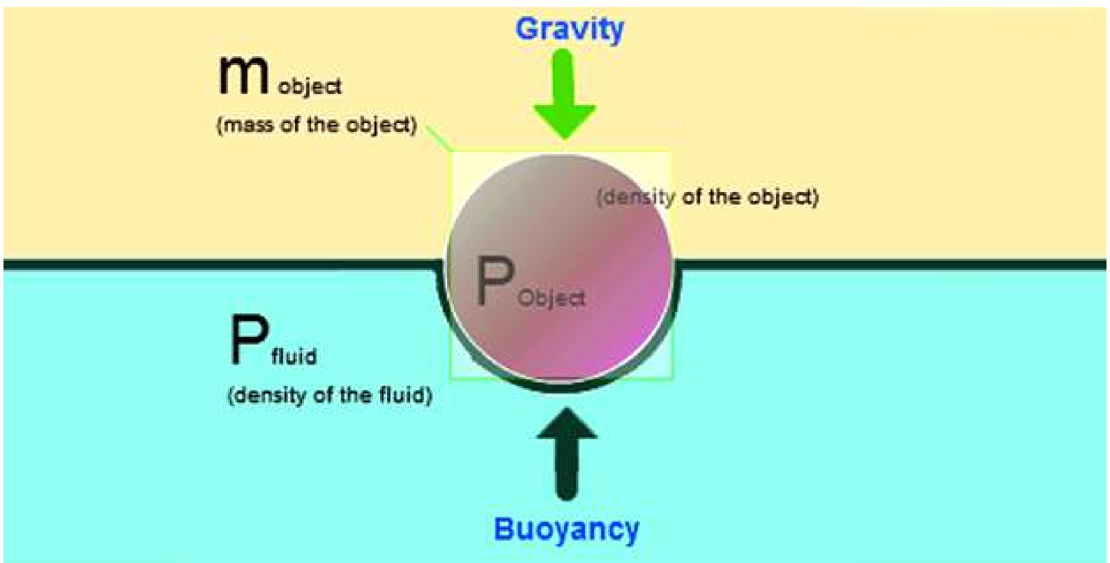


Fig. 1.1 Buoyancy acting on object

When an object is immersed in water or any other fluid, we observe that the object experiences a force from the downward direction opposite to the gravitational pull, which is responsible for the decrease in its weight. This upward force exerted by the fluid opposes the weight of an object immersed in a fluid. As we know, the pressure in a fluid column increases with depth. Thus, the pressure at the bottom of an object submerged in the fluid is greater than that at the top. The difference in this pressure results in a net upward force on the object, which we define as buoyancy.

1.2.1 Use of Buoyant Force in Amphibious Structure

The float line is the line that denotes when the building will begin to float. According to buoyant principle, if an object displaces a volume of water which weights a greater than the object then it will float. Likewise if an object displace a volume of water that weighs less than the object then the structure will not float. The building will have a static square or rectangular foundation the volume of water can be altered only by the height of the building. This means that if the sea level rises the water volumes also expands, so if the sea level rises the structure with less weight than the sea water will float. The float line is to be designed for 5 feet below the pier if the water level rises and the grade becomes steeper it will not because the pier will be completely inundates at that points.

Fig. 1.2 Buoyant force in Amphibious Structure

1.3 CLIMATIC CONDITIONS IN INDIA

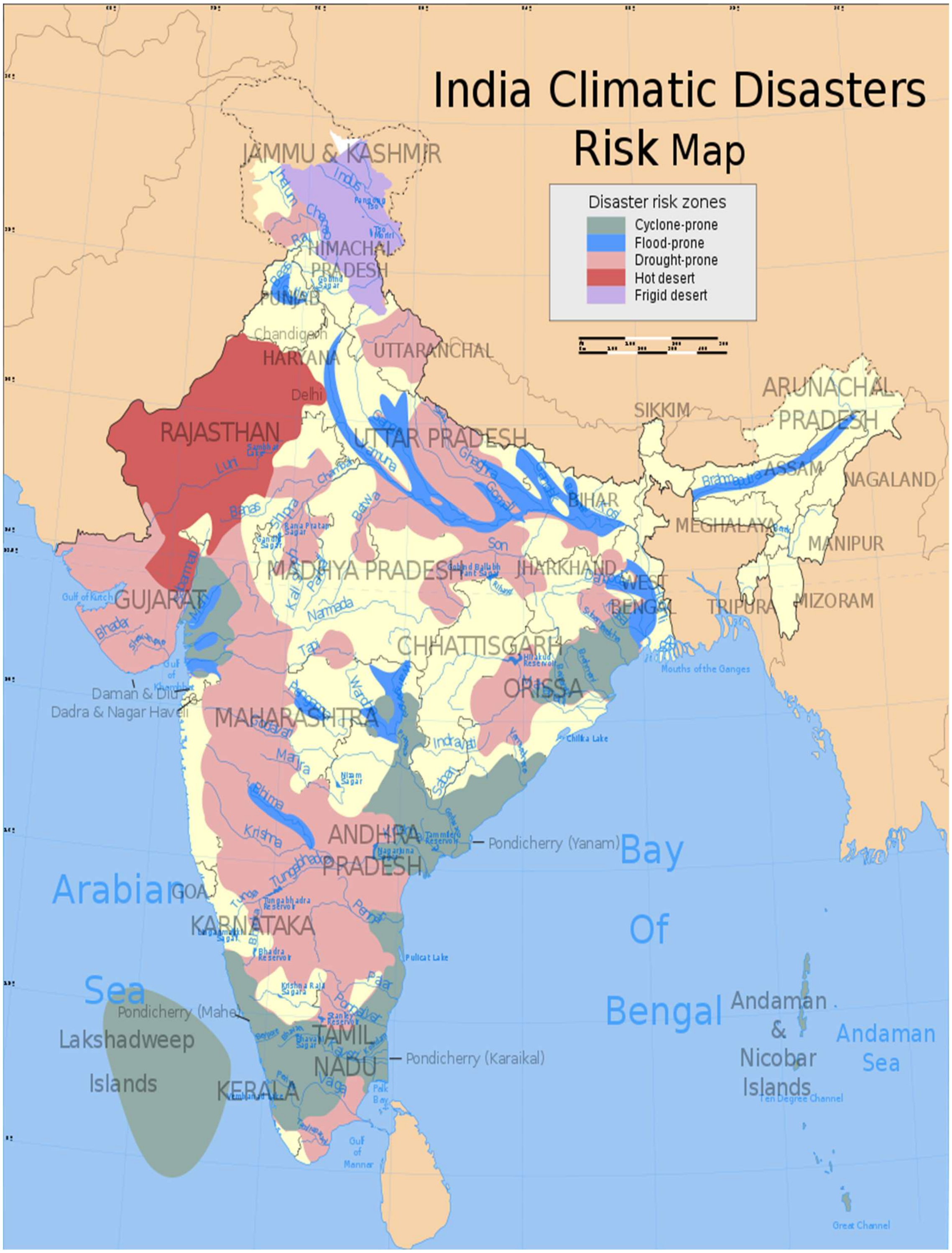


Fig. 1.3 Climatic Disaster Risk Map of India

1.3.1 Reality of Climate Change

Indian coastline is vulnerable to various natural hazards, including storms, extreme tides, and sea level rising from global climate change. The term climate change describes the variable consequences of global warming over time. The research conducted by IPCC (Intergovernmental Panel on Climate Change) found that the globe temperature has been increased 1.5˚F in past 100 years. Leading scientists around the world agree that climate change is a reality and that human activities are intensifying the greenhouse effect. The sea level rise is because of melting of glaciers due to global warming, discharges from ice sheet and expansion of ocean.

A study on sea level rise and greenhouse gas emissions was conducted to determine the risks associated with coastal communities in India. Figure 1 is a map generated to depict the areas that will be affected by sea level rise and flood in Indian bay within the next 100 years.

1.3.2 Problems Caused by Climate

- The mean sea level rise along the Indian coast is projected to rise from 1.0 to 1.4 meters by the year 2100.
- A 1.4 meter sea level rise will put 4,80,000 people at risk of a 100 year flood event, given today's population.
- A wide range of critical infrastructure, such as roads, hospitals, schools, wastewater treatment plants, power plants, and more will be at increased risk of inundation in a 100 year flood event.
- An estimated 550 square miles of wetlands along the Indian coast are vulnerable to sea level rise, especially if marine life cannot move further inland because of levees, bulkheads, and seawalls and other development blocking inland migration.
- Nearly million worth of property is at risk of flooding from a 1.4 meter sea level rise, and the majority of this property is residential development.

1.3.3 Amphibious Living

Currently living on water is niche in market and is not considered equivalent to house built on land by majority of population. But with a growing population that tends to migrate towards water and the gradual rise in sea level, urban areas must consider expanding new development on the water. Not only have water dwellings proven efficient in times of extreme flooding, but the cost of building and living in a water dwelling can be significantly less than a house built on land. In many other parts of world living on and near water already exists in many building typologies but in India still it is new concept. Amphibious structures is one of the best answer for global climate change in India where buildings won't always be in water but during flood condition it will start floating with increasing water level and come back to its original level as water resides.

Building on water is not a new method. People have lived on and next to water for centuries; building communities on floating reeds, elevating houses on piles, retrofitting boats to become residences and designing amphibious architecture have been used to adapt to water regions around the world. Now is the time for coastal regions to adapt to rising water levels by learning to live with water, not defend against it.

Fig. 1.4 Living in Amphibious Structure

1.4 INDIAN COASTAL REGIONS

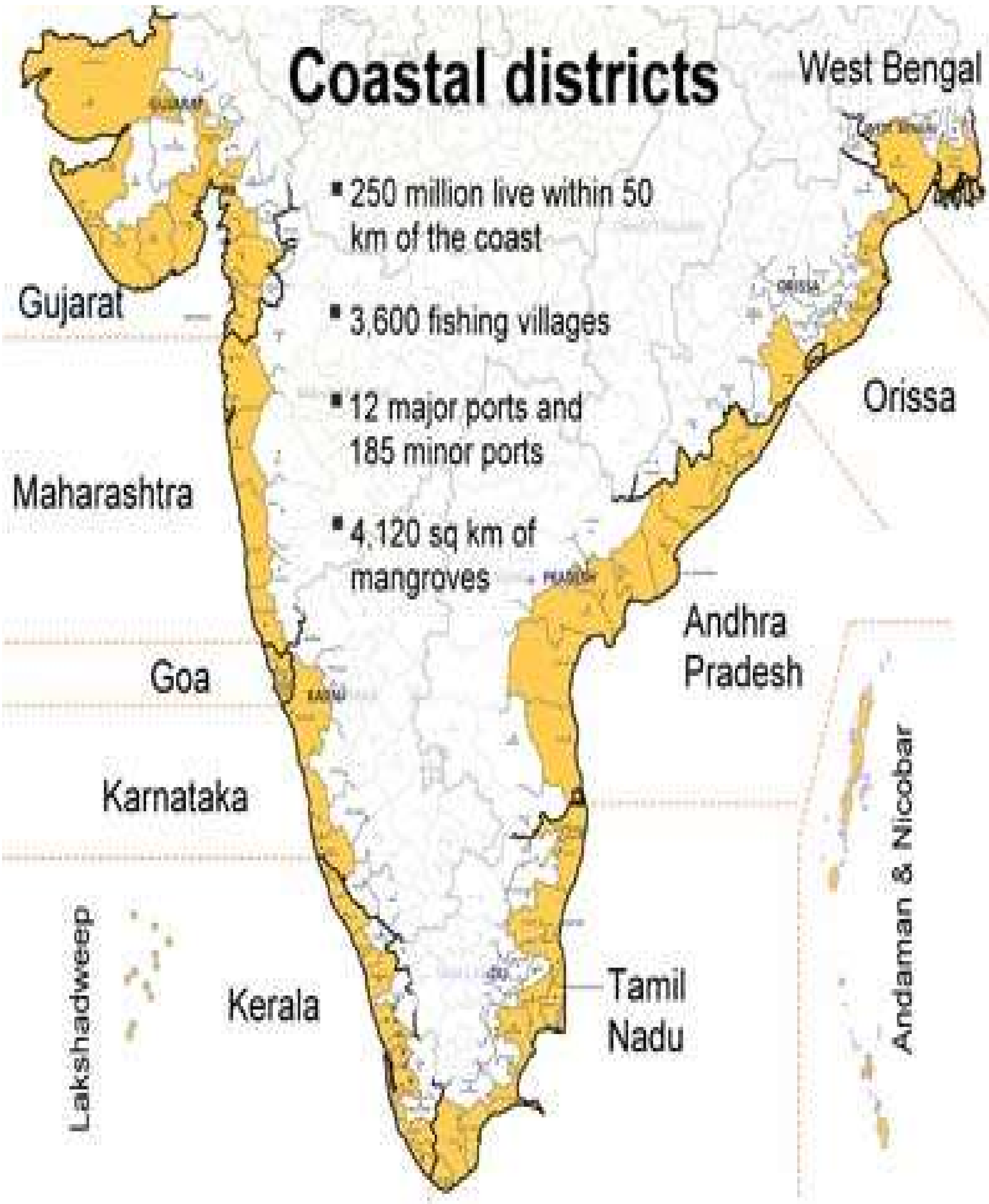


Fig. 1.5 Coastal Regions in India

1.4.1 History and Geography

The Union of India is the seventh largest country in the world covering an area of 32,87,590 square kilometers and it is an important country of south Asia. It is 4 times larger than Pakistan, India is 12 times largest that UK and 8 times largest than Japan. India has both positive and negative impacts on water. The Indo-Gangetic plains, also known as the Great Plains are large alluvial plains dominated by three main rivers the Indus, Ganges, and Brahmaputra. They run parallel to the Himalayas from Jammu and Kashmir in the west to Assam in the east, and drain most of northern and eastern India. The plains encompass an area of 700,000 km^2. Historically, water has been the primary mode of communication with the rest of the world. It has been the mode of transportation for importing and exporting goods. It is an essential lifeline of the country, an element without which India cannot survive. Water is an overpowering element in the landscape of the country. It erodes and shapes the land every season. River banks are devoured and washed away, and new land is created somewhere else. The homeless follow the path of the water in search of newly created river banks.

The monsoon rains wash the lands every year with great intensity. This is an expected event in the people's lives, and they prepare for its arrival. This cyclic nature of water has become an important part of life for every citizen. As a result of the monsoon season and the excess water from the river beds, the land is flooded every year. The farmers acknowledge this seasonal flooding and make accommodations for it in their farming practices. India comprises eight states and two island group along the coastline with approximate 7,500 km length. Nearly 25% of India's population residing along the coasts.

1.4.2 Flood Prone Areas in India

India, being a peninsular country and surrounded by the Arabian sea, Indian ocean and bay of Bengal, is quite prone to flood. As per the geological survey of India (GSI), the major flood prone areas of India cover almost 12.5% area of the country.

Every year, flood, the most common disaster in India causes immense loss to the countries property and lives.

The states falling within the periphery of "India Flood Prone Areas" are west Bengal, Orissa, Andhra Pradesh, Kerala, Assam, Bihar, Gujrat, Uttar Pradesh, Hariyana and Punjab.

The intense mansoon rains from south west causes rivers like Brahmaputra, Ganga, Yamuna etc to swell their banks, which in turn floods the adjacent areas.

Over the past few decades, a central india has become familiar with precipitation events like torrential rains and flash floods. The major flood prone areas in India are the river banks and deltas of Ravi, Yamuna-Sahibi, Gandak, Sutlej, Ganga, Ghaggar, Kosi, Teesta, Brahmaputra, Mahanadi, Mahanada, Damodar, Godavari, Mayurakshi, Sabarmati and their tributaries.

Fig. 1.6 Flood Prone Area

Table No. 1.1 An overview about state-wise flood prone areas

state-wise Flood Prone Areas	
State	**Area liable to Floods (million Ha.)**
Uttar Pradesh	7.336
Bihar	4.26
Punjab	3.7
Rajasthan	3.26
Assam	3.15
West Bengal	2.65
Haryana	2.35
Orissa	1.4
Andhra Pradesh	1.39
Gujarat	1.39
Kerala	0.87
Tamil Nadu	0.45
Tripura	0.33
Madhya Pradesh	0.26
Himachal Pradesh	0.23
Maharashtra	0.23
Jammu & Kashmir	0.08
Manipur	0.08
Delhi	0.05
Karnataka	0.02
Meghalaya	0.02
Pondichery	0.01
Total	33.516

CHAPTER TWO

LITERATURE REVIEW

2.1 REVIEW OF LITERATURE

1. “Floating Foundation in Geological Environment Prone to Sink Hole” Dr. Eduard Vorster, Technical Director (1987).

The Gautrain Rapid Rail Link is a state-of-the-art rapid rail network currently under construction in Gauteng, South Africa. The project comprises of a link between Pretoria, Johannesburg and the OR Tambo International airport with a total length of approximately 66km. The structure described in this paper will cross a dolomite area with a 3.1km long viaduct (v5c) south of Pretoria. The site is generally underlain by dolomitic ground with occasional syenite intrusions. The area is well known for the risk of sinkhole and do line (area settlement) formation due to the erodibility of the in situ soil, cavernous ground and bedrock conditions and potentially variable water table conditions (if left uncontrolled). Sinkholes and do lines may affect the rail services and may have catastrophic consequences if left untreated. The bedrock profile is highly undulating, sometimes with deep valleys or grykes between bedrock pinnacles.

2. “Very Laege Floating Structure Application, Analysis & Design” E. Wantanbe ,C.M. Wang, T. Utusonomiya &T. Moan (2004).

Very large floating structures (VLFS) have attracted the attention of architects, city planners, and engineers because they provide an exciting and environmentally friendly solution for land creation from the sea as opposed to the traditional land reclamation method. The applications of VLFS as floating piers, floating hotels, floating fuel storage facilities, floating stadia, floating bridges, floating airports, and even floating cities have triggered extensive research studies in the past two decades. The VLFS technology has developed considerably and there are many innovative methods proposed to minimize the hydroelastic motion, improve the mooring system and structural integrity of the VLFS. This keynote paper summarizes the applications, research and development of VLFS over the past two decades.

3. “Overview of Megafloat: Concept, Design Criteria, Analysis & Design”, Hideyuki Suzuki (2004)

This paper presents an overview of research and development on Megafloat, carried out by the Technological Research Association of Megafloat (TRAM) and other researchers. Megafloat is a type of very large floating structure (VLFS), pursued by TRAM, to develop technology for ocean space utilization and to show soundness of the technology and readiness for construction. On-site experiments with a 1000-m-long experimental model, as well as subsequent studies, are introduced.

4. “Floating Houses for Flood Plains”, Dura Vermeer (2006).

One solution to the housing crisis and the challenge of mitigating climate risk that is being put forward with increasing vigour is to allow houses to be built in areas deemed at risk from flooding at a far greater rate than is “You could build homes that go up and down [with rising and falling flood water levels] that mean you do not displace any water off the site. The Dutch are very good at this,” says Flood line technical director Faruk Pekbeken.

2.2 OBECTIVES

The goal of this study is to explore how important Amphibious Housing is to coastal and riverside areas.

1. How to overcome the difficulties with floods and rising sea water.
2. To discover whether Amphibious Housing is a suitable method for India.
3. To ensure the safety of life and protection from flood
4. Sustainable and affordable way of achieving Amphibious Architecture for India
5. To change our current understanding towards floating structures.
6. The proposal for this dissertation will provide sustainable structure for the people of India to create amphibious structures protected from flood.

CHAPTER THREE

METHODOLOGY

3.1 AMPHIBIOUS STRUCTURE

Amphibious Structure are characterized by the specificity of their buoyant foundation, which allows them to stay, fixed on the ground during regular circumstances and float up as high as necessary when the

water level rises. In order not to float away, amphibious structures are fixed in place with a system of vertical guidance posts. When the water level goes back to normal, the structure descends precisely back to its initial position without any damage. Amphibious architecture refers to an alternative flood mitigation strategy that allows an otherwise-ordinary structure to float on the surface of rising floodwater rather than succumb to inundation. An amphibious foundation retains a structure connection to the ground by resting firmly on the earth under usual circumstances, yet it allows a house to float as high as necessary when flooding occurs.

An amphibious house is a building that rests on the ground on fixed foundations but whenever a flood occurs, rises up in its dock and floats there buoyed by the floodwater.

The Amphibious House is a highly innovative approach to tackle extreme flooding. The 250 tonne house, which sits on the ground within a purpose made dock, is able to rise upto 2.7m when a flood occurs, bouyed by the flood water; whilst remaining connected to all utilities through flexible servicing.

3.1.1 Advantages

1. The cost of floating house is cheap than concrete one.

2. The major advantages of float house is that the resident can stay in home during flood.

3. It has low density but it gives high strength.

4. It will not break down so it will not spread into surrounding.

5. Use of low cost material and locally available material can improve the vernacular character of the place and also efficiency of the structure.

3.1.2 Disadvantages

1. This cannot be constructed as a multistoried as a multistoried building.

2. It is subjected to strong external loading due to wind, ice and other environmental condition.

3. There are restrictions to aesthetic view as there is limitations of size and shape of the house.

4. Height limitations are restricted to the mooring post heights.

3.2 MATERIAL ANALYSIS

Materials of the structure play the important role in the amphibious dwellings. Since the structure is near the water and salt water will cause the materials to corrode. Designer should take a special concentration on the selection of the material. By the above mentioned case studies few materials are discussed in this following chapter. Some of the materials are EPS blocks, pontoons, barges, GFRC coating, Concrete, Ferro cement, and Bamboo.

3.2.1 Eps Blocks

Expanded Polystyrene (EPS) or Extruded Polystyrene (XPS) is a Geofoam that is manufactured into a large lightweight blocks. The blocks varies in size but are mostly in 2m x 0.75m x 0.75m. These geofoam is a light weight void fill. It is used in many applications such as light weight fill, green roof fill, compressible inclusions, and thermal insulation and sometimes it is used in drainage also.

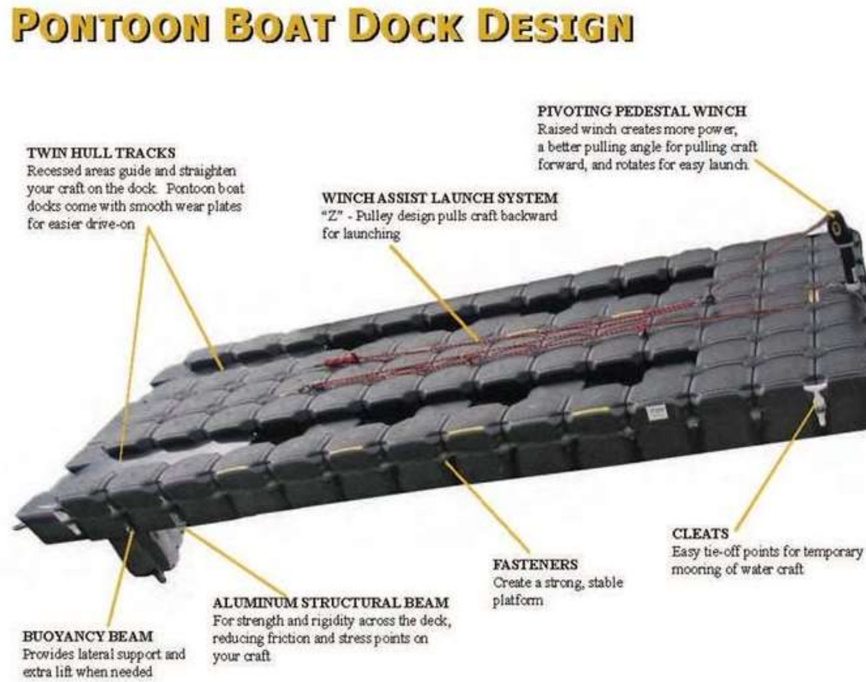
Fig. 3.1 EPS Block

It works on the principles with geocombs which has been defined as “any manufactured material crested by an extrusion process that results in a final product that consists of numerous open ended tubes that are glued, bonded, fused or bundled together.” The cross sectional geometry of an individual tube typically has a simple geometric shapes. The overall cross section of the assembled bundled tubes resembles a honeycomb that gives its name.

3.2.2 Pontoons

Pontoons are formed in Orsta Marina Systems in 2003 in Netherland is an authorized manufacturer of pontoons. It is a leading manufacturer and installer of pontoon equipped and floating breakwaters for leisure and commercial applications with more than 3000 completed projects. Pontoons is an air filled structure providing for buoyancy. Polystyrene is commonly used as the core material in floating docks and pontoons. It is cost effective has good floatation properties and is east to cut into custom pontoon profiles. Polystyrene can be used for both concrete and vinyl encasing of pontoons.

Fig. 3.2 Pontoons



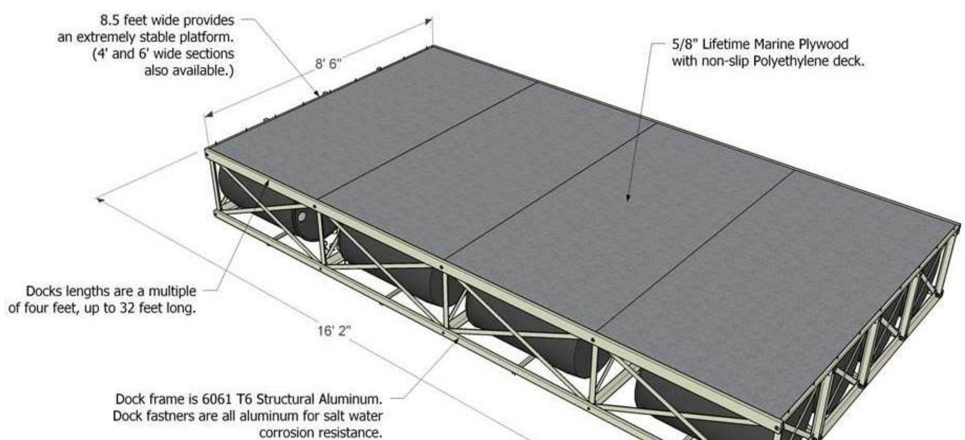


Fig. 3.3 Design of Pontoon Boat Dock

3.3 RAFTS AND PLATFORMS

The Amphibious house design is divided based on the type of its floating material platforms. In some countries, various materials have been developed for the footing of the floating house, including the following:

3.3.1 Styrofoam Platforms

Styrofoam is a material derived from polystyrene that in the process of manufacturing is using a mixture of air bubbles so that it can expand and has a light weight like foam. Platforms with Styrofoam materials used are styrofoams in the form of beams with a length of two meters, width one meter and a thickness of half a meter, for the number of it is based on the needs. The more spacious and heavy the building, the more the styrofoam needed.

Fig. 3.4 Amphibious House with Styrofoam Platforms

3.3.2 Bamboo Platforms

Bamboo is a material that has light specific weight and also cavity. Some people think that the cavity in the middle of bamboo as a weakness, but actually this is not true. Bamboo does have a cavity in it, but the central cavity on bamboo is actually a characteristic of bamboo power and serves as a bracer. The bracer can strengthen the bamboo and makes the elements commonly used as structures to be lighter and less rigid. A bamboo also has an elastic character and is not easily broken so that its structure becomes more powerful and reliable.

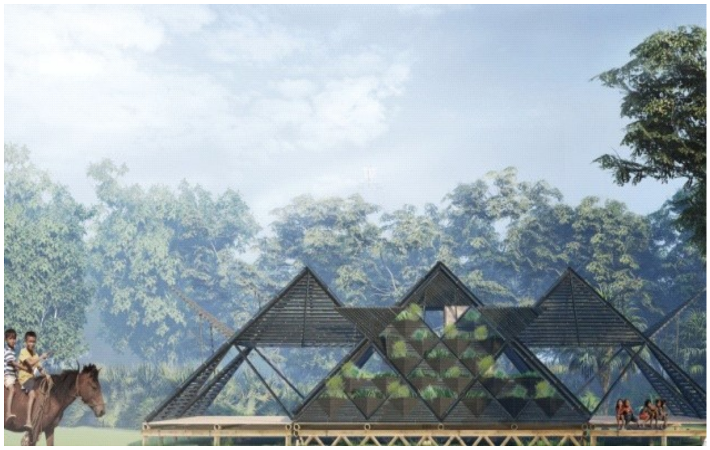


Fig. 3.5 Amphibious House with Bamboo Platforms

3.3.3 Barrel Platforms

The footing of the floating house design is a structure that is under the house serving to withstand the total load of the building to float the house. This floating house material is plastic barrels that have a good buoyancy, lightweight and easy to obtain as it is commonly available around us.

Fig. 3.6 Amphibious House with Barrel Platforms

3.3.4 PVC Pipes Platforms

Amphibious 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, so it becomes a whole structure (platform). PVC Pipe is a plastic material that has an air cavity in it so it can float on the water.

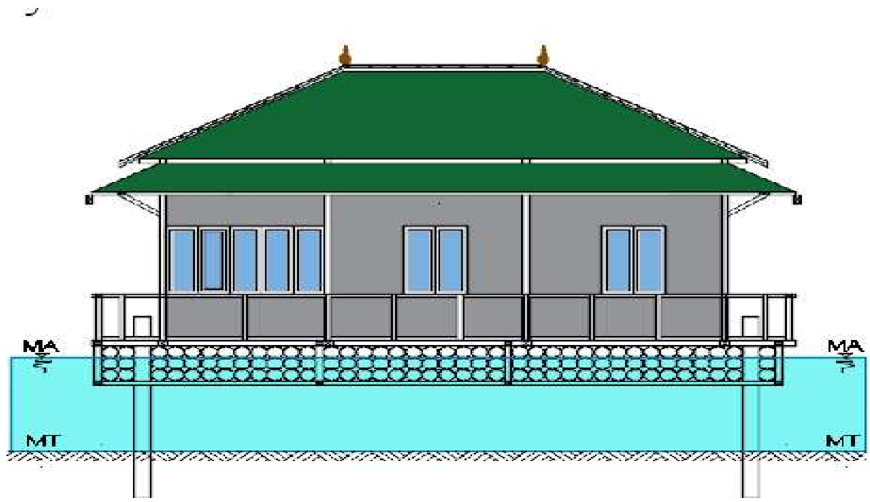


Fig. 3.7 Amphibious House with PVC Pipes Platforms

3.4 TEMPORARY MOORING FACILITIES

Floating pontoon will be designed, assembles and installed temporary mooring facility suitable for inland waterways or sea area wherever it is needed giving the right mooring and docking system for the boats that will be operating from it. The pontoons can be customized with access ramps, walkways, handrails, mooring cleats and fenders.

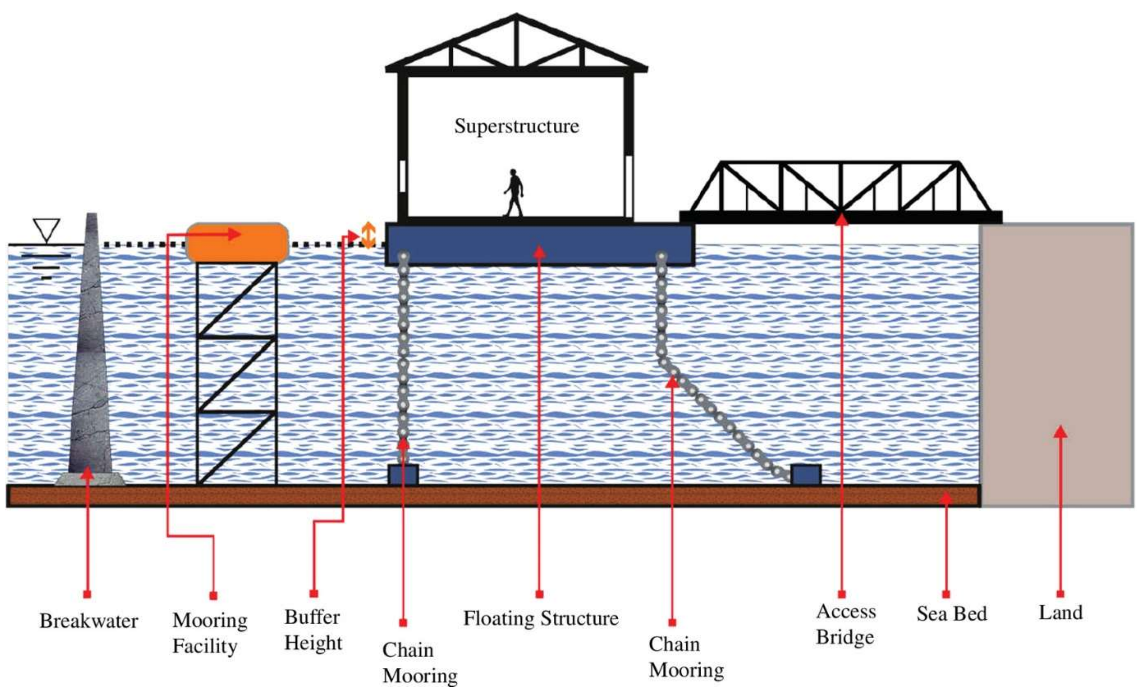


Fig. 3.8 Temporary Mooring Facility Suitable for Waterways

3.5 DESIGN OF AMPHIBIOUS STRUCTURE

There are certain criteria to be followed to design an amphibious house to be livable, functional and enjoyable. These house must be a valuable replacement for normal home. The home must be adaptable and flexible. This home should replace the existing home and as well as it should also able to float with the climate change. To make the float during flood condition and make it recedes carefully after the flood is a challenging process for the architects to design. In order to fulfill this role as a functioning and desirable amphibious home certain criteria has been identified: Capability to float, float line, buoyant foundation height calculation, Structure type and utility access.

Fig. 3.9 Amphibious Structure Design

3.5.1 Capability of Floating

The most critical design guidance factor which decide whether the home will actually will be able to float during flooding conditions. As seen in the previous examples with the supports of the mooring poles and the simple calculation of the buoyant foundation the house can make to float during flood. If the total weight of the entire home including the dead and live load of the house should be less than the volume of the water then the house can float. A water tight walls and floor should be taken into consideration so that the structure stands independently without any extra support. Light weight building materials should be used to make the building equivalent to the volume of the water.

Fig. 3.10 Floating House in Flood Condition

3.5.2 Foundation

Foundation is the important part of the structure to support the light weight structure and to float during flooding condition. Deep foundation are the structural component that transfer loads into deeper layer of earth material than a shallow foundation. Deep foundation includes pile foundation with driven pile, drilled shafts, and micro piles and grouted in place piles. Structure design engineers are responsible for calculating the pile design load and for providing other structural detail. With the site seismicity and the factored load the structural engineer should calculate and derive the foundation technique and material for the proposed site condition.

Fig. 3.11 Foundation of Structure

3.5.3 Structure Material

To make the structure float the selected material should be of light weight material. The foundation is made up of a strong concrete hull or of any other material and the structure above the foundation which will float should be made up of light weight material. These material should also be water proof material and should promote insulation and other passive heating and cooling technique to be sustainable structure. A future measure to reduce the weight of the building is developed by light weight wood framing doors and windows.

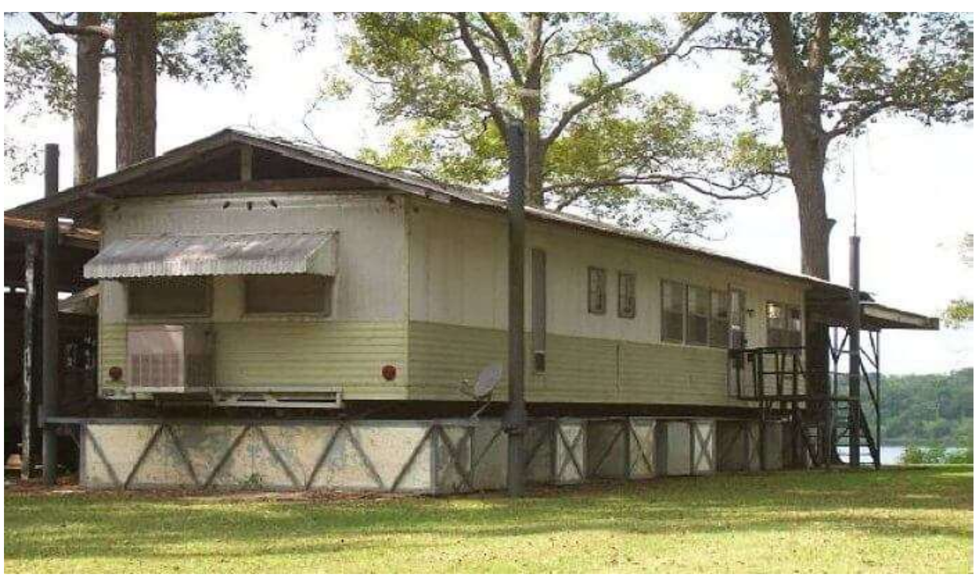


Fig. 3.12 Structure made of Light Weight Material

3.6 CONSTRUCTION OF AMPHIBIOUS HOUSE

The amphibious structures are under normal circumstances rest on concrete foundation and also starts floating when the water level rises and also during flooding. The advantage of these homes is that they are more or less like ordinary homes with parking space, a garden and access from road.

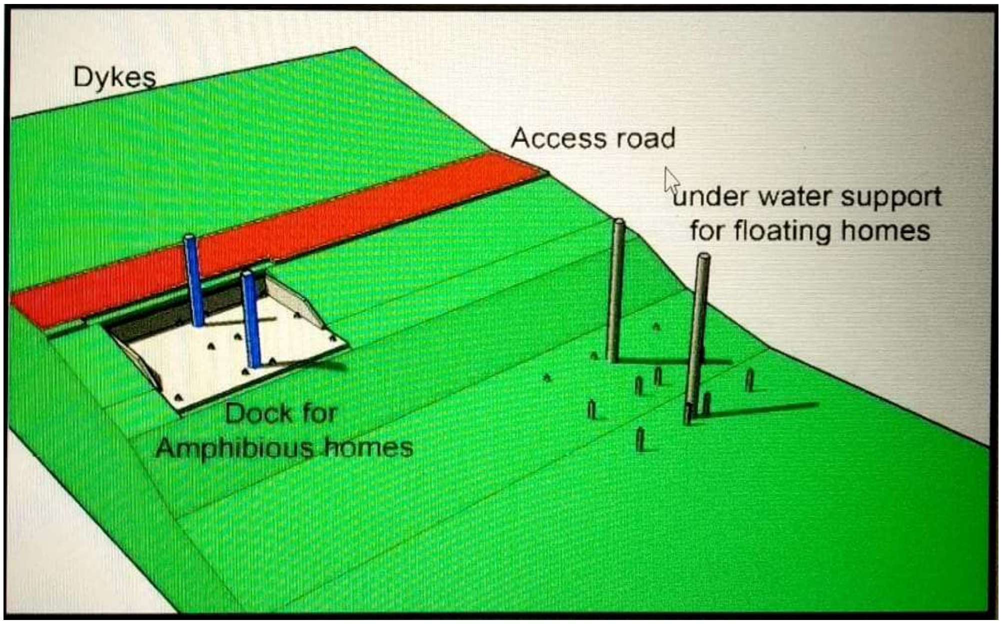


Fig. 3.13 Toposurface of Land

The inhabitant feel that the house is floating only during flood conditions. Two houses are kept in place by the support of two mooring poles. These steel columns are driven deep into the ground. Even in the extreme flood condition the structure will be in place and can withstand the current of flowing water with help of these steel column. These steel column are connected by steel framework. The houses connected also limits the waves on the structure. Two houses weights around 200 tons. As the water level rises the houses will rise along with the mooring poles. The amphibious will be lifted out of their docks, and that will be filled with water. A constant descent should be maintain after the flood, for that the docks should be maintain obstacle free at all time. If anything got struck underneath the house as the water withdraws, there will be problem in constant descent of the structure. The basis of structure of the house is to provide a light weight structure on top of concrete box. The basic timber structure was prefabricated and then assembled in the site. The roof was made up of steel and wood and then covered with PVC roofing in site and then lifted up to the structure. The house was designed based on the view of water. The arched roof lower towards the dyke side and rising towards the east, provide good view from living room and master bedroom looking towards towards the east, provide good view from living room and master bedroom looking towards the lakh.

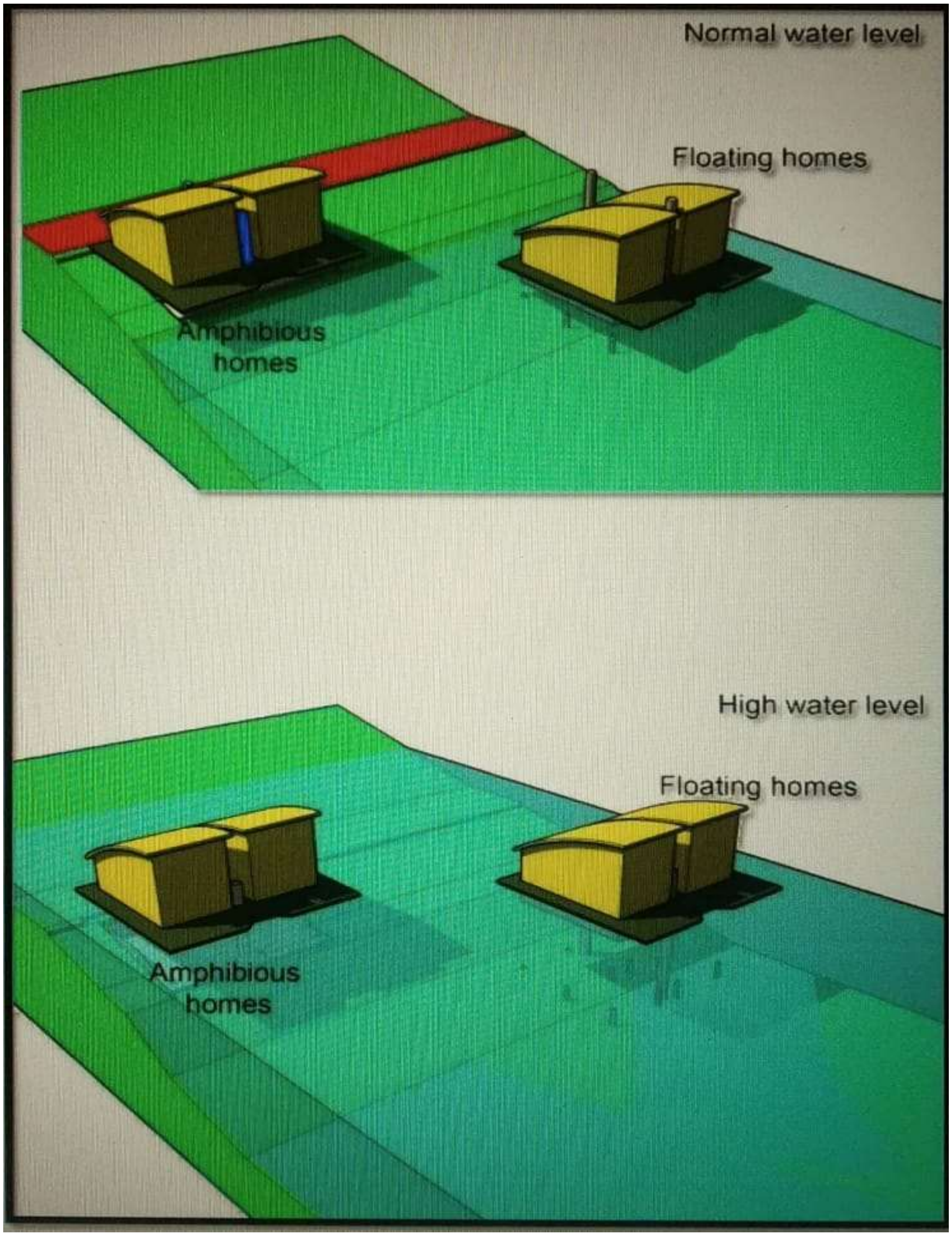


Fig. 3.14 View of Amphibious Homes in Different Water Levels

3.6.1 Services

The house gets all the facilities like other houses in Netherland. The house is heated by the central heating system with natural gas. It has connection with water, sewage, electricity and gases network like all other houses.

The only difference is the connection between the house and the pipeline on the land. Between each pair of houses there is a connection from the dock to sides of the houses. The length was this connection is oversized for normal condition but it will remain connected in the flooding condition. The flexible pipelines are made for both amphibious and floating houses.

Fig. 3.15 Flexible Pipeline Facility

3.7 WATER DWELLING

- Water dwellings can be categorized by their foundations and their relationship to the water.
- These dwellings include terp dwellings, static elevation, pile dwellings, amphibious dwellings and floating dwellings.
- Some types have been used for centuries while others are relatively new technique, such as the amphibious house, however each type has proven resilience in the event of rising water levels.

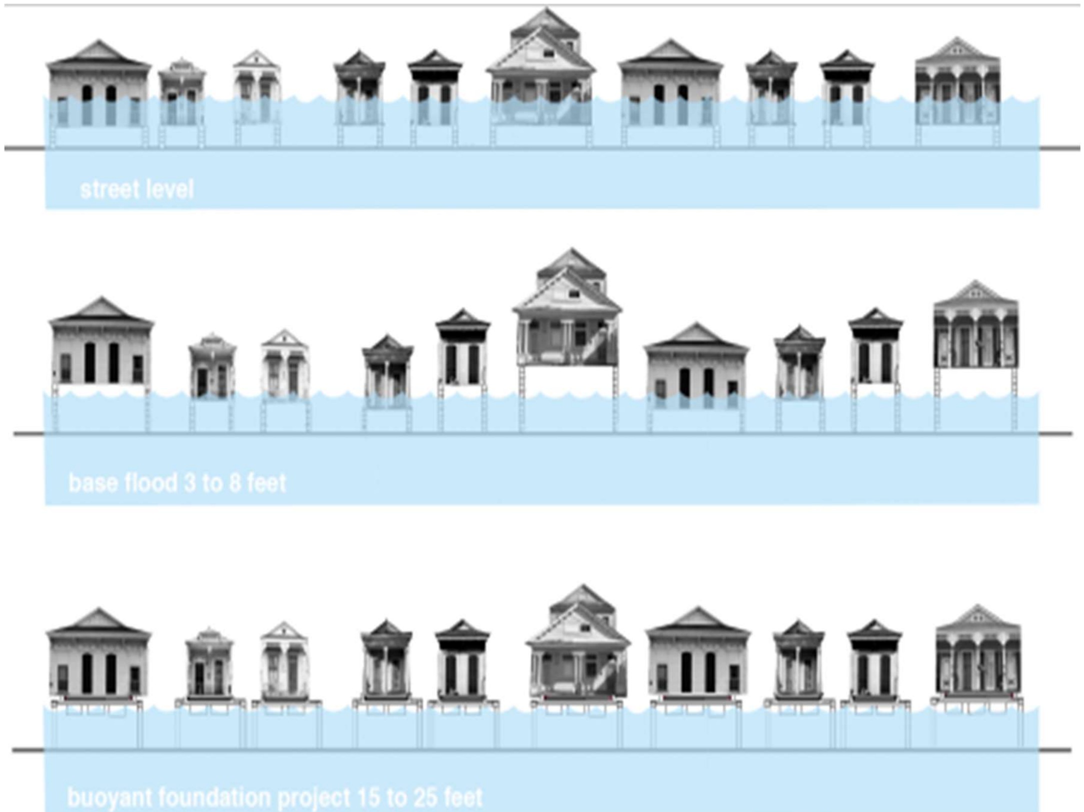


Fig. 3.16 Water Dwelling

3.7.1 Static Elevation

One of the most common retrofitting methods is elevating a house to a required or desired Base Flood Elevation (BFE).

- When a house is properly elevated, the living area will be above all but the most severe floods.
- Several elevation techniques are available.
- In general, they involve

(1) Lifting the house and building a new, or extending the existing, foundation below it.

OR

(2) Leaving the house in place and either building an elevated floor within the house or adding a new upper story.

Fig. 3.17 Static Dwelling

3.7.2 Pile Dwelling

Pile dwellings are a type of housing built on top of concrete, steel or wooden poles and can be found in shallow water, coastal areas, or lakes where changes in the water level can be predicted. This type of dwelling typically rests 8-15 feet from the ground and has been used throughout the world as means of protection from water. In Indonesia, Singapore, and other countries these housing are called as "kelong" which are built for fishing.

Fig. 3.18 Timber Pile Dwelling

Timber pilings have been used for 6,000 years and continue to be one of the leading types of driven piles. Timber is often used in pile foundations because it is a readily available and renewable resource. Because it is light in weight, timber is also more easily handled, driven and cut than other types of piles. According to the Federal Highway Administration, timber pile foundation underwater will last indefinitely and timber piles partially above water can last up to 100 years or longer if they are properly prepared and treated.

Concrete piles can be pre-cast or cast-in-place, and they can be reinforced, prestressed or plain. They do not corrode like steel piles or decay like wood piles. concrete is more readily available than steel. Pre-cast concrete piles are shaped and molded

according to shape, length and size prior to being driven into the ground. Cast-in-place piles are poured into holes in the ground where a rod has been previously driven and removed.

Fig. 3.19 Concrete Pile Dwelling

Steel pilings can be formed into many different shapes but the most common steel pile types have rolled circular, X-shaped or H-shaped cross sections. They are very strong and are great for driving especially in firm soil and can be easily cut off and can also be easily joined by welding. Although steel pilings can last up to 100 years, they are prone to corrosion, especially when submerged in water.

3.7.3 House Boats

Houseboats began with the conversion of ships and fishing vessels into livable environments. These types of houses resemble a land based property in its design and construction yet are buoyant enough to withstand the forces of water. The dwellings have been a part of American history since the early 1900s where the earliest houseboats in Seattle were recorded in 1905, and peaked with over 2,000 houseboats in the 1930s. During the 1940s, World War II brought much activity to the shores of California as shipbuilders and factory workers were transported to San Francisco. The need for housing brought many workers to transform old fishing boats and decommissioned war surplus into residential dwellings in Sausalito Bay.

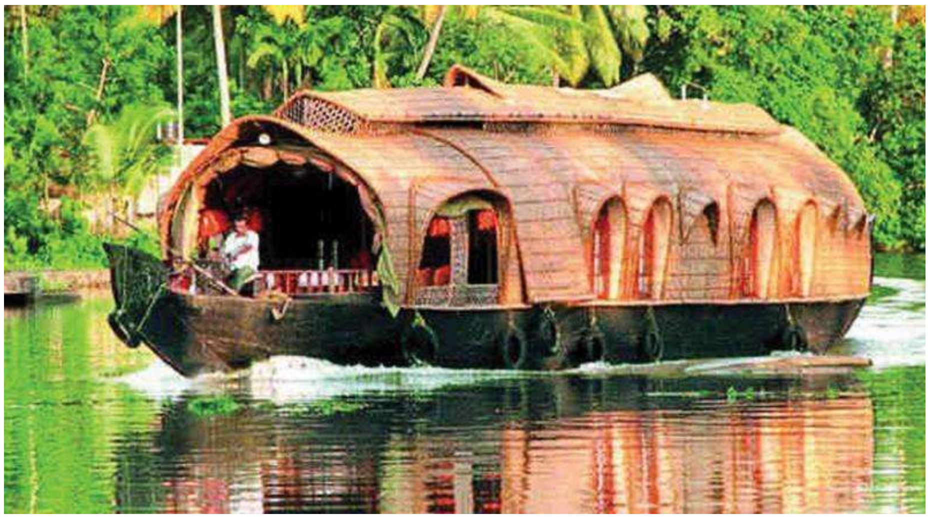


Fig. 3.20 House Boats

3.7.4 Amphibious Dwelling

Amphibious housing is a dwelling type that sits on land but is capable of floating. During a sudden rise in water a house will be lifted by the water provided either by pontoons or a hollow basement in order to ensure it remains dry and will then return to the ground as the water recedes. By sliding along two vertical mooring poles that are driven deep into the ground the houses are capable of rising vertically while restricting horizontal movements on the water. Amphibious housing is a dwelling type that sits on land but is capable of floating

During a sudden rise in water a house will be lifted by the water provided either by pontoons or a hollow basement in order to ensure it remains dry and will then return to the ground as the water recedes. By sliding along two vertical mooring poles that are driven deep into the ground the houses are capable of rising vertically while restricting horizontal movements on the water.

Fig. 3.21 Amphibiation Provides Flood Protection

Although the amphibious house resembles a houseboat there are some essential differences between the two types. The hollow basement of an amphibious house is exposed when there is no water forcing designers to conceal the base in the ground or in water. The second difference is the distribution of forces in the base. When the property is sitting on land it lacks the even upward force of the water which it experiences when it floats making the basement larger than that of the barge of a houseboat. The biggest difference between houseboats and amphibious homes is their connection to land. Typically amphibious homes are designed where water levels are moderate but are rarely prone to extreme flooding therefore all utility services can be connected to the municipal pipes whereas houseboats must contain all utilities within the structure. Examples of these houses can be found throughout the Netherlands most notably the Maasbommel water dwelling situated along the River Maas.

Fig. 3.22 Amphibious Dwelling

3.7.5 Terp Dwelling

A terp is an artificial earthwork mound created to provide safe ground in the event of a rise in water levels. The first terps were built in the Netherlands during 500 B.C where tides from the nearby rivers affected daily routines. The terps were built up to 15 meters high and was intended to keep a house dry and provide enough space for cattle and food storage. Around 1000 A.D the inhabitants began to connect these mounds to prevent the sea from flooding their lands, commencing the formation of a permanent dyke system. The terp dwelling is connected to the land and remains dry until a maximum water level has been reached.

Fig. 3.23 Terp Dwelling

3.8 ADVANTAGES AND DISADVANTAGES OF BUILDING TYPES

Table No. 3.1 Advantages and Disadvantages of Building Types

Building Type	Advantage	Disadvantage
Terp dwelling	1. Can be used for large plots of land	1. Difficult access to living areas 2. House can still be flooded due to height limitations 3, Residents cannot leave house when flooding occurs
Static elevation	1.Elevates house to required base flood elevation level 2. Preserves original architecture winds 3.Capable of high density houses	1.Difficult access to living areas 2.Increased vulnerability to 3.House can still be flooded due to height houses limitations
Pile dwelling	1.A solution when there is a lack of construction ground 2.Capable of high density limitations houses	1.House can still be flooded due to height limitations 2.Increased corrosion due to its submergence in water
House boats	1.A solution when there is a lack of construction ground 2.Capable of mobility 3.No height restrictions allow the house to rise and high as any water level	1.It is subject to stronger external loadings due to wind, rain and ice 2.Increased corrosion due to its submergence in water 3.House must be loaded Symmetrically to maintain even levelling
Amphibious dwelling	1. A solution when there is a lack of construction ground under normal conditions but will rise when flood occurs.	1.It is subjected to stronger external loading due to wind rain and ice.

	2.house remain on the ground under normal conditions but will rise when flooding occurs. 3.utilizes municipal pipes and electrical connection. 4.capable of high density houses 5.minimized carbon footprint	2. structure must be loaded symmetrically to maintain even levelling. 3. height limitations are restricted to the mooring post height.

3.9 IMPORTANCE OF WATER DWELLING STRUCTURE

Although there are many types of strategies to defend against rising sea levels amphibious buildings are a proven flood protection strategy that gives a community defence against and improves its ability to recover from disaster. When flooding occurs, the house vertically rises with the water levels to remain safely above water then settles back into place as the water recedes. In addition comfort is achieved because all buildings will have the same facilities as a building on land, including heating, cooling and ventilation and utilizes the same municipal pipes and electrical connections. The buildings and places that we create in the next ten years will form the backbone of an amphibious lifestyle for the next five decades and beyond. In order to prepare for the future, designers and builders must not look at the limitations of water but at the opportunities it presents.

Fig. 3.24 Water Dwelling Structure

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 STRUCTURE WEIGHT CALCULATIONS

4.1.1 Considerable Incoming Loads on Structure

a) The total weight of family members = 235 kg
4 members (60kg, 50kg, 55kg, 65kg)

b) Weight of food (one month) = 250 kg

c) Weight of seed of different crops = 200 kg

d) Self weight of the structure = 900 kg

e) Weight of stored drinking water = 80 kg

f) Weight of the utensils, clothes and others = 200 kg

Total incoming loads = 1810 kg

4.1.2 Calculations and Considerations of Weight of Structure

- Floor wt. (live load + dead load) = 3+3 = 6 KN/m^2
- Ceiling wt. (live load + dead load) = 1.5 KN/m^2
- Wall (dead load) = 0.4 KN/m^2
- Area = 6m x 8m = 48m^2
- Floor = 48 x 6 = 274 KN
- Ceiling = 48 x 1.5 = 68 KN
- Total= 274 + 68 = 342 KN

A) Weight of structure using Ferrocement:

- Size Wall weight of Ferrocement = 3m (height) x 0.2m (thickness) x 1m (unit length)

  = 0.6 m^3

- Density of Ferrocement = 1332.09 to 1457.89 kg/m^3

  = 13.3209 to 14.5789 KN/m^3

  = 0.6 x 14.5789

  = 8.7473 KN

  8.747 KN x 160 m = 1399 KN ----- (since 160m is the total length of wall)

- Total load = 274 KN + 68 KN + 1399 KN

  = 1741 KN = 174100 kg

B) Weight of Structure Using Eps Blocks:

- Size of EPS blocks = 48″ x 48″ x 96″

  = 1.22 m x 1.22 m x 2.44 m

  = 3.66 m^3

- Density of EPS blocks = 24 kg/m^3

  = 24 x 3.66

  = 87.84 KN

- Total load = 87.84 + 174100 = 174187.84 KN

4.1.3 Total Weight of The Structure

Based on the calculation result of considerable incoming loads and self weight of structure including Ferrocement and EPS blocks of the floating house design, it can be obtained that the total weight in the floating house is as follows: = Total incoming loads + Total weight of structure = 1810 kg + 174187.84 kg = 175998 kg (downward direction)

4.2 NUMBER OF FLOATING MATERIALS CALCULATION FOR STRUCTURE

Based on the calculation results, we know that

- Area of structure = 6m x 8m = 48 m^2
- Total load of structure (TL) = 175998 kg
- Safety Factor = 1.5 ------ (consider)

4.2.1 Number of Plastic Barrels Required for Amphibious Structure

A) Calculate weight of empty plastic barrels:

Weight of plastic barrel (G) = 8.6 kg/pcs

Diameter of plastic barrel = 0.58 m

Height/ length of plastic barrel = 0.93 m

B) Calculate Buoyancy of fully submerged plastic barrels:

Buoyancy of plastic barrel = $\pi/4 \times d^2 \times \rho \times g \times h$

= $\pi/4 \times 0.58^2 \times 1000 \times 10 \times 0.93$

= 2457 kg/pcs

So the total buoyancy of 1 plastic Barrel (F-G) = 2457 – 8.6

= 2448.4 kg/pcs

= 2449 kg/pcs (upward direction)

C) Calculate total floating force of plastic barrel:

Where,

TF = Total floating force

TL = Total load of structure

SF = Safety factor (Assume 1.5)

TF/TL = SF

TF = SF x TL

= 1.5 x 175998

TF = 263997 kg

D) No. of Barrels = TF/ Total buoyancy of 1 plastic barrel

= 263997/2449

= 107.79 Nos.

= 108 Nos.

Hence, no. of plastic barrels required for amphibious structure are 108 Nos.

4.2.2 No. Of Bamboo Required For Amphibious Structure

A) Calculate weight of Bamboo:

Weight of bamboo (G) = 12 kg/pcs

Diameter of bamboo = 0.10m

Height/ length of bamboo = 6m

B) Calculate Buoyancy of fully submerged bamboo:

Buoyancy of bamboo $= \pi/4 \times d^2 \times \rho \times g \times h$

$= \pi/4 \times 0.10^2 \times 1000 \times 10 \times 6$

= 471.23 kg/pcs

= 472 kg/pcs

So the total buoyancy of 1 bamboo (F-G) = 472 – 12

= 460 kg/pcs (upward direction)

C) Calculate total floating force of bamboo:

Where,

TF = Total floating force

TL = Total load of structure

SF = Safety factor (Assume 1.5)

TF/TL = SF

TF = SF x TL

= 1.5 x 175998

TF = 263997kg

D) No. of Bamboo = TF/ Total buoyancy of 1 Bamboo

= 263997/460

= 573.90 Nos.

= 574 Nos.

Hence no. of bamboo required for amphibious structure are 574 Nos.

4.2.3 No. Of Polyvinyl Chloride (PVC) Required for Amphibious Structure

A) Calculate weight of empty PVC pipe:

Weight of PVC pipe (G) = 35.46 kg/pcs

Diameter of PVC pipe = 0.15m

Height/ length of PVC pipe = 6m

B) Calculate Buoyancy of fully submerged PVC pipes:

Buoyancy of PVC Pipe $= \pi/4 \times d^2 \times \rho \times g \times h$

$= \pi/4 \times 0.15^2 \times 1000 \times 10 \times 6$

= 1061 kg/pcs

So the total buoyancy of 1 PVC pipe (F-G) = 1061 – 35.46

= 1025.54 kg/pcs

= 1026 kg/pcs (upward direction)

C) Calculate total floating force of PVC pipe:

Where,

TF = Total floating force

TL = Total load of structure

SF = Safety factor (Assume 1.5)

TF/TL = SF

TF = SF x TL

= 1.5 x 175998

TF = 263997 kg

D) No. of PVC pipes = TF/ Total buoyancy of 1 PVC pipe

= 263997/1027

= 257.30 Nos.

= 258 Nos.

Hence, no. of PVC pipes required for Amphibious structure are 258 Nos.

4.3 ESTIMATION OF STRUCTURE WITHOUT FLOATING MATERIALS

Table No. 4.1 Estimation of Structure

Sr. No	Materials	Quantity	Rate	Price (Total)
1	Fencing			
	a. Bamboo pillar	3 pcs	167.67/pcs	503/-
	b. Bamboo wire	6pcs	170/pcs	1020/-
	c. Bamboo mat	6 nos	250/mat	1500/-
	d. Timber	1.5 cft	1800/cft	2700/-
	For 2 doors			
	For 2 windows			
	e. Nails	3kg	75/kg	225/-
	f. G.I wires	2kg	80/kg	160/-
2	Roofing			
	a. Wood Frame & Rafter	2.5 cft	1800/cft	4500/-
	b. Bamboo purlin	3pcs	75/pcs	225/-
	c. Screw	1.5kg	320/kg	480/-
	d. CI sheet	1.2/ft	4000/ft	4800/-
3	a. Ceiling	1no. (12′x10″)	250/mat	250/-
	b. GI wire	1.5kg	80/kg	120/-
4	Flooring			
	a. Wooden Frame	2.3cft	2250/cft	5175/-
	b. Bottom Frame of bottom mat	3pcs	120/mat	360/-
	c. Bamboo mat	1no. (12′x10″)	250/mat	250/-
	d. Nails	3kg	75/kg	225/-
	e. GI wire	1kg	80/kg	80/-

5	Foundation			
	a. Wooden Poles for coastal pile foundation	65pcs	150/pcs	9750/-
	b. Installation charges			19000/-
6	Walls			
	a. Internal walls (plywood)	45.93m^2	92/m^2	4225.56/-
	b. External walls			
	Ferrocement	33.51m^2	250/m^2	8377.5/-
	EPS blocks	33.51m^2	300/m^2	10053/-
7	Labour Cost			
	a. Rough Carpenter	2nos/ 4months	11200/month	89600/-
	b. Joister	2nos/ 2months	6000/month	24000/-
	c. Trim carpentry	1nos/ 2months	9000/month	18000/-
	d. Framer	2nos/ 3months	10000/month	60000/-
	e. Roofer	2nos/ 2months	9000/month	36000/-
	f. Head mason	1nos/ 78days	800/month	62400/-
	g. Mason	2nos/ 78days	600/month	93600/-
	h. Helper	3nos/ 78days	400/month	93600/-
		Estimated cost		**551100/-**

- Work charged establishment = 3% = 16533 /-
- Contingencies = 5% = 27550 /-
- Tools and Plants = 1% = 5511 /-
- Water charges = 1% of (551100 + 5511) = 5567 /-
- Contractors Profit = 10% of (551100 + 5511 + 5567)
  = 56218 /-
- **Total Estimated Cost =** 551100 + 16533 + 27550 + 5511 + 5567 + 56218
  = 662479 /-

4.4 ESTIMATION OF STRUCTURE WITH FLOATING MATERIALS

4.4.1 Estimation of Plastic barrel as floating material

- Rate per piece = 800/piece
- No. of Barrels = 108 nos.
- ∴ Price of plastic Barrels = 800 x 108 = 86400 /-
- Total Estimated cost = 86400 + 551100 = 637500 /-
- Work charged establishment = 3% = 19125 /-
- Contingencies = 5% = 31875 /-
- Tools and Plants = 1% = 6375 /-
- Water charges = 1% of (637500 + 6375)
  = 6438.75 /-
- Contractors Profit = 10% of (637500 + 6375 + 6438.75)
  = 65031.37 /-
- **Total Estimated Cost** = 637500 + 19125 + 31875 + 6375 + 6438.75 + 65031.37

  = 766346 /-

4.4.2 Estimation of Bamboo as Floating Material

- Rate per piece = 110/piece
- No. of Bamboo = 574 nos.
- ∴ Price of plastic Barrels = 110 x 574 = 63140 /-
- Total Estimated cost = 63140 + 551100 = 614240 /-
- Work charged establishment = 3% = 18427.2 /-
- Contingencies = 5% = 30712 /-
- Tools and Plants = 1% = 6142.4 /-
- Water charges = 1% of (614240 + 6142.4)
  = 6203.82 /-
- Contractors Profit = 10% of (614240 + 6142.4 + 6203.82)
  = 62658.62 /-
- **Total Estimated Cost** = 614240 + 18427.2 + 30712 + 6142.4 + 6203.82 + 62658.62

  = 738385 /-

4.4.3 Estimation of Polyvinyl Chloride (PVC) Pipe as Floating Material

- Rate per piece = 170/piece
- No. of PVC pipes = 258 nos.
- Price of PVC pipe = 170 x 258 = 43860 /-
- Total Estimated cost = 43860 + 551100 = 594960 /-
- Work charged establishment = 3% = 17848.8 /-
- Contingencies = 5% = 29748 /-
- Tools and Plants = 1% = 5949.6/-
- Water charges = 1% of (594960 + 5949.6)
  = 6009.09 /-
- Contractors Profit = 10% of (594960 + 5949.6 + 6009.09)
  = 60691.87 /-
- **Total Estimated Cost =** 594960 + 17848.8 + 29748 + 5949.6 + 6009.09 + 60691.87

  = 715208 /-

4.5 ESTIMATION OF LOAD BEARING STRUCTURE

- Centre line length of long wall = ((0.23/2 + 3 + 0.23/2) x 3) + ((0.23/2 + 3 + 0.23/2) x (1) + ((0.23/2 + 3 + 0.23/2) x 1)

  = 19.38 + 3.23 + 3.23

  = 25.84m
- Centre line length of short wall = ((0.23/2 + 3 + 0.23 + 2 + 0.23 + 0.23/2) x 3)

  = 23.97m
- Total centre line length = 25.84 + 23.94

  = 49.81m

Table No. 4.1 Comparison of Cost

	Amphibious House	RCC Framed structure	Load Bearing structure
Material cost & Labour cost	6,37,500 /-	87,01,316 /-	6,23,834 /-
Total Estimated cost	For 1) Plastic barrel = 7,66,346 /- 2) Bamboo = 7,38,385 /- 3) Polyvinyl chloride (PVC Pipe) = 7,15,208 /-	15,68,422 /-	12,69,940 /-

CHAPTER FIVE

CONCLUSION

5.1 CONCLUSION

1. The estimated cost of amphibious house is low compared to RCC & Load bearing structure.

2. The material used in foundation base should be appropriate, economic and locally available.

3. The costing of amphibious house in the comparison of all the floating materials used is similar which is around 7 lacks.

4. The total estimated cost of RCC structure calculated is 15,68,422 /- which is more than estimated cost of Load bearing structure calculated as 12,69,940 /-

5.2 FUTURE SCOPE

1. Amphibious House involves increasing the number of storey of the infrastructure, also making the necessary arrangements for the parking management of vehicles that are being used by individuals.
2. The concept has been deployed for the house and some infrastructures at limitations, but we look forward to deploy it to large scale infrastructures like Warehouses, Multi-storey Buildings, Hospitals, Industrial enterprises.
3. The concept can also be elongated into green house that can be having electricity while staying afloat, also being able to use other essential requirements.
4. Also the material used for the construction of the building of architecture can be more lightweight. So that the load balancing becomes easy.

CHAPTER SIX

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