RESEARCH ON DESIGN OF WATER TIGHT JOINTS OF SUBMERGED FLOATING TUNNEL

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Abstract – *In 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.*

Key Words: **Archimedes Bridge, Joint design, submerged floating tunnel, Water Proof materials**

1. INTRODUCTION

Submerged floating tunnel (SFT) is innovative structure when compared with the other conventional off shore bridge and tunnels. Usually on sea tunnels are immersed inside the sea bed, whereas this SFT is suspended in the meter down brim of sea level with the help of floating structures called as Pontoons or anchored with the help of steel cables called as Tethers. AS the tunnel is suspended, it has to counter attack many loads. In the process of counter attacking the tunnel joints may break/crack because of the continues effect of waves. We can renovate these cracks if they appear inside of tunnel but in the other case if they appear on the outer portion of the tunnel it is difficult to repair. To solve this problem, in this paper we are going to discuss about the suitable materials and joint design.

2. Preliminary survey of the materials:

2.1 Aluminum Alloys

There are so many alloys in the aluminum family with different compositions. In these alloys, the alloys with less amount of iron content is prescribed for the construction or lining of the joints. Aluminum 6061 has the best possible strength and less amount of iron content and budget friendly when compared to the other alloys of aluminum. In the above alloy the ferrous content will be around 0.7%, thus the metal doesn't get oxidized and helps us to counter attack the impact generated the currents as the tensile strength much better compared to the traditional raw metals.

2.2 Geo-membranes

These Geo-membranes are the materials made of flexible polymeric material and impermeable by the nature. This helps us to use it as water proofing materials and helps us to provide a barrier for movements of fluids and water. These are mainly used to control the seepage of water, but in SFT the condition is flooding but not seepage. So to hold the Geo-membranes a steel plating is provided behind them.

3. Water Tightness and Joint between the tunnel segments

3.1 External Water Proofing of the tunnels

External waterproofing for tunnel elements should be considered for both steel tunnels and concrete tunnels. The waterproofing should envelop every part of the element exposed to soil or water with materials impervious to the surrounding waters. For steel tunnels the outer steel membrane would act as waterproofing membrane, while for concrete elements either steel or synthetic membrane should be used. For steel waterproofing membranes used on either concrete or steel elements, an appropriate corrosion protection and monitoring system should be used to ensure that the minimum design thickness is maintained during the life of the facility or an added sacrificial thickness should be provided. Non- structural steel membranes should be no less than 1/4 in (6 mm) thick.

The membrane should be watertight. Typical materials used for concrete elements include two coats of a spray-applied elasticized epoxy material; steel plates; and flexible PVC waterproofing sheet. Minimum thickness should be no less than 0.06 inch (1.5 mm), and anchored to the concrete using T-shaped ribs. The materials of the waterproofing system should have a proven resistance to the specific corrosive qualities of the surrounding waters.

Depending upon the type of waterproofing used, it may require protection on the sides and top of the tunnel elements to ensure that it remains undamaged during all operations up to final placement.

3.2 Joints

3.2.1 Immersion Joint

3.2.1.1 Gina-Type Seal

Immersion Joint (or Typical Joint) The immersion joint is the joint formed when a tunnel section is joined to a section that is already in place on the seabed. After placing the new element, and joining it with the previously placed element, the space between the bulkheads (dam plates) of the two adjoining elements is then dewatered. In order to dewater this space, a atertight seal must be made. A temporary gasket with a soft nose such as the Gina gasket (Figure 1) is most often used. In addition, an omega seal is also provided after dewatering the joint from inside of the joint.

Figure 1 Gina-Type Seal

3.2.1.2 Omega-Type Seal

For immersion joints, the primary compression or immersion seal is usually made of natural or neoprene rubber compounds. The most common cross-section used today is the "Gina" type. This consists of a main body with designed load/compression characteristics and an integral nose and seating ridge. The materials used should have a proven resistance to the specific corrosive qualities of the water and soils and an expected life no shorter than the design life of the tunnel unless the gasket is considered temporary. For flexible joints, a secondary seal is usually required in case of failure of the primary seal.

It is usually manufactured from the chloroprene rubber and has certified resistance properties against the ozone, oxygen, water, fluids, soil etc. It has some bulges on either side of the hands which act as reinforcement as show in (Figure 2).

Figure 2 Omega-Type Seal

3.2.2 Closure Joint

Where the last element has to be inserted between previously placed elements rather than appended to the end of the previous element, a marginal gap will exist at the secondary end

This short length of tunnel sometimes is completed as cast-in-place and is known as the closure or final joint.

The form of the closure or end joint is dependent on the sequence and method of construction. In some cases, closure joints may also be immersion joints.

3.2.3 Earth quake Joint

This may be an immersion joint of special design to accommodate large differential movements in any direction [1] due to a seismic event. It also applies [2] to a semi-rigid or flexible joint strengthened to carry seismic loads and across which stressed or unstressed prestressing components may be installed.

3.2.4 Segment or Dilation Joint

Moveable segment joints must be able to transmit shear across the joint and well as allowing dilatation and rotation. The joints contain an injectable rubber-metal water stop as well as neoprene and hydrophilic seals.

4. Design of Joints between Elements

All immersed tunnel joints must be watertight throughout the design life, and must accommodate expected movements caused by differences in temperature, creep, settlement, earthquake motions, method of construction, etc. Displacements in any direction should be limited so that the waterproof limits of a joint are not exceeded. Joint shear capability should take into account the influence of normal forces and bending moments on the shear capacity of the section; the design should take account of shear forces generated where the faces of the joints are not normal to the tunnel axis. Joints must be ductile in addition to accommodating longitudinal movements. Tension ties may be used to limit movement so that joints do not leak or break open, especially during a seismic event.

The axial compression of tunnel elements and bulkheads due to depth of immersion should be taken into account in determining joint dimensions at installation.

The design of primary flexible seals at tunnel joints must be designed to take into account the maximum deviations of the supporting frames relative to their theoretical location, the maximum deviation of the planes of the frames, and any relaxation of the seal. The seal is required to have a minimum compression [3] of 3/8 inch (10 mm) greater than the compression required to maintain a seal. Just in case an initial seal is not obtained after immersion and joining, it may be advisable in some cases for the immersion joint to be designed so that a backup method of obtaining an initial seal is available.

For flexible joints, a secondary seal (omega) [4] capable of carrying the full water pressure should be fitted across the inside of the joint and should be capable of being inspected, maintained and replaced. The seal should be capable of absorbing the long-term movements of the joint. The secondary seals should be provided with a protective barrier against damage from within the tunnel. All joints in the tunnel should be finished to present a smooth surface.

The metal hardware in joints should have a design life adequate to fulfill its purpose throughout the design life of the joint. Nuts and bolts for primary and secondary seals should be stainless steel. Plate connections between elements should be corrosion-protected to ensure that the design life is obtained.

The mounting procedure or the mounting surface for the primary seal of immersion joints must allow for fine adjusting and trimming of the seal alignment in order to compensate for construction tolerances. It is recommended that the gasket be protected from accidental damage until the time of immersion. All embedded parts, fixings, including the bolts and their corrosion protection system, mating faces, clamping bars and other fixings, must have a design life at least equal to that of the tunnel structure. Where clamping bars and other fixings are used for the secondary seal, these need to have a design life at least equal to that of the secondary seal. The gasket assembly should have provision for injection in case of leakage.

Conclusion

The concept of Submerged Floating tunnel may be old in theoretical discussions but coming to the practical application and construction it is entirely new to the world. Thus, all the design parameters regarding the joints and waterproofing them to be carefully studied with real life parameters.

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