SUNKEN TUBES

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STATE OF THE ART

Although land tunnels have been constructed for centuries, subaqueous tunnels are generally considered to be a relatively new concept. The first successful underwater tunnel of record was constructed in the nineteenth century beneath the Thames River in London under the guidance of Marc Brunel. The tunnel was started in 1821 and took nearly 30 years to construct. Beseiged with problems—both construction and financial—its ultimate success hinged on Brunel's invention of a tunnel shield and the use of compressed air to prevent inflow of water.

Even in that era engineers were searching for other means of underwater tunneling. Before Brunel's efforts, Wyatt is credited with the conception of a tunnel in about 1812 that was composed of several circular brick tubes that would later be placed in a predredged trench beneath the river bottom and backfilled with a minimum earth cover of 1.5 m (5 ft). Records exist indicating that three of Wyatt's brick tube elements were built and sunk in a dredged trench with modest success. The scheme was not pursued further at that time. Engineers continued, however, to be impressed with the trench type of tunnel method of construction, and the concept gradually began to assume a prominent position in the design and construction schemes for subaqueous tunnels to such an extent that railroad and rapid transit systems began to employ this novel tunnel method early in the twentieth century. The development of the "horseless carriage" stimulated the need for highway tunnels. Although the shield type of construction dominated in the beginning, the trench type of tunnel construction gradually began to assume a competitive position. At the present time, trench tunnels can sometimes be built for half the cost of compressed air shield tunnels. Where practicable, they are usually more economical than cut-and-cover methods.

Trench tunnels are usually constructed where soil conditions under waterways are conducive to the dredging of an open trench with stable side slopes. Tube elements of convenient lengths, usually in the 90 to 110-m (300 to 350-ft) range, are constructed either in dry dock facilities, existing shipways, or in special man-made outfitting basins. The tube elements may be constructed totally of concrete or of a combination of steel shells lined with concrete. Most trench tunnels in the eastern United States have been constructed as composite, concrete-lined steel shell elements. In either instance, the tubes are closed on the ends with temporary watertight bulkheads. Individual completed tube elements are then launched and floated into position over the dredged trench. Tubes may be bouyant, requiring ballast for sinking, or may be heavy enough for final placement without ballast. The latter case would require pontoons, after the outfitting basins are flooded, for support through launch and delivery stages, and the former method would permit placement of structural concrete lining after tube launch and while the tube is afloat. This construction stage is usually accomplished at the construction site. This method of tube construction is quite flexible and permits the use of small shipyards that are more readily available than drydocks. Since this type of tunnel is quite often constructed in built-up areas, space for man-made basins is more often than not unavailable.

Upon delivery to the tunnel site, the tube elements are then lowered into position in a predredged trench onto a prepared gravel foundation course or onto pile bents. A means is provided to effect a watertight connection between adjacent tubes and to allow the joint connection to be dewatered. After the dewatering occurs, the bulkheads are then removed and the interior joint lining is installed. The backfilling around the tubes and joints is then completed. Subsequent contracts complete the tile finish, ceiling, and electrical-mechanical equipment.

FUTURE RESEARCH

Bottom Soundings

Present-day electronic sounding equipment does not appear to be capable of obtaining sufficiently accurate results in deep water. Hand line soundings on a close grid are usually relied on.

Testing of Welds

In addition to the requirements that 10 percent of all welds be X-rayed, it is usual to specify that all modular butt welds be soap and air tested. This method of testing welds is archaic and far from reliable when one considers the number of welds that could ultimately result in potential leaks.

Grout Voids

Full contact of concrete to the underside of the steel shells in tunnel roof is desirable. The present method for discovering voids requiring grout consists of rapping shell with rods or hammers and could be improved.

Watertight Joints

Research in ways to improve the type of watertight joints between sections of the tunnel and the methods for installing the joints should be pursued.