Floating Structure

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***Abstract*—** *The rising population of India has led to the unmanageable use of land which ultimately leads to the destruction of our environment. Population is on the rise with each day passing and it is becoming a huge concern for the world. As per latest data (2017), population has already crossed 753.04 crores in the world. This paper presents the study concerning floating buildings to counter the ill effects of growing population in terms of energy efficiency performance and improving awareness to build them.*

***Keywords*— Floating Structure, Energy Efficiency, Global Warming, Urbanisation, Concrete Pontoon**

I. INTRODUCTION

Rapid population growth has already made the situation vulnerable to the negative consequences of climate change. Global warming has already affected many parts of the world and is still affecting the untouched parts of the world. Global warming makes the water level and when the sea rises, the water covers many low land islands. This project focuses on the design and construction of integrated habitable floating structure for fluctuating water level, an alternative to the land structure. The development of integrated floating structure system is a new idea and approach at present. The selection of the materials with consideration of density and strength will determine the practicality of this construction technology.

II. PREVIOUS AND NEW GENERATION TECHNOLOGIES

During the Cholas period for their invasion across rivers, they made use of trained elephants that swim on the surface, over which they transported all elements of battle by laying planks over elephants.

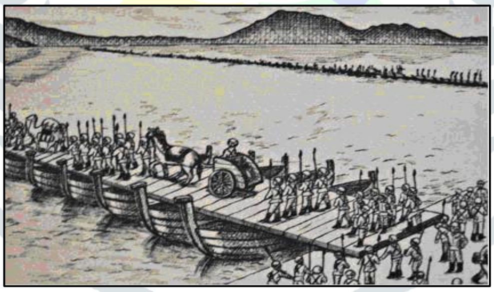

Fig. 1: Old Floating Bridge

The techniques evolved over the last 30+ years are based on a reinforced concrete shell with a core of expanded polystyrene. Large floating pontoons or docks are built in one piece, unharmed or undamaged where launching and transportation is practical. In other cases a large floating pontoons or docks can be built in components and assembled as a single piece close to its desired location. Marinas which is a specially designed harbour with moorings and walkways are joined using a patented proprietary connector which allows movement between sections.

In general, there are two types of floating mechanism which are floating on the water and floating on the air. For this project, the investigation will be done on the fundamentals of floating mechanism for the structure to float on water. In human technology, we tend to design various types of floating structure to fulfill our needs either for transportation or living.

Concrete pontoons stand out in contradistinction to other pontoons for its firmness and imperishability. The concrete pontoons are filled with foam plastic which is then covered from all sides with concrete. The pontoons made up of concrete are designed to last for 40-50 years when compared with the pontoons which are lighter in weight and are made up of wood, for its functioning in harsh environmental conditions. The pontoons constructed from concrete and Styrofoam achieves a high degree of buoyancy along with high degree of stability thus making it practically unsinkable. The constructed pontoon structure has negligible effect on the built environment as well as on the aquatic life and has low to zero maintenance.

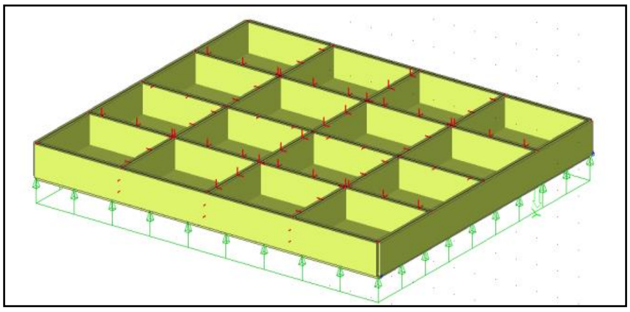

Fig. 2: Pontoon

The most important thing for a floating structure is the weight of the construction. The buoyant force or lift capacity of the pontoon must be one-third higher than the weight of the structure above it for the stability of the entire structure. This weight must also include the self-weight of the pontoon. The structure constructed above the pontoon is almost half the weight of the pontoon.

Fig. 3: Floating Pontoon

Floating structures are linked up to the shore line so that fresh water can be brought straight into the house and sewage can be pumped back into town lines.

Floating structure design has slowly developed through the years, however it has only been recently that designs have become more environmentally aware and have begun to challenge the boundaries. This is mainly due to increasing concerns of the changing environmental conditions. With proper designs the floating structures can be situated far away from the shores so that it can rise and fall during high and low tides and is connected either to the shore or to the seabed so that it does not get carried away during the times of flood.

III. SUPERSTRUCTURE

The superstructure is 4m in height. Loads on the slabs are transmitted through the steel columns to the bottom floating compartment slab. Figure 4 shows the floating structure model. Analysis in Staad.pro v8i structural analysis software has been carried out and the maximum bending moment for the superstructure slab and beams and maximum axial force for the columns.

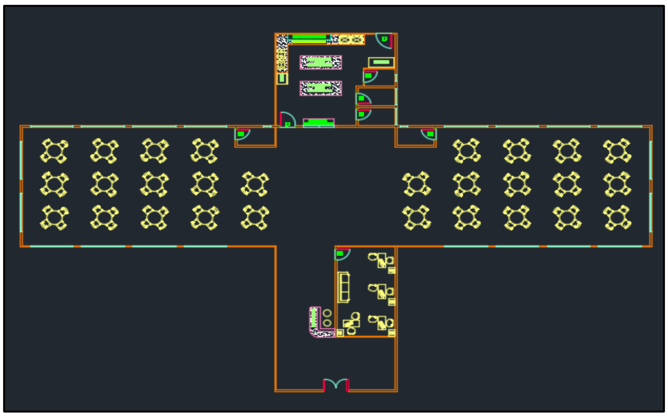

Fig. 4: Architectural Plan

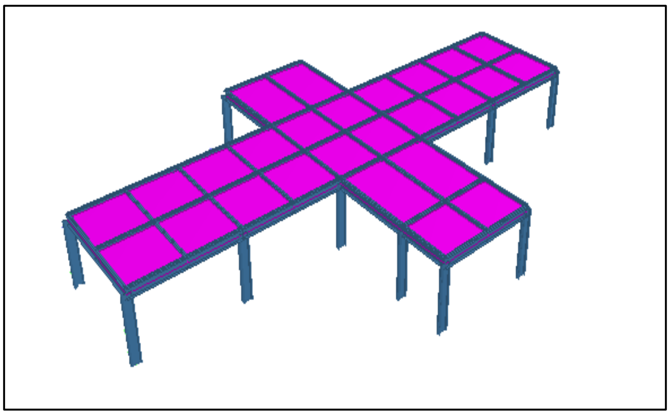

Fig. 5: Floating Structure Model

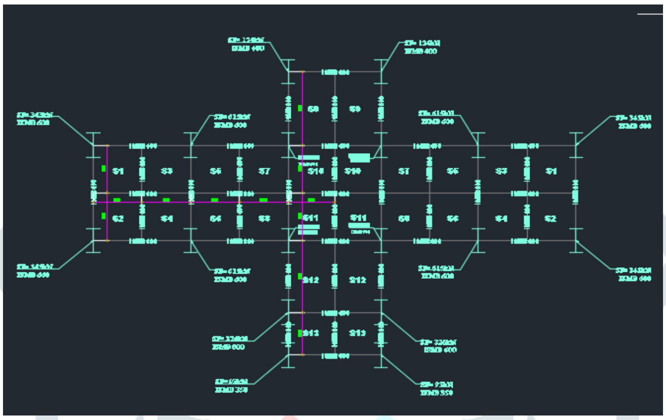

Fig. 6: Structural Plan

The Floating Structure in figure 4 has been designed using the combination of steel sections and reinforced concrete alone. The grade of concrete chosen is M25 and reinforcing steel is Fe415, for slab and ISMB sections for beams and columns. 10mm Φ bars with an effective cover of 25mm has been chosen for the reinforcement detailing in slab. The thickness of the slab of superstructure is 125mm.

- Maximum Bending Moment for slab = 12.65 kN-m
- Maximum Shear Force for Slab = 23.35 kN

The floating structure transmits a load of 4676 kN to the floating base or pontoon below.

IV. FLOATING COMPARTMENT

The floating compartment or pontoon consists of 34 nos. of slabs supported on all four sides. The entire size of the pontoon is 60m x 45m x 8.475m. The dimension of the pontoon's top slab is 60m x 45m x 0.775m while that of bottom slab is 60m x 45m x 0.70m. The thickness of shear wall is 300mm and is 7m high. The grade of concrete chosen is M40 and reinforcing steel is Fe415. The thickness of the top slab has been determined by the embedment of steel columns in the concrete of pontoon's top slab. The depth of embedment in the concrete has been determined by using the Pocket Base approach. The approach uses Working Stress Method or W.S.M. The depth of embedment is found to be 744.92mm. Thus, providing an overall depth of 775mm of pontoon's top slab. The safe axial load carrying capacity at this depth is 709.21 kN which is far greater than the axial load of 615 kN of the column section. The maximum shear force and bending moment values for pontoon's top slab is as follows:

- Maximum Bending Moment = 773.88 kN-m
- Maximum Shear Force = 454.51 kN

The concrete wall has been provided to carry the load of the structure above. The thickness of concrete wall is 300mm with an unsupported length of 7m. The total area of the concrete wall is 175.14 sq.m. The grade of concrete chosen is M40 and reinforcing steel is Fe415 for the design of concrete wall. The concrete wall has been designed as per IS 456:2000, Clause 32. The maximum load acting on long wall and short wall is 425 kN/m and 355 kN/m. The load carrying capacity of this wall section is 2502 kN/m length.

The dimension of the pontoon's bottom slab is 60m x 45m x 0.70m. The grade of concrete and that of reinforcing steel is M40 and Fe415 and 20mm Φ bars with an effective cover of 35mm to the steel from the bottom. The maximum shear force and bending moment values for pontoon's bottom slab is as follows:

- Maximum Bending Moment = 2255.53 kN-m
- Maximum Shear Force = 994.52 kN

The total weight of the pontoon including the imposed load upon it is found to be 145061.8 kN.

V. Force of Buoyancy

When a body is immersed in a fluid, an upward force is exerted by the fluid on the body. This upward force is equal to the weight of the fluid displaced by the body and is called force of buoyancy or simply buoyancy. It is based on Archimedes Principle which states that, "upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaces and acts in the upward direction at the center of mass of the displaced fluid." As referred to imposed load and dead load which had been computed in the previous section, the total unfactored imposed and dead loads on the structure are as below:

The total load on the structure = 4676 + 145061.8 = 149737.8 kN

The structure is being planned on Vihar Lake having a maximum depth of 34m. Thus, the weight of water replaced by the submersed part of the structure is equal to the compartment weight submersed in water. The total area of the hollow space of the compartment has been calculated equal to 2524.861 sq.m. Thus, the total weight of air which is trapped inside this compartment is as follows:

Total weight of water being replaced by air = [(2524.861 x 7) x 1000] x 9.81/1000 = 173382.2 kN

From the analysis above, it is noted that total weight of structure is 149737.8 kN which is lesser than the weight of water replaced by the air in the compartment, which is 173382.2 kN. Hence the buoyant force, F_B is:

Buoyant force, F_B = 173382.2 – 149737.8 = 23644.38 kN

VI. Degree of Floating Stability

The buoyant force, which supports a floating body, is equal to the weight of fluid displaced by the body. As the force of buoyancy is a vertical force and is equal to the weight of the fluid displaced by the body, the centre of buoyancy will be the centre of gravity of the fluid displaced. The term stability refers to the tendency of a body to return to its original state after it has suffered a small disturbance. The degree of stability refers to how quick will the body return to the upright or its original position. For floating structure, the structural stability is very important to prevent structural failure caused by bending moment and displacement. Moreover, failure in maintaining the floating stability will cause the object to overturn. Thus, the stability is one of the security requirements for all the floating structural design.

For the study of floating stability, its purpose is to determine the positions that various solids will assume when floating in a fluid, according to their form and the variation in their specific gravities. For rigid body in a state of equilibrium, the resultant of all forces and resultant moment of the forces is equal to zero. If the rigid body subjected to a small disturbance from a positive equilibrium, tends to return to that state, it is said to possess positive stability. If the disturbance causes the rigid body excursion from the equilibrium positive position tends to increase, then the body is said to be in a state of negative stability. For stability the meta-centric height must be positive.

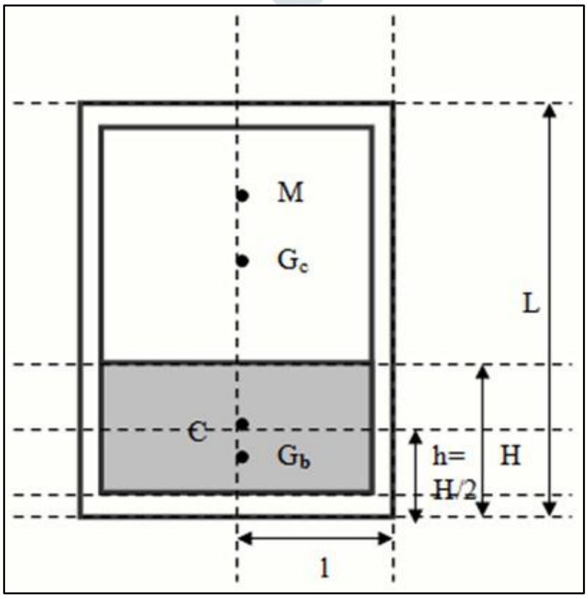

Fig. 7: Meta-centric height for a cubical floating body

The expression for the Meta-centric height, GM is,

Meta-centric height, GM = I/V - CG where,

I = Moment of Inertia; V = Volume; CG = Centre of Gravity

The meta-centric height for the floating structure is calculated as 28.265m.

Basically, floating house model is to be able to have at least 500mm above the water surface when it is fully loaded. The buffer height of 500mm above water surface is to cater for any miscellaneous loading added which might cause the structure to be just above the water surface. The idea of buffer height of 500mm above water surface is to prevent the water from spreading onto the slab. As referred to the target of having at least 500mm height above the water surface as discussed, this height is evaluated as below:

Height above water surface = [(23644.38 x 1000)/9.81] / (60 x 45 x 45) = 0.89m = 890mm

VII. MERITS AND DEMERITS

Merits:

- Manufacturing and installation process is simple
- Suitable for all types of water including oceans
- Unlimited Size is possible
- Excellent Stability of the structure
- Low maintenance

Demerits:

- Mooring Connector technology is still exploratory
- The cost of construction is high as skilled labours and high end equipments are required

VIII. CONCLUSION

This paper analysed a brief description of the general characteristics of floating structures and energy resources produced by tides. Construction of floating structures shows that they not only have environmental benefits but also conserve onshore energy resources resulting in economic benefits. The design is carried out using light weight construction materials and the entire structure has a stable arrangement. This paper presented that floating structures can be an interesting way to combine tidal energy resources and floating architecture. This upcoming technology will be in practice in many part of the world, when the existing land surface is taken away by the rising water level and increasing growth of population.

REFERENCES

[1] A. Ambica and K. Venkatraman, “Floating Architecture: A Design on Hydrophilic Floating House for Fluctuating Water Level”, Vol. (8)32, ISSN: 0974-6846, 2017.

[2] M. Hari Sathish Kumar, E. Saravanan, S, Manikandan, S. Akash Kumar, “DESIGN OF FLOATING BRIDGE CROSS OVER”, Vol. (4), ISSN: 2395-0056, 2017.

[3] R.M. Manoj Kumar, J. Amit Binglesh, “ECONOMICAL DESIGN OF FLOATING BRIDGES”, Vol. (12), ISSN: 0976-1353, 2015.

[4] Shahryar Habibi, “Floating Building Oppurtunities For Future Sustainable Development And Energy Efficiency Gains”, Habibi, J Archit Eng Tech 2015.

[5] The Structure Is Designed With The Reference From The Book “Design Of Reinforced Concrete Elements” By “Krishna Raju” And “Limit State Method” By “B.C Punmia”.

[6] The coefficient values are taken from the code book “IS: 456-2000”.

[7] The concrete has been designed as per “IS 10262:2009”.

[8] The design of beams and columns has been carried out from the code book “IS 800:2007”.

[9] The design of slab has been carried out from the code book “IS 456:2000”.

[10] The live load is taken from the code book “IS 875 PART 2” according to the building.