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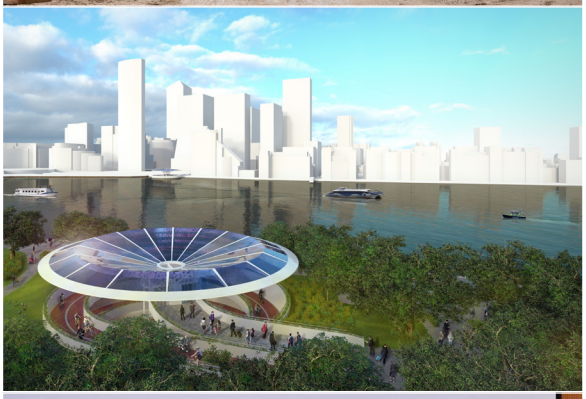
Boring and Expensive?



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Boring and Expensive?

TJ looks into an ingenious tunnel under the River Thames in London designed for pedestrian and cycle use.

Outside of the tunnelling community, there is all too often a perception that tunnels are boring (in the non-excavation sense) and expensive. Perhaps the view that tunnels are expensive comes from the well-publicised and substantial delays and cost over-runs that have affected many recent major infrastructure projects which had a significant tunnelling scope. However, when we investigate beyond the headlines, we invariably find that the tunnelling component itself was delivered on time and on budget, and that the reported inefficiencies could instead be attributed to poor procurement and overall project management.

As for "boring", a collaboration between CECL-Global's Colin Eddie and Cezary Bednarski of Studio Bednarski, has demonstrated that this certainly does not have to be the case. They have jointly developed a proposal for a breath-taking new pedestrian and cycle tunnel between Rotherhithe and Canary Wharf in London.

Background and Timeline

In 2018, a Transport for London (TfL) consultation showed overwhelming public support for a new walking and cycling crossing between Rotherhithe and Canary Wharf, and this resonated with the Mayor of London's aim for 80% of Londoners' trips to be by cycling, walking or by public transport by 2041. Again however, the public perception was that a tunnel would be more expensive and have a greater environmental impact than other options, and a lifting bridge study was therefore commissioned shortly after the consultation.

In 2019, when the estimated cost of the bridge rose above £600M, TfL announced it would pause work on the bascule bridge option on the grounds of affordability, and subsequently started to explore a "fast turn-up-and-go ferry service".

This provided Eddie and Bednarski the incentive (albeit unsolicited by TfL) to look critically at a tunnel option that could be in continuous use throughout the whole year, without being navigation- or weather-dependent.

Entrance to the Thames Garden Tunnel that could transfer pedestrian and cyclists across London's iconic river.

Collaboration

Eddie, a tunnel engineer, and Bednarski, an architect, were perhaps strange bedfellows and had not previously collaborated (in fact they had never met). Given the relatively predictable but challenging geology at the location of the proposed crossing comprising Lambeth Group and Thanet Sands, the initial concepts were all rather predictably conventional circular TBM-driven tunnels. These early concepts provoked an exasperated reaction from Bednarski that the ideas lacked "spatial poetry" – a phrase a tunnel engineer does not often hear. Eddie therefore suggested the concept of utilising a triple-headed TBM, and this piqued Bednarski's creative flair for the remarkable.

The concept

The relatively short (380m long) tunnel would be driven with a minimum cover of 8m under the riverbed. The proposed horizontal radius of the tunnel is circa 600m and the vertical radius around 5000m. The horizontal curve helps to visually conceal the length of the tunnel as only a short section of it will be seen from any point along the length of the tunnel.

The vertical radius is needed to pass under the lowest point of the riverbed with adequate soil cover above, at the same time keeping the depth of the access shafts (and therefore the length of the cycle ramps) to a minimum. The internal tunnel diameter will be 8.3m for each of the three bores, with an overlap between the three circular bores.

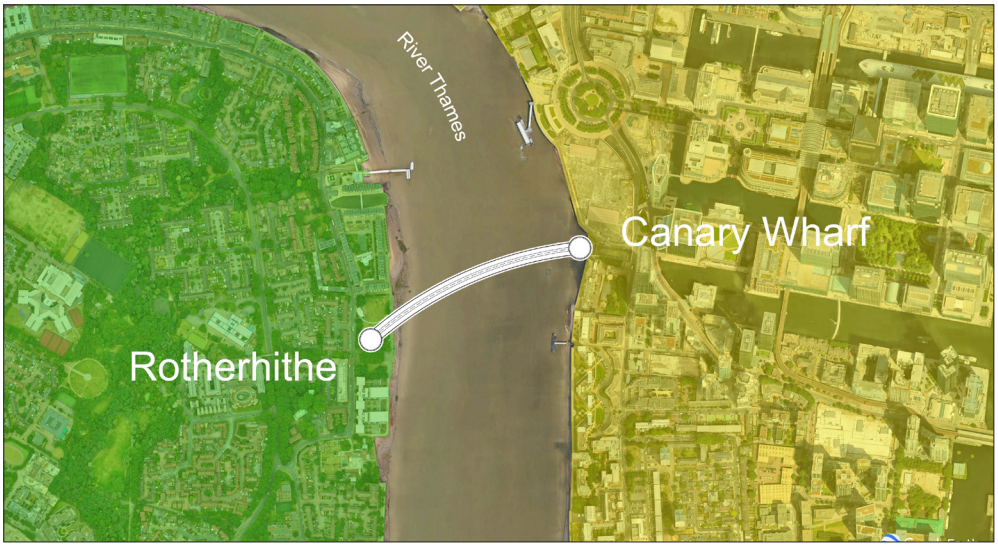
Access to the tunnel is planned via two circular cycle ramps and large twin pedestrian lifts, set in "Geo-Craters" that separate cyclists from pedestrians and allow an uninterrupted journey under the river. The cycle ramps, at the regulation gradient of 1:20, will run along the outer perimeter of the 'Geo-Craters' along a conical pathway, so that cyclists have a full view of the cycle path in front of them. The access 'Geo-Craters' will be protected from the elements by glass canopies carrying UPV panels, which allow daylight into the 'Geo-Craters'.

Unused volumes left at both of the shafts after the spiral ramps have been inserted will be used as plant rooms for handling air, power and other operational requirements. The invert of the tunnel under the tunnel deck will contain the services for the tunnel. There will also be a substantial amount of free space that could be used for additional utilities that need to cross the Thames at this location.

The provisional location on the Rotherhithe side is located in Durand's Wharf Park, to tie in with existing pedestrian and cycle routes. On the Canary Wharf side, the proposed entry point is located within the river at an abandoned entrance to the South Dock and accessed via a ramp.

The tunnel would constitute a critical component of London's cycling network, surpassing expectations of both TfL and Sustrans (custodians of the National Cycle Network in the UK) in improving connectivity in London. It is likely that the tunnel would be used mostly for commuting, and most users would be local people going to work and returning home.

The tunnel will be open to the public at all times. Distinct zones will be created within the tunnelled space: cycle lanes will run along one bore, with bi-directional travellators on the opposite side, and paved walking areas in all three cross-section zones of the tunnel. The central zone is given to a linear garden and a stream with crossings over it.



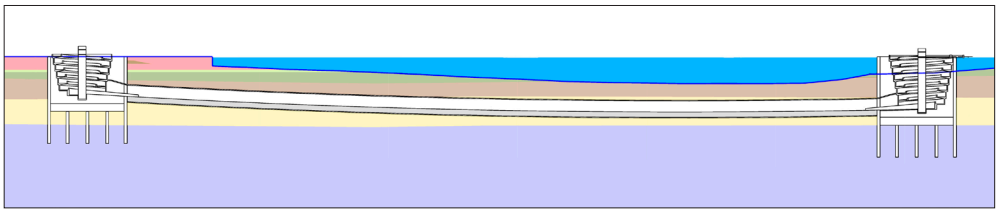
Location map of the proposed tunnel

Construction

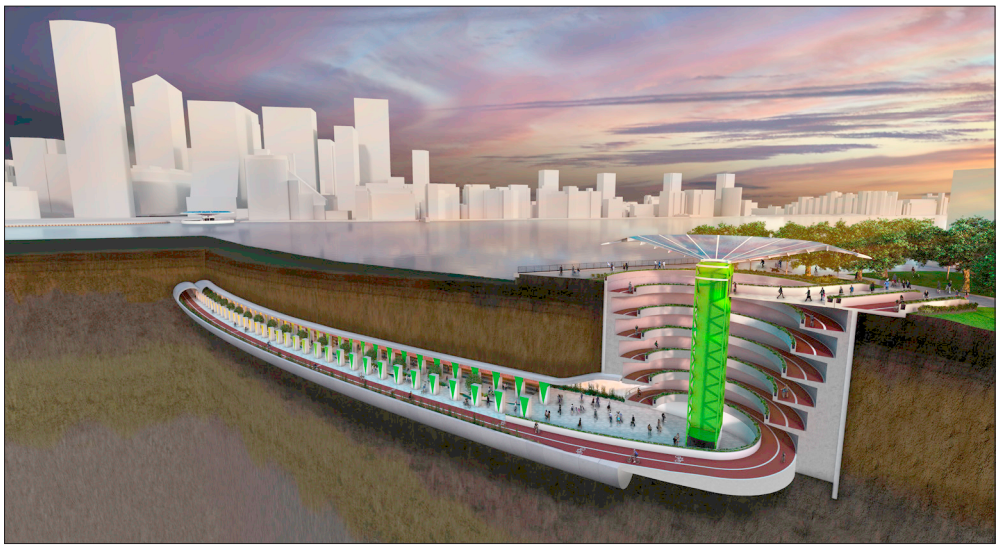
There is already a wealth of tunnelling experience around the Canary Wharf area. In the 1980s, the London Docklands Development Corporation began work in earnest to regenerate the docklands and create one of the main financial centres of the world. The geology is well understood and many kilometres of tunnels for sewers, cables and metros have been completed in recent decades.

The tunnel will be driven using a triple-headed TBM measuring approximately 9m high by 22m wide (the first of its kind to be used in the UK). This type of TBM is produced almost exclusively in Japan by Underground Infrastructure Technologies Corporation (UGITEC) with whom the authors have collaborated with in the development of this proposal.

The TBM would be assembled in a 37m internal diameter circular diaphragm wall shaft on the Canary Wharf side of the crossing, before being driven across to the reception site on Durand's Wharf (also a 37m diameter D-wall shaft).



The project's longitudinal section



Use of the shafts for user entrance and egress

The route passes under the river through the Lambeth Group, comprising Clays, Sands and Gravels, and the Thanet Sands, and the TBM will excavate a total of 70,000m^3 of soil which would be transported away by barge.

Challenges during construction include the lack of suitable free space for site establishment, materials storage, and soil disposal. The drive site would therefore have to be created in the river, using a temporary working platform (outside of the navigable channel) and materials in and out will also be via the river. This technique has been successfully adopted for many of the recently completed London Tideway worksites.

After the tunnel has been driven and the TBM removed, the shafts would be used to create conical cycle ramps, with twin lift cores at their centres, and the leftover cavities would be used to house technical plant rooms and additional emergency access needed for the safe operation of the tunnel.

The tunnel lining system would be formed from a single-pass precast concrete segmental lining comprising two ring types. Whilst the constant vertical and horizontal radii greatly simplify the segment geometry, accurate plane control will be essential. After the completion of each 2.5m long ring, the plane of the leading edge will be surveyed by scanning and minor plane corrections will be made by the introduction of tailored EPDM packers. It is therefore anticipated that progress will be modest (around one 2.5m long ring per shift).

The ring will be boltless and reinforced with a hybrid system of GFRP bars and steel fibres to provide a sustainable and robust solution. Watertightness will be achieved using a double cast-in EPDM gasket system with cross-compartmentalisation.

Visual Stimulation and Ambience

Moving along a tunnel can be a monotonous experience. The designers' aim was to alleviate this feeling. To achieve this, firstly, the colour scheme will be different on the Rotherhithe side from that on the Canary Wharf side. The schemes will merge at the centre of the tunnel length to mark the halfway point of the passage. Secondly, planting, paving and the perforated acoustic panels will add to the stimulating ambiance of the tunnel.

Fresh air will be drawn from above ground level and be pushed through the tunnel. Plants will be selected to aid air purification and fragrance.

The access 'Geo-Craters' have been designed in a conical shape so that as much natural day light as possible can reach the cycle ramps, the bottom of the 'Geo-Craters' and the entry portals to the tunnel. Artificial light in the tunnel will be low energy, LED-based and fully controllable so as to add intensity and colour. The potential for blinding glare at the tunnel exits will be controlled. Diurnal light will be designed for the central zone with the trees and plants.

Echoing is the most frequent acoustic issue with tunnels, especially those that have smooth walls. To manage this, the tunnel will be lined with perforated acoustic panels, either in Copper or Corten. The pattern of perforations will be custom-designed by artists to reflect local history. Plants will also play a large part in achieving acoustic damping. It is also intended that art soundscape will be designed for the tunnel. This may change every day over a week, or any other time or in light-linked patterns. Sound artists will be invited to collaborate. It is further intended that the sound of water trickling along the stream would be audible in the tunnel.

Plants will be selected drawing from international experience, including The Lowline in the New York City borough of Manhattan (formerly known as the Delancey Underground) which started construction in 2019 but unfortunately is currently stalled due to lack of funds.

Business Case

In recent years CECL have undertaken benchmarking for major infrastructure clients in the UK. They are therefore confident that, with appropriate procurement and management, this concept proposal could be delivered more economically than the proposed bridge solution. The estimated construction period would be 4.5 years (including the procurement period for the massive TBM).

Taking advantage of air rights above the 'Geo-Craters' would offer an opportunity for locating buildings there, maybe in the form of towers, all subject to planning and commercial viability. If feasible, income from such developments could be used for example to fund the running and maintenance costs of the tunnel.

Eddie and Bednarski recognise that the current economic climate may not be favourable for the delivery of this concept at this location, at this time. They hope however that this article will promote a conversation about the more visionary use of underground space and that a tunnel option should be perceived neither as boring nor expensive.