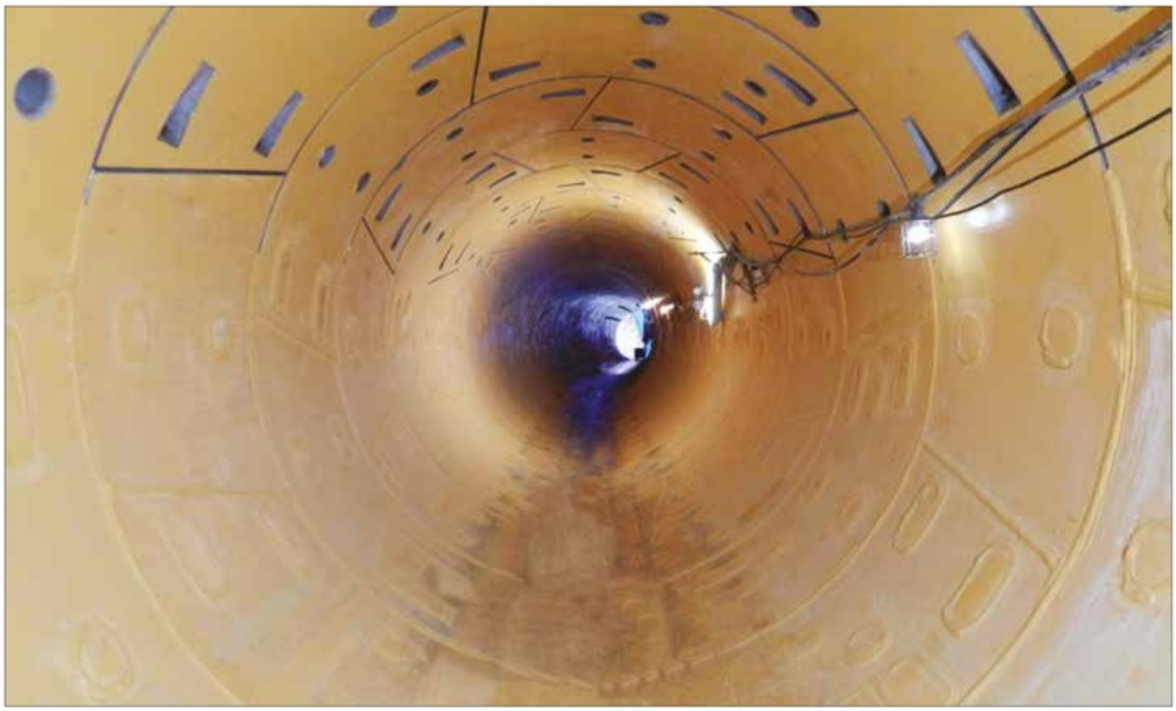
Tunnelling Journal



Have segments turned a corner?

Materials and technologies that speed up installation and lower lifetime costs are finally coming of age. By Kristina Smith.

The first SolidCast Polymer manholes were installed in 1998 as part of the Greater Houston Wastewater Program. The City of Houston was looking to trial new products and so borrowed the polymer concrete structures from the chemical processing industry, where they had been used successfully for years in highly corrosive environments.

From polymer concrete manholes, surely the next logical step is to polymer concrete tunnel segments? They could potentially allow a one-pass lining, saving the materials and time needed to add a second lining to protect the first against corrosion.

It's a step SolidCast Polymer president Rich Cubeta has been eager to take for a long time, but to date polymer concrete segments have been considered too expensive. "It's been talked about a lot, but it's just economics," says Jon Kaneshiro, technology leader for tunnels, at Parsons.

That could be set to change, thanks to a new idea that significantly cuts the amount of material required. Currently SolidCast Polymer segments are under consideration for a deep waste water project in Dubai, where Parsons is responsible for design, programme management and construction management.

It does feel like the pace of change is quickening generally in this field. Other areas where advances are being made include the use and understanding of fibre reinforcement, new forms of hybrid, integrated protective linings and testing technology.

There are several reasons for this: we are building more tunnels globally as populations migrate to cities and authorities need to move infrastructure, services and other facilities underground. Communication is faster and easier, with information being shared informally, as well as formally, on platforms like LinkedIn.

Despite the fear factor, some owners have a public innovation agenda. And, while procurement methods and forms of contract may not yet be

entirely helpful to that aim, it does mean that more consulting engineers and contractors are working to push new ideas forward.

Kaneshiro also highlights growing environmental conscience: "Concrete has a tremendous carbon footprint, which is another reason why these polymer resins need to be looked at," he says. "I would like to see a paradigm shift."

Slimmer and stronger

For a corrosive environment – such as a waste water tunnel – polymer concrete would be ideal. Cubeta says that 300 years-plus is a very conservative estimate of its life, a statement that he says is backed up with research. But there are other benefits too.

Because polymer concrete is so much stronger than Portland Cement concrete, polymer concrete segments could be far thinner, Cubeta reckons a three-inch (75mm) thick polymer segment would be equivalent to 11 inches (280mm) in concrete. However, there's a caveat:

"You can go a little bit thinner but you still need the area to thrust on," explains Kaneshiro. "You might be able to save a couple of inches." Dowels and gaskets must be accommodated too.

Cubeta considered ways to reduce the amount of polymer used per segment. Adding waffles to the outside face was rejected because it could hinder the flow of the anulus grout; waffles on the inner lining would impede the flow of the water within.

Then he came up with the idea of using cores, formed with cores made of light-weight materials such as Styrofoam, to reduce the volume of polymer used, a technology he calls QOR-TEC which he eventually managed to patent recently. "We found out that by including the cores, we lost less than 5 percent of the segment's load-bearing characteristics," says Cubeta. "If you did the same thing with Portland Cement concrete, you lose almost 50 percent."

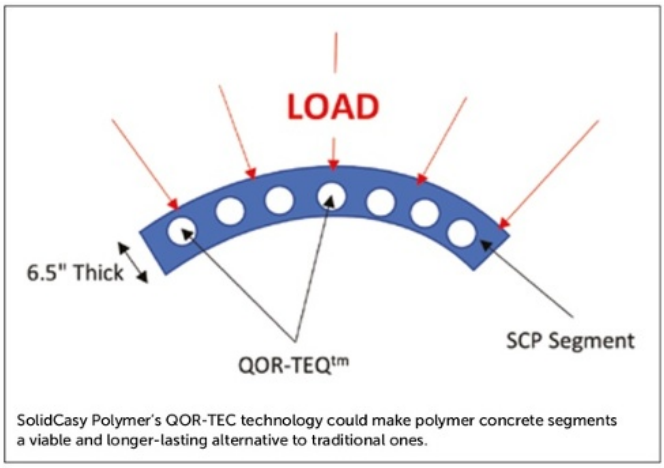
The polymer concrete segments would be far lighter than standard ones too, making handling easier and they are faster to manufacture. "We can cast these materials and then in five or six hours pull them out of the mould. In seven or eight hours, the material will be cured. There's no need for an oven," says Cubeta.

With the capital cost reduced thanks to QOR-TEC, Cubeta hopes he has cracked the market this time. "It's pretty frustrating," admits Cubeta. "If I'd come up with this idea ten years ago, we could have won those jobs."

Time and schedule savings

Another idea which allows a one-pass segmental lining to be used in aggressive environments is to cast the protective layer into the concrete segments. This isn't new – it's been at least ten years in the making – but incremental developments are moving it on.

There are two recent projects to talk about: Contract 2 of the Twinning of the West Trunk Sewer Project for the Region of Peel in the US and the main trunk sewer for the Inner Doha Re-sewerage



SolidCasy Polymer's QOR-TEC technology could make polymer concrete segments a viable and longer-lasting alternative to traditional ones.

Implementation Strategy (IDRIS).

One of the earliest uses of this type of system was on the Upper Northwest Interceptor in Sacremento in 2009 when Ameron's T-Lock PVC liner system, commonly used with cast-in-situ linings or precast pipes, was cast into segments, and the joints welded on site.

The first version of Herrenknecht's Combisegment were also used in 2009 on the Yuzhny Sewage Pipeline in Tzariayno, Moscow. These featured a GRP cast-in liner, which proved to be too rigid; the materials is difficult to get into the moulds and can break is something heavy is dropped onto it.

The latest Combisegment has an HDPE liner which is far more flexible. The other improvement is that the EDPM gasket is integrated into the plastic liner during the first step of the manufacturing process so that no welding is required. This version is being used for the first time by Technicore Underground on a section of the West Trunk Sewer Project, a 3m-diameter tunnel which runs mostly through shales, with some mixed ground, and water pressure of up to 2.6 bar in places.

"There was a little bit of a learning curve but once we went past that, it went fairly well," says Technicore CEO Tony DiMillo of the Combisegments.

One of the first issues came during the

Technicore used Herrenknecht Combisegments on the West Tunnel Sewer Contract 2 in Mississauga, which requires no welding because gasket and liner are joined during the manufacturing process

casting process itself, which was done by Ewing Fabricators, part of the Technicore group of companies. The HDPE lining material was distorting due to the heat of hydration.

The supplier's solution was to heat up the material and cut it to size at a higher temperature before it was put into the injection mould. However, this approach was not ready in time for the first of the two sections, so Technicore had to cast the linings in without attaching them to the gaskets and weld the joints afterwards.

There were a few challenges during installation too. There was difficulty with the vacuum erector which wasn't always able to get a good seal on the HDPE. "That did slow us down but overall it was only 85 rings so it was not too bad," says DiMillo. "If I were to do it again I'd probably go back to the old way of using a ball and grab system."

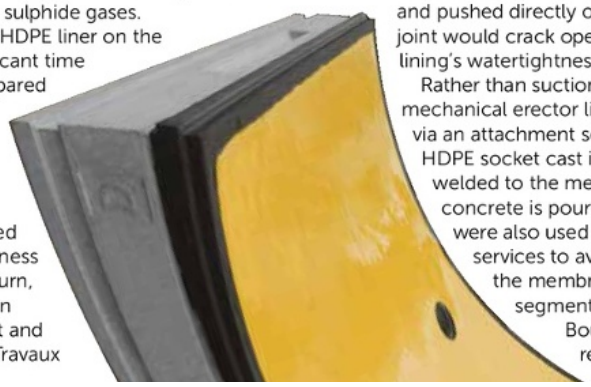
The tunnel segments on the IDRIS-MTS01 project have to cope with a tougher environment than those in the West Trunk Sewer. Externally, there is up to 5 bars of pressure with ground water that can contain salts, sulphides and chlorides and internally the presence of hydrogen sulphide gases.

Using an integrated HDPE liner on the project brought significant time and cost savings compared to the original design which called for a 250mm thick secondary concrete lining with protective HDPE liner. It decreased the overall lining thickness by 200mm which, in turn, reduced the excavation quantity by 20 percent and meant the Bouygues Travaux Public and Urbacon Trading & Contracting JV could use two TBMs rather than four.

"The removal of the secondary concrete lining – which represented between three and five months on the critical path after the TBMs had finished their drives – was a key element in securing the overall programme," says Thibaut Lockhart of Bouygues, who was technical manager on the project.

But the decision to cast the HDPE into the segments was driven as much by quality considerations as cost, says Lockhart: "We knew it would be complicated to cast this kind of secondary lining to guarantee the quality of the concrete," he says. "If you are doing a 16km-long tunnel, there are bound to be issues with quality at several points that have to be repaired."

Bouygues looked at the Combisegment system but were not confident that it was the right solution for IDRIS, says Lockhart, due to site-specific constraints. The resin used to overmould the gasket and to achieve connection with the membrane did not meet the durability requirements. Tests showed that if the TBM rams were not positioned correctly and pushed directly on the resin frame, the joint would crack open, compromising the lining's watertightness.



Rather than suction pads, the TBM's mechanical erector lifted the segments via an attachment screwed into an HDPE socket cast into the segment and welded to the membrane before the concrete is poured. These sockets were also used to support the TBM services to avoid drilling through the membrane, once the segments were installed.

Bouygues' system did require 2.5km of