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Review paper on Design and Analysis of Underwater Tunnel

[1]Prof. Preeti Morey , [2]Vishal D. Chopade, [3]Sofiya R. Nagrare, [4]Bhagyashri R. janwe, [5]Sujit A. Mehshram,

[1,2,3,4,5]Department Of Civil Engineering Suryodaya College Of Engineering And Technology Nagpur , Maharashtra, India.

[1]preetymorey88@gmail.com, [2]04vishalchopade@gmail.com, [3]sofiyanagrare@gmail.com, [4]bhagyashrijanwe@gmail.com, [5]Sujitmeshram001@gmail.com

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ABSTRACT

The development of underwater tunnels is a critical advancement in modern transportation engineering, enabling efficient connectivity across water bodies while minimizing environmental and surface disruption. This study focuses on the structural analysis and modelling of an underwater tunnel using ABAQUS and Autodesk Revit. The tunnel model is developed in Revit to create a detailed 3D representation, including geometry, reinforcement detailing, and alignment. The generated model is then analysed in ABAQUS using Finite Element Analysis (FEA) to evaluate structural performance under various loading conditions such as dead load, live load (vehicular load), soil pressure, and hydrostatic pressure. The study considers realistic boundary conditions and material properties to simulate actual site conditions. The results obtained include stress distribution, deformation characteristics, and factor of safety of the tunnel structure. The analysis shows that the maximum stress and displacement values remain within permissible limits, indicating that the design is structurally safe and stable. This integration of BIM and FEA tools enhances accuracy, visualization, and efficiency in tunnel design. Overall, the study demonstrates that the combined use of Revit and ABAQUS provides a reliable and effective approach for designing and analysing underwater tunnels, ensuring safety, durability, and optimal performance.

1. INTRODUCTION

A. BASICS OF TUNNELS

A tunnel is a man-made underground passage built to pass through obstacles like soil, rock, or water without disturbing the surface above. It is constructed by excavating the ground. In general, the length of a tunnel is at least twice its width. Tunnels are useful when fast transportation is needed and when it is difficult or expensive to acquire land for roads.

B. TUNNEL DESIGN CRITERIA

Proper planning and design are very important in tunneling. Each tunnel is unique and depends on its shape, alignment, location, and construction method. While designing a tunnel, several important factors must be considered:

1. Space requirements based on its use.
2. Alignment of the tunnel.
3. Provision of underground stations (if required).

4. Fire safety measures and operational systems.
5. A well-designed tunnel should also include proper horizontal and vertical alignment, good ventilation, adequate lighting, electrical and safety systems, drainage facilities, and security arrangements.

C. CONSTRUCTION TECHNIQUES OF TUNNEL

Immersed Tube Tunnel: Prefabricated sections are made on land, floated to the site, and then submerged and connected underwater.

Monolithic Concrete Element Construction: The monolithic type is the simplest form of concrete tunnel construction. In this method, each tunnel section is built as one continuous piece, which behaves like a beam and carries loads along its length.

Segmental Concrete Element Construction :
The segmental type of concrete tunnel was developed as an improvement over the monolithic design. It uses separate sections joined together, which helps reduce or eliminate the need for an external waterproofing layer.

Prestressed Concrete: A modified form of the monolithic concrete tunnel uses prestressing along its length. This method helps reduce the need for additional steel reinforcement and creates compressive force in the concrete, which helps close small cracks and reduces the chances of water leakage.

Composite Sandwich Tunnel: Steel–concrete composite sandwich construction is a modern tunnel-building method that has been widely developed in Japan, with additional research carried out in the United Kingdom. In this method, concrete is placed between two steel plates, so a highly flowable, self-compacting concrete mix is required. One of the main challenges is to properly fill the space between the plates and ensure the concrete is compacted well without leaving any gaps.

D. TYPES OF TUNNELS

Circular Tunnels: These are structurally efficient and well-suited for withstanding high water pressure, making them ideal for water tunnels and situations where the surrounding ground exerts significant pressure.

Rectangular Tunnels: These are often preferred for pedestrian and road tunnels due to the ease of creating flat surfaces for walking or driving,

Horseshoe-shaped tunnels: This shape is common in rock tunnels, as the flat bottom facilitates hauling and transportation of materials.

Other Shapes: Egg-shaped tunnels, elliptical tunnels, and segmental (D shaped) tunnels are also used, each with its own advantages depending on the specific conditions and requirements of the proje

2. LITERATURE REVIEW

A. Ke Li, Xinghong Jiang, (2016)
Submerged floating tunnel, as a new type traffic structure crossing different waters, has short research history. However, because of its novelty and superiority, it has been a hot research topic The research concludes that the elliptical section has better fluid and structure property than the rectangular section.

B. M S S Krishna Shanmukha (2021)
The construction of Submerged Floating tunnel, the main consideration is about the water leakage into the tunnel segments through the joints as the concrete is vulnerable to deterioration because of constant wave impacts on the tunnel joints. In this research paper, we are discussing about the most practical and economical joint modifications and designs which can act as waterproofing materials to stop the leakage of water into the tunnel.

C. Fathima Shirin (2021)
Submerged floating tunnel is an innovation which introduces a new trend in transportation engineering. It provides a fast and easy access of transportation where the conventional methods are not applicable. SFT is adopted when the water bed is too deep, rocky and highly undulated where submerged tunnels and bridges are not economical.

D. Shinde Aditya Jalinder, Prof. R. R. Dhawane, Sah Abhinandan Binod, Dude Rushikesh Gangadhar, Shirke Aniket Anil, may (2022)
Engineering says that Tunnel Construction is a difficult work and underwater tunnel construction more difficult than underground construction. In this paper, a brief description of the underwater tunnel construction is done which is constructed using under water techniques. Worldwide population in growing fast so we need to use under water surface. The aim of this paper is to study of underwater tunnel construction it's techniques & methodology.

E. J.Bala Krishna, P.Raghuram Reddy, P.Saikrishna, P.Sandeep, R.Sai Charan, Jan (2025)
The Submerged Floating Tunnel (SFT) is an innovative solution for crossing waterways,

utilizing buoyancy to support the structure at a moderate depth of 20-50 meters.

CONCLUSIONS

- Underwater tunnels are a modern development in transportation that use advanced technology.
- They help reduce travel time and make transportation faster and more efficient.
- They also help in reducing energy use, air pollution, and noise.
- These tunnels support sustainable development and contribute to the country's growth.
- Submerged floating tunnels remain stable due to buoyancy and water pressure.
- However, they are not strong enough to fully resist wave and current forces.
- There is a possibility of structural damage at the center of the tunnel due to wave impact.
- To improve safety, stronger reinforcement and more rigid materials are required.
- With further research, underwater tunnels can become a safe, cost-effective, and sustainable transport option in the future.

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