MARKET OVERVIEW

On the spot

Hans de Wit, MSc, managing director of Tunnel Engineering Consultants (TEC), and Joeri Vinkx, senior project co-ordinator at Volker Stevin International, answer WT’s questions about the immersed-tunnels market.

Q What is the picture for immersed tunnels around the world?

JV: After a few years of relatively low demand, the immersed tunnel is back in the spotlight. Due to global demand and ever-changing economics and congestion all over the world, especially in water-rich environments, the immersed tunnel often offers a financially and/or technically competitive alternative to bored tunnels or bridges.

The impact on daily life is relatively low, as tunnel elements can be produced outside the congested areas, dramatically reducing the hindrance to the environment. In addition, immersed tunnelling consists of four operations (dredging, tunnel ramp/entrance construction, tunnel-element construction and tunnel installation), which can take place concurrently and can generally be completed in less time than a bored tunnel.

HdW: There appears to be a growing interest in immersed tunnels globally. TEC organised seminars in India and Indonesia last year and observed a growing awareness of the potential of immersed tunnels (there), especially in port areas where air clearances are getting more important (70-80m is not an exception, which would result in major and expensive bridges).

Unfortunately, over the last couple of months some of the countries we are working in have been facing some economic setbacks, e.g. due to low oil prices that seem to slow down large infrastructural projects (Brazil, China, Middle East).

Q How have immersed tunnel works changed?

HdW: Immersed tunnels have become wider (2 x four-lane or 2 x five-lane, multimodal rail and road), deeper and conditions more challenging (several off-shore or close to off-shore). And the tunnels have grown longer (6km HZMB and Shenzhong in China; 18km Fehmarnbelt Fixed Link), which require special approaches in terms of road/tunnel safety/ventilation and for the production of tunnel elements at the factory (cast and launch). Last but not least, recently tunnels have been built in very challenging ground conditions in which soil treatment on a large scale was applied (HZMB – sand compaction piles; Busan – cement deep mixing piles).

JV: Over time, design optimisations have been made for joints, concrete mixtures, rebar configurations, foundation types and earthquake resistance. For the installation phase, a lot of effort has been put into standardised production methods for tunnel elements as immersed tunnels tend to get longer.

Many changes have been made to the immersion equipment in order to reduce disturbance on the surroundings and to cope with more challenging environmental conditions. For example, Volker Stevin designed a modular containerised immersion catamaran system. The biggest advantage is that our immersion equipment can be shipped all over the world and assembled with rather ordinary equipment within a short time span. Secondly, the modular system can be adapted in geometry and floats for every tunnel project, thus usable for most tunnel cross-sections and environmental conditions. Thirdly, the practical execution of the technical system gives us a very reliable and stable system to immerse elements in a controlled way to the bottom of a waterway.

Q How do you ensure best practice?

HdW: A big advantage of immersed tunnels is that the majority of the construction work can be done by local companies, which has been recognised by authorities as beneficial for the local economy.

Only a small part of the work (5-10%), such as transport and immersion activities, dredging (to some extent) and rubber tunnel seals require special subcontractors and/or suppliers. It is important that local contractors are aware of the fact that for a small but essential part of the work they can limit the project risks (and improve quality) by involving these specialists.

JV: Keep a broad overview on all relevant aspects in all different fields of design, building, immersion and finalisation of an immersed-tunnel project.

Maintenance should be an integral part of this assessment. Interface management is crucial, as from the start design choices are made that could lead to high risks or costs in the end. This all comes down to an experienced consulting company or an experienced subcontractor with sufficient experience with immersed tunnels. Special focus should be on the details and the thorough in-depth assessment of the design.

Q Why is an immersed tunnel the best option?

HdW: Immersed tunnels do not have to be circular in cross-section (such as bored tunnels). Almost any cross-section can be accommodated, making immersed tunnel particular attractive for wide highways and combined road/rail tunnels. Hydraulic impact and blockage effects become more and more an issue in a lot of places.
when it comes to the realisation of a crossing. Especially in rivers with large discharges and substantial sediment transport, the presence of obstacles in the river (such as bridge piers) may result in serious scouring and sedimentation, resulting in banks or even small islands and the changing of embankments during periods of high discharge.

JV: The big benefit of an immersed tunnel is the reduced environmental impact as the typical cross-section of an immersed tunnel is optimised with relatively low ‘ineffective’ cross-sections. Furthermore, immersed tunnels have relatively short approaches, which have an impact on tunnel lengths and required space.

Q: What immersed tunnels are you involved with now?
HdW: The Øresund Bridge Fixed Link between Denmark and Sweden (tender stage nearly finished); Santos tunnel in Brazil (tender for construction about to start); Shaq Crossing in Doha (concept design and additional studies just completed; next stage is tendered); Coatzacoalcos (Mexico, close to completion) / Marieholm Tunnel in Gothenburg (Sweden, construction just started). In the future: Oosterweel Link in Antwerp (Belgium); North/West Link in Rotterdam (the Netherlands); Shenzhong Crossing, China (next stage); high expectations of projects in India and Indonesia.

JV: Volker Stevin International is currently involved in the investigation on the finalisation of the Coatzacoalcos tunnel. Besides this tunnel, we are tendering for various other immersed-tunnel projects around the globe.

TECHNICAL CONSIDERATIONS
Floating ideas

Alun Thomas and Lars Lundberg from Ramboll discuss why immersed tunnels are often the best option on construction projects.

While the Øresund bridge has gained notoriety from the television series ‘The Bridge’, for tunnellers the other part of the fixed link between Denmark and Sweden – namely the immersed tube tunnel – is much more interesting.

The Øresund tunnel is a typical example of why one would choose an immersed tube instead of any other method – such as a bridge or a bored tunnel. Figure 1 illustrates how the length of the crossing of a waterway differs in each case. If a high and wide clearance is needed for large ships in the navigational channel, this forces up the costs of a bridge.

If the crossing carries a railway line, the limits on the gradient affect the bored tunnel and the bridge more adversely than the immersed tunnel.

The ground conditions do influence immersed-tunnel design, as will be discussed later, but the impact is less than for bored or mined tunnels. Advocates of TBMs may dispute this but tunnelling with low cover in soft ground carries considerable risks. Finally, immersed tunnels can be built in any shape of cross-section so the space can be optimised, especially in comparison to circular bored tunnels.

Figure 2 (overleaf) shows an excellent example of this from the Fehmarnbelt tunnel, which will span the 18km stretch of sea between Denmark and Germany and is designed by a team led by Ramboll. This fixed link will carry a high-speed railway as well as a motorway. Two or three very large-diameter bored tunnels would have been needed, if that option had been chosen, instead of the 42m-wide immersed-tube elements.

In addition, there may be very specific local constraints. In the case of the