A Review on "Finite Element Analysis of EPS-Based Floating House Foundation for Flood Disaster Mitigation"

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***Abstract*—This review paper presents the study of an innovative floating foundation system using Expanded Polystyrene (EPS) for flood disaster mitigation. The purpose of this study is to analyze the structural behavior and feasibility of EPS-based floating house foundations using Finite Element Analysis (FEA). The paper includes objectives, methodology, and analysis of buoyancy, stability, and load-bearing capacity under varying flood conditions. The proposed system aims to provide a sustainable, cost-effective, and resilient housing solution in flood-prone areas.**

***Index Terms*—EPS, Floating Foundation, Flood Mitigation, Buoyancy, Finite Element Analysis, Sustainable Housing**

I. INTRODUCTION

Flooding is one of the most common and destructive natural disasters worldwide, especially in low-lying and coastal regions. Traditional fixed foundations are highly vulnerable to flood damage, resulting in economic loss and displacement of people. In recent years, adaptive construction techniques such as floating and amphibious structures have gained importance.

Floating house foundations are designed to rise with increasing water levels, thereby preventing structural damage. Expanded Polystyrene (EPS) is widely used due to its lightweight nature, high buoyancy, and resistance to water absorption.

Finite Element Analysis (FEA) plays a crucial role in modern structural engineering by enabling simulation of real-life conditions. It helps engineers predict stress, deformation, and failure conditions accurately. This study integrates EPS material technology with FEA to develop a reliable floating foundation system.

1. Flood and Buoyancy Concept

Flooding is a natural phenomenon that occurs when water overflows onto normally dry land due to heavy rainfall, river overflow, storm surges, or poor drainage systems. It causes severe damage to buildings, infrastructure, and human life, especially in low-lying and coastal regions. Traditional fixed foundations are not designed to withstand prolonged water exposure, leading to structural failure and economic loss.

To overcome these challenges, the concept of buoyancy is applied in floating and amphibious structures. Buoyancy is the upward force exerted by a fluid on an object immersed in it, as explained by Archimedes' principle. According to this principle, a body submerged in water experiences an upward force equal to the weight of the displaced fluid.

In floating house foundations, lightweight materials such as Expanded Polystyrene (EPS) are used to provide buoyancy. When floodwater rises, the foundation lifts the structure above water level, preventing damage. As the water recedes, the structure returns to its original position.

The effectiveness of this system depends on factors such as load distribution, material properties, stability, and anchoring mechanisms. Proper design ensures that the center of gravity and center of buoyancy remain balanced, preventing overturning or excessive movement.

Understanding flood behavior and buoyancy principles is essential for designing safe and efficient floating foundations, which can significantly reduce the impact of flood disasters.

1.1 Need for Study

- Increasing flood frequency and intensity
- Failure of traditional foundation systems

- Need for resilient and adaptive housing
- Requirement for cost-effective solutions

1.2. Floating Foundation Concept
Floating foundations work based on Archimedes' principle, where the upward buoyant force balances the weight of the structure.

1.3. Main components:
- EPS buoyant blocks
- Structural frame
- Anchoring system
- Vertical guide posts

The structure rises and falls with water levels while maintaining stability.

1.4. Properties of Expanded Polystyrene (EPS)
Expanded Polystyrene (EPS) is a lightweight, rigid, and cellular plastic material widely used in construction, especially for floating structures due to its excellent buoyancy and durability. It is produced by expanding polystyrene beads, which results in a closed-cell structure filled with air, making it highly efficient for insulation and flotation applications.
One of the most important properties of EPS is its low density, typically ranging from 10 to 30 kg/m³. This low density makes the material extremely lightweight, which is beneficial for reducing the overall load on the structure and enhancing buoyancy. Due to its high air content, EPS can float easily on water, making it suitable for floating foundation systems.
EPS exhibits good compressive strength, which allows it to withstand structural loads without significant deformation. This property is essential in floating foundations, where the material must support the weight of the building while maintaining stability.
Another significant property is its excellent buoyancy. EPS can displace a large volume of water relative to its weight, generating sufficient upward force to support structures. This makes it an ideal material for use in flood-resistant housing systems.
EPS also has low water absorption due to its closed-cell structure. Even when exposed to water for long durations, it retains most of its physical properties, ensuring durability and long-term performance in wet conditions. Additionally, EPS provides thermal insulation, which helps in maintaining indoor temperature and improving energy efficiency. It is also resistant to decay, does not support mold growth, and has a relatively long service life. Furthermore, EPS is easy to handle, transport, and install due to its lightweight nature. It can be cut and shaped easily, allowing flexibility in design and construction. However, EPS has some limitations, such as sensitivity to high temperatures and relatively lower strength compared to conventional construction materials. Therefore, it is often combined with protective layers or structural framing to enhance its performance.
Overall, the unique combination of lightweight, strength, buoyancy, and durability makes EPS a highly suitable material for floating house foundations used in flood disaster mitigation.

II. LITERATURE REVIEW

Amphibious housing has been identified as an innovative solution for flood-prone regions. The study on amphibious houses [1] explains that such structures are designed to float during flood conditions while remaining grounded during normal conditions. These houses reduce structural damage and provide safety during flooding events.
The Thames Amphibious House case study [2] demonstrates a real-world implementation where a house is designed to rise vertically with water levels using a buoyant foundation system. This study highlights the importance of guideposts and anchoring systems in maintaining stability. The concept of buoyant foundations has been further explored in the Buoyant Foundation Project [3], which focuses on retrofitting existing buildings with floating capabilities. This approach makes it possible to convert traditional structures into flood-resilient systems. Koen Olthuis' keynote on amphibious architecture [4] emphasizes the future of floating urban development and the need for adaptive design strategies in response to climate change. The first international conference on amphibious architecture [5] also highlights advancements in floating structures and their engineering challenges.
Proverbs and Lamond [6] discussed flood-resilient construction techniques and emphasized the importance of adapting buildings rather than resisting water forces. Similarly, studies on sustainable construction materials [7], [12] highlight the use of

lightweight and eco-friendly materials such as bamboo and EPS in resilient housing.

Research conducted in developing countries [8], [10] shows that low-cost and locally adaptable housing solutions are essential for effective disaster mitigation. These studies emphasize the importance of affordability and community-based approaches.

Ahmed and Sobuz [9] discussed challenges in construction implementation, highlighting the need for proper planning and management in adopting new technologies. Nkwunonwo et al. [11] reviewed flood modeling techniques and emphasized the importance of accurate prediction for urban flood management.

Nilubon et al. [13] studied amphibious architecture in Bangkok and concluded that such systems provide flexible and adaptive solutions for flood-prone urban areas.

Indian Standard codes such as IS:1904–1978 [14] and IS:875 Part 2:1987 [15] provide guidelines for foundation design and load calculations, which are essential for the safe design of floating foundations.

III. SUMMARY OF REVIEW

From the above literature, it is observed that flood disasters are increasing globally, and conventional construction methods are insufficient to handle such conditions. Amphibious and floating housing systems have emerged as effective solutions for flood mitigation.

The use of buoyant foundations, particularly with materials like EPS, provides an economical and efficient alternative to traditional foundations. Case studies such as the Thames Amphibious House demonstrate the practical feasibility of such systems.

Research also highlights the importance of proper anchoring systems, load distribution, and material selection for ensuring stability and safety. Additionally, sustainable and locally available materials play a crucial role in making these solutions affordable.

However, there are still challenges related to design optimization, large-scale implementation, and long-term durability. Therefore, advanced analysis techniques like Finite Element Analysis (FEA) are necessary to accurately predict structural behavior and improve design efficiency.

IV. CONCLUSION

The present review indicates that EPS-based floating house foundations are a promising solution for flood disaster mitigation. Amphibious housing systems can effectively reduce structural damage and improve safety in flood-prone areas. The integration of Finite Element Analysis allows for detailed evaluation of structural performance under various loading conditions. With proper design, material selection, and anchoring systems, floating foundations can be successfully implemented. Future research should focus on improving material performance, optimizing design parameters, and developing cost-effective solutions for large-scale applications. The adoption of such innovative technologies can significantly enhance disaster resilience and sustainable development.

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