

Bristol City Centre Tunnel

£9m project to give the city centre area a 1 in 50 year storm protection

by
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The city centre of Bristol is served by an existing combined sewer system. Inadequate capacity leads to highway and property flooding, and as part of an upgrade to the city's sewage system, works began on the £9 million Bristol City Centre Flood Alleviation Scheme in 2007. The goal of the project is to improve the Bristol sewer system, remove 57 properties from the flooding register, and reduce spills to the city's Floating Harbour, giving the city centre area a 1 in 50 year storm protection. The scheme accepted by Wessex Water is a gravity combined sewer tunnel connected to an existing four mile long northern foul interceptor constructed in previous years (1990 -1994).



Primary Lining with Ribs and Laggings

Courtesy of Wessex Engineering and Construction Services

Drive shaft

The construction of such an ambitious & prestigious engineering project in the heart of the buzzing city centre has been carried out by traditional drill and blast methods. With little open space available for a new construction site the drive shaft required has been excavated between the existing NCP car park and Ice Rink in Frogmore Street. In limited space, excavation of a drive shaft of 6m wide and 16m long began. This drive shaft was located within 3m of the car park foundation in a horizon of mixed and weathered sandstone with rock head on the one end. Due to the rock formation and the proximity of existing structure this shaft was supported with a system of 40 (No.), 300mm diameter steel cantilever piles spaced at varying centres around the shaft perimeter linked by a concrete ring beam at the surface and requiring a wailing beam at the midpoint of the shaft. The rock faces between the piles were supported with 75mm of steel fibre with reinforced shortcrete applied.

The dimensions of the tunnel itself accommodated a BORAT – twin boom drilling jumbo and scoop tram, approx.4, 5m wide by 3m high. During the dig, additional side cuts and slashes were constructed to allow storage, turning and passing points for plant.

Tunnel Drive

850m of excavation were required in UK's second strongest red rock with more than 500 controlled explosions using a pin point coordinate system applied to map direction between every point. The result proved to be a great achievement and example of good team work.

Drilling and driving our way through, to almost 75m deep below the surface in places, running under precious historical buildings wasn't easy task. Tunnelling through hard rock almost always involves blasting; however there were restrictions involving agreed vibration limits which limited the amount of explosives. The project included bringing 150 kilos of explosives into Bristol each day to blast holes.

The repeated process of drilling, packing, controlled blasting, vacuuming out the fumes created during explosion, removal of muck and stabilization of support has been a constant process, with a target drill of approximately 20m a day through over 200 changes in ground strata with rock strengths in the excess of 450Mpa.

Drill bits designed to last for 30m of drilling actually lasted only for a 3m. As we progressed we came across the variety of surfaces, which



The initial tunnel (left) and the completed lining (right)



Courtesy of Wessex Engineering and Construction Services

ranged from rock more than a dozen times the hardness of concrete to very soft saturated clay. As the tunnel progressed, ground water combined with weak beds, ground fracturing and horizontal layers of rock added to be challenging project.

The most difficult and anticipated moment arrived on 17th November 2009, the last 10m of the drive was the hardest task, as we had to break through the structure of the existing sewer without help of explosives, using temporary works constructed on the other side of the drive.

Tunnel Lining

After a successful tunnel drive from Frogmore Street to Woodland Road the next stage of the project was the final lining.

The tunneline system which is owned by Barhale uses a sectional steel shutter that is pre-tensioned in the host tunnel before concrete is pumped under pressure into the extrados void. In the case of the Bristol tunnel the host structure was too large for this approach so an alternative method had to be devised. Barhale's method for this was to design a pre lining shutter of conventional ribs and laggings that would act as a bulk filler to roughly form a circle and then to install the tunneline inside this in a 2 stage operation.

The initial lining was a three quarter circle cast to the tunnel shoulders to a diameter of 2.7m using steel ribs and timber laggings. These were installed and advanced at an average rate of 35m per day working day and night to complete the 805 metre tunnel. Following on some 120m behind this, the tunneline shutter was fixed and pre-tensioned inside the initial cast and a second crew engaged to undertake the concreting work.

Site Agent Grant Slade commented "overall, the concrete programme took 5 weeks placing 6000m³ at an average of 240m³ per day, and with over 26,000 man-hours worked on this section of the contract without accident or incident, it's a great testament to the skill and competence of the Barhale workforce and co-operative working in planning this phase of the project with Wessex Water."

Once lining was completed the drive shaft was backfilled and the area reinstated.

The project team

Wessex Engineering and Construction Services (WECS) was the principal contractor, designer and CDM coordinator, working in cooperation with Donaldson Associates (designers), Specialist Engineering Services (tunnel excavation) and Barhale Construction (tunnel lining). This hands-on approach by Wessex Water has proved fruitful.

Completion

Two years from commencement of construction and the new sewer is now taking waste water safely out of the city, to be treated at the one of the ten largest sewage treatment works in UK at Avonmouth. The tunnel came in exactly on the budget and on time, and has been fully functional since early March 2009, well in time for the potential risks of increased summer flooding. The only public signs left of the project are two additional manholes in Frogmore Street.

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