



(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 5, May 2025

⊕ www.ijirset.com 🖂 ijirset@gmail.com 🖄 +91-9940572462 🕓 +91 63819 07438





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405478|

Study and Analysis of Underwater Submerged Floating Tunnel

Prof. Avinash A. More, Chaitanya R. Sawant, Awais Panhalkar, Wahid G. Pathan,

Sauban S. Gazge

Associate Professor, Department of Civil Engineering, Rizvi College of Engineering, Bandra, Maharashtra, India

U.G. Student, Department of Civil Engineering, Rizvi College of Engineering, Bandra, Maharashtra, India

ABSTRACT: Tunnel are important structures serving in transportation and crossing over the obstacles like rivers, mountains, roads etc. But the construction of traditional tunnel involves much blasting, boring and earthwork making it large funding project and still there are some limitations in tunnelling through hard mountainous terrain. For this the construction of underwater tunnel can be better option. In past decades, few underwater submerged floating tunnels (SFT) have been constructed and are still in operation. Underwater construction of tunnel overcomes mountainous terrain challenges but has its own problems and challenges. The project discusses about the study of underwater submerged tunnel and its types. It also involves the study of forces acting upon it and designing an underwater submerged tunnel model in REVIT software and analysing it in ABAQUS CAE software that can withstand the forces applied over it safely.

KEYWORDS: Tunnel, underwater submerged floating tunnels, REVIT software, ABAQUS CAE software

I. INTRODUCTION

The Tunnel is an underground or undersea passageway. It is dug through surrounding soil, earth or rock, or laid under water, and is usually completely enclosed except for the two portals common at each end, though there may be access and ventilation openings at various points along the length. A tunnel may be for foot or vehicular road traffic, for rail traffic, or for a canal. Some tunnels are used as sewers or aqueducts to supply water for consumption or for hydroelectric stations. Utility tunnels are used for routing steam, chilled water, electrical power or telecommunication cables, as well as connecting buildings for convenient passage of people and equipment

An underwater tunnel is a tunnel which is partly or wholly constructed under the sea or a river. They are often used where building a bridge or operating a ferry link is unviable, or to provide competition or relief for existing bridges or ferry links. One of the kinds of underwater tunnel is Submerged Floating Tunnel (SFT). A Submerged Floating Tunnel (SFT), also known as an Archimedes Bridge, operates based on the principle of buoyancy and is designed to "float" at a fixed depth underwater, typically 20 to 50 meters below the surface. The SFT works by balancing buoyancy with anchoring systems to remain stably submerged, offering a protected, efficient transportation route across water bodies. It combines principles of marine engineering and tunnel construction to create a durable and adaptable infrastructure solution. Stability of SFT depends on the balance between dead load, moving load, buoyancy and anchoring force. Besides of those conventional loads, SFT is also subjected to environmental loads, such as the action of wave and current, which plays an important role in structure design, construction and durability. Types of Submerged Floating Tunnel are: Rock Type floating tunnel, Tethered (Cable) Type floating tunnel, Pontoon Type floating tunnel and Pier Type floating tunnel, among which our project focuses on studying, designing and analysis of Tethered (Cable) Type floating tunnel

II. LITERATURE SURVEY

1. Keqian Zhang et al, Department of Civil Engineering, China (July 2010); Published paper discussing about the tubular design segments for submerged floating tunnels (SFTs), focusing on Structural analysis approaches SFT tube load is divides into permanent load, variable load and accidental load. The permanent includes structure weight, buoyancy, hydrostatic pressure, concrete shrinkage etc. The variable load includes vehicle load, water head





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405478|

load, wave-current load, temperate load, construction load etc. The accidental load includes seismic, sunken ship load, blast load, leakage etc. SFT tube is designed under ultimate limit state and serviceability limit state just as traditional hydraulic structure design, moreover, the stress and displacement should be analysed and checked under progressive damage limit state and fatigue limit state based on structural reliability theory. structural performance, hydrodynamic behaviour, and material selection. It evaluates different cross-sectional shapes and reinforcement methods to optimize stability and durability in underwater conditions. Computational simulations and experimental studies are used to assess load-bearing capacity, resistance to environmental forces, and failure modes. The study highlights the importance of buoyancy control, anchor placement, and material fatigue resistance. Findings contribute to the advancement of SFT technology for efficient and safe underwater transportation infrastructure

2. Yiqiang Xiang et al (December 2016). The paper discusses key challenges in the design and construction of submerged floating tunnels (SFTs), focusing on hydrodynamic forces, structural integrity, and construction feasibility. It highlights issues such as vortex-induced vibrations, wave load estimation, and accidental load scenarios like collisions and seismic events. The study explores fluid-structure interactions, durability concerns in marine environments, and advanced numerical models for assessing structural responses. Additionally, it reviews construction complexities, including underwater assembly, alignment control, and anchoring methods. The paper emphasizes the need for further research to enhance SFT safety, efficiency, and economic viability.

III. METHODOLOGY

The project starts by studying the Traditional tunnel and then underwater submerged tunnel along with its types. Also, the forces acting on the underwater tunnel and its behaviour were also studied. Then for obtaining the designing parameters tunnel, the actual site was selected by collecting various geographical and spatial data. The bathymetrical and topographical data of India was obtained from GEBCO'S GAZETTEER website and GOOGLE EARTH and it was rendered, processed and studied in QGIS software. On the basis of these study the final site was selected in the **Gulf of Kutch**. **Gujarat**, **India**. The proposed tunnel connects the **Okah**, Gujarat, India to **Bada**, Gujarat, India in the Gulf of Kutch. covering the distance of 47.32 kilo metres. The location is selected on the basis of the underwater depth available below the selected site is averagely 60 to 70 metres; having small rocky undulated peaks.



Fig. Tunnel site location from GEBCO'S GAZETTEER and GOOGLE EARTH





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025 |DOI: 10.15680/IJIRSET.2025.1405478|



Fig. Site elevation details and tunnel alignment in QGIS software

After obtaining the site details about elevations, the modelling work was started in REVIT. The tunnel of 25m in diameter (external), 48 km long, held in position by cables arranged in shaped 'W', connected with tunnel at one end and other with connectors, connected with the foundation block having its embedded piles in stratum below seabed; was modelled. Then this model was analysed in the student learning version ABAQUS CAE software. During analysis, due to its limitations of advance features, number of nodes and elements; Only the section of 300m in length of tunnel was analysed for Hydrostatic and Buoyancy load and for dynamic wave current load. Based on this analysis the results were obtained and the conclusion was made.

Following are the tunnel's design considerations:

- 1. Floating Tunnel type = Type 2 Tethered stayed submerged floating tunnel
- 2. Total Length= 48 kilometres
- 3. Internal diameter= 23 m
- 4. External diameter= 25m
- 5. Thickness = 2m
- 6. Shape of cross-section = Circle
- 3-dimensional shape = Hollow cylinder
 Bepth from water surface = 20m
- 9. Elevation from sea bed = 70m
- 10. Arrangement of tension cables = W Type tether arrangement.
- 11. Distance between adjacent W cables arrangement = $150 \, {\rm m}$
- 12. Diameter of Cables = 60 mm
- 13. Foundation = Cable Anchored Pile foundation
- 14. Transportation = 6 lanes two-way traffic and 2 metro rails (1 up and 1 down)
- 15. Internal Arrangement = Box framed through arrangement consisting of one up direction 3 traffic lanes below the one down direction 3 traffic lanes above and two directional up and down metro rails below down directional traffic lanes.



Fig. Submerged floating tunnel model cross-section

14595





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405478|

- 16. Magnitude of Hydrostatic pressure = 196200 kN/m
- 17. Magnitude of Buoyancy force = 686700 KN/m
- 18. Magnitude of wave current force = 13 KN/m
- 19. Diameter of Tethers (Cables) = 60 mm
- 20. Diameter of Pre-stressed Longitudinal reinforcement = 540 mm
- 21. No. of Longitudinal reinforcement = 10
- 22. Diameter of Lateral reinforcement = 40 mm
- 23. No. of Lateral reinforcement = 16

IV. RESULTS AND DISCUSSION

The analysis of the submerged floating tunnel was performed in ABAQUS CAE software which is simulation and analysis software from the company Dassault Simulia. As far as our project concerns, we have used its student learning version which is only for study purpose. The actual length of the tunnel is **48 Km**, but for software version compatibility it has been analysed for a section of only **300 m**. The tunnel was analysed for two loading cases: under combined Hydrostatic and Buoyancy pressure effect and other case under wave current effect. Seismic load effect has not been considered, as our prime objective is to check tunnel's stability under constant regular forces.

The following are the Results obtained:

V. HYDROSTATIC AND BUOYANCY PRESSURE RESULTS:

The results obtained from the analysis states that, Due to the combine effect of both Hydrostatic and Buoyancy force The junction of 1^{st} level slab and 2^{nd} level slab to their edges with interior surface experiences some stresses and displacement. The maximum pressure developed at junction is **2.19 kN/m**. This can be due to, not given provision of interior reinforcement as because of the limitation of nodes and elements in the student's version. Still, this can be rectified by providing interior slab reinforcement. Talking about the overall stability of the submerged tunnel under the hydrostatic and buoyancy force; Because of alone buoyancy force the tunnel stays stable in its position successfully without sinking and can carry the imposed load in it. Tethers (Cables) successfully stabilizes the tunnel by being in tension without failing. Because of this buoyance force the tunnel can carry its self-weight and moving imposed loads, for more increasing traffic and imposed load, more depth is required from the bottom of tunnel to the seabed, producing much buoyance force.



Fig. Stresses at interior due to Hydrostatic-Buoyancy force





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

[DOI: 10.15680/IJIRSET.2025.1405478]



Fig. Stable tunnel due to Hydrostatic-Buoyancy force

VI. WAVE PRESSURE RESULT

The results obtained from analysis for wave force states that, the tunnel experiences large compressive and tension force at centre that leads to the failure of the tunnel. The maximum force of **10kN** is experienced at the centre of the tunnel due to back and forth action pattern of wave. The strengthening of tunnel is required by increasing reinforcements number and their diameter. Increament in the reinforcement area can help tunnel to sustain the wave load effect without causing failure of the tunnel. The prestressed steel tendons of overall diameter of 540mm is been used in this tunnel section which is needed to be increased upto 600mm or more than that, for absorbing the current forces and sudden impacts. As the tunnel remains stable vertically due buoyance force, this increased number of steel tendons can stabilizes the tunnel longitudinally. This can help the tunnel to withstand wave current force as well as many sudden impact forces.



Fig. Wave Pressure (Maximum Stress)





www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405478|



Fig. Wave Pressure (Minimum Stress)

VII. CONCLUSION

In conclusion, this research successfully studies and analyses the submerged floating tunnel, its types and the forces acting upon it and concludes that: The tunnel remains suspended and stable underwater due to buoyance force; Although it remains stable under Hydrostatic and buoyancy force, but requires to be strengthen more for able to withstand lateral wave and current forces. The prepared software model of tunnel withstands the hydrostatic and buoyancy force, but fails to withstand wave current force. The wave force impact causes the tunnel to fail from the centre arising the necessity for more rigid structure with strong reinforcement and with stronger shell material. Rectifying these challenges and limitations; and carrying more research on this concept may open new economical and sustainable way of future transportation.

REFERENCES

- 1. Brancaleoni F., Castellani A., D'Asdia P. (1989). The response of submerged tunnels to their environment. Engineering Structures, 11:1, 47-56.
- Centre for Marine and Petroleum Technology CMPT (1998). Floating structures: a guide for design and analysis. Oilfield Publications Inc., UK.
- 3. Faggiano B., Landolfo R., Mazzolani F.M. (2005). The SFT: an innovative solution for waterway strait crossings. IABSE Symposium Structures and Extreme Events.
- 4. Donna Ahrens, Submerged Floating Tunnels-A Concept whose Tune Has Arrived [J]. Tunnelling and Underground Space Technology, 1997, 4. Vol: 12. 317- 336.
- 5. T. Fujii. Submerged Floating Tunnels Project in Funk Abay Design and Execution [C]. International Conference on Submerged Floating Tunnels, Sandnes, Norway, 29-30 May, 1996.









INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY





www.ijirset.com