Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte
Band: 78 (1998)

Artikel: A50 Blythe Bridge to Longton - Meir Tunnel
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DOI: https://doi.org/10.5169/seals-59021

A50 Blythe Bridge to Longton - Meir Tunnel

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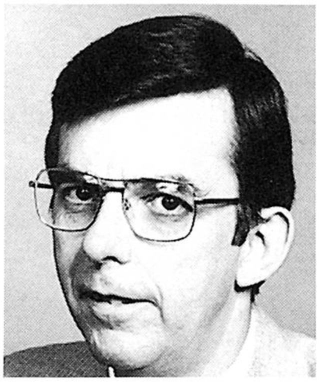

Bob McKittrick, born 1944, graduated with a BSc in Civil Engineering from Glasgow University. He joined Scott Wilson in 1967 and worked for 7 years in Hong Kong project managing developments in Tuen Mun New Town. His main expertise is bridgeworks.

Summary

Meir Tunnel, 284 metres long between portals, forms part of the upgrading of the A50, through a heavily trafficked urban area of Stoke-on-Trent in England, to dual carriageway. Construction was preceded by the diversion of a large number of utilities, followed by temporary traffic diversions. The walls of the twin cell were formed by contiguous bored piles; ground was then excavated to a depth of 2 metres to enable the roof slab to be constructed. Excavation was then carried out beneath the roof, the base was cast, carriageway laid, linings, lighting and controls installed. The tunnel is self-ventilating. Varying levels of lighting are provided; radio re-broadcast facility is provided for emergency services; three crossover openings are provided in the central wall.

1 History

In the mid 1980s a scheme was developed by Scott Wilson, as consultants to the (then) Department of Transport, to improve the environment of the centre of Meir (Figure 1) by constructing the proposed A50 dual carriageway below existing ground level and carrying the A520 on a low level bridge over a new pedestrian area. This plan was presented in June 1986 to the public who rejected it on the grounds that they wished the Meir crossroads area to remain unchanged. The scheme was then amended considerably and a Public Inquiry was held in November 1990. The proposals were rejected in part and the scheme was further changed and re-presented to the public in 1992 followed by a second Public Inquiry in the summer of 1993. The final scheme which evolved resulted in a lengthened tunnel and an at-grade roundabout above it so as to minimise changes to Meir.

The main objectives of the project were to:

- improve safety for pedestrians, cyclists and drivers
- reduce traffic noise and air pollution
- improve the appearance and amenity of the centre of Meir
- minimise the traffic impact on Meir and retain its existing character and potential for development.

2 Description of the Works

The contract comprises:

- 2 km of dual two-lane carriageway with a 2.5 m wide central reserve
- a tunnel some 284 metres long
- a roundabout and slip roads above the tunnel
- four footbridges (including a cable-stayed one using carbon fibre cables)
- numerous retaining walls.

Figure 1: Meir Crossroads prior to construction

3 The Tunnel

3.1 Ground Conditions

The general geology of the route consists of Middle Coal Measures overlain successively by pebble beds, Keuper Sandstone and Keuper Marl. The tunnel is located within the pebble bed strata. The pebble bed strata consist of interbedded red weakly-cemented sandstones and weakly-cemented to un-cemented quartzitic conglomerates. The pebble bed strata are underlain at depths of about 35 m (west end) to 70 m (east end) by Middle Coal Measures deposits at the tunnel site. In the vicinity of the tunnel construction, groundwater is about 14 m below existing ground. There are many coal seams beneath the site but there are no recorded workings and no plans to mine beneath the site in the future.

3.2 Concept Design

Both 'bottom up' and 'top down' methods of construction were considered.

For 'bottom up', thought was given to forming temporary excavation sides by grouting, soil nailing, sheet piles and king piles/lagging walls. A sequence of construction was developed. For 'top down', consideration, for the side walls, was given to diaphragm walls, secant piled walls and contiguous bored pile walls. Again a sequence of construction was prepared.

The following comparisons resulted:

'Top Down' Construction	'Bottom Up' Construction
• Excavation support walls form integral part of Permanent Works	Excavation support walls independent of permanent works.
• Depth of walls depends on ground conditions and will have to be specified by the Engineer	Excavation support is the responsibility of the Contractor.
• No ground anchors or temporary works impinge on adjacent buildings.	Temporary ground anchors located beneath some adjacent buildings.
• Excavation width is the minimum required and is not enlarged in tunnel approaches.	Excavation width is larger and is further widened in tunnel approaches to construct heel of retaining wall.
• Sequence of excavation is dependent on permanent works requirements.	Sequence of excavation is not dependent on permanent works requirements.
• Monitoring of excavation is required to ascertain deflection of the wall and settlement and displacement behind the wall.	Monitoring of excavation is required as for 'top down' construction plus monitoring of ground anchors.

Although 'bottom up' construction appeared to offer a cost saving it imposed significantly more disturbance and 'cut and cover - top down' using contiguous bored piles was specified in the contract.

3.3 Detailed Design

The tunnel comprises two cells, each being 9.5 m wide between secondary cladding, and contains a 7.3 m carriageway together with 0.2 m edge strips, a 1.0 m outer verge and a 0.8 m inner verge. 900 mm diameter contiguous piles form the side and central walls which are clad using vitreous enamelled steel panels. The East tunnel portal is to have a decorative brickwork feature as it effectively will be a 'gateway' to the City of Stoke-on-Trent.

During the detailed design a trial bore was constructed to confirm the feasibility of constructing bored piles and measure the resulting noise and vibration levels both of which were less than those generated by passing traffic. The piles forming the tunnel walls were generally to penetrate six metres below the tunnel invert giving them an overall length below existing ground level of at least 13.5 metres.

The design was based on the concept of constructing the south cell first and diverting traffic through it whilst the north cell was built. Consideration was given to using the road pavement as a prop for the piled walls but this was rejected as imposing an unnecessary constraint on the contractor.

The original public utilities were located in the existing roadway or footways. To allow construction of the new road and tunnel they had to be diverted and have been repositioned in the new cycleway, footways or service roads. The costs involved, which were paid separately by the Client, were estimated to be about £5 million.

3.4 Tunnel Statistics

Length of tunnel	:	284 m
Volume of structural concrete	:	8700 m^3
Tonnage of reinforcement	:	3700 tonnes
Number of contiguous piles	:	810
Total length of piles	:	7500 m
Volume of earth excavated	:	50,000 m^3
Predicted peak hour traffic flows in the year 2012	:	Westbound 2600 vph Eastbound 3300 vph
Permitted traffic speed	:	64 kph (40 mph)
Costs	:	£4 million between portals + £2 million for lighting & communications

3.5 The Tunnel Equipment

The tunnel is provided with sophisticated monitoring and environmental equipment. Although its length of 284 metres does not require forced ventilation (the piston effect of passage of vehicles through the tunnel will achieve this) many other features are provided.

All control and monitoring systems emanate from the tunnel control building located on the western approach to the tunnel. The tunnel control building is protected by fire detectors linked to an automatic gas extinguishant system and by an anti-intruder security system.

Two separate 11kV substations are provided in the tunnel control building, each being supplied independently from primary sources by the MEB. Each of the two supplies, A and B, will be capable of independently maintaining all tunnel and control building services with automatic changeover in the event of a failure of either one. In the event of a complete failure of the mains electricity system, an uninterruptible power supply (UPS) will come into operation, again with two alternative systems, to supply power to essential services for a minimum of two hours to allow time for evacuation of the tunnel, diversion of traffic and restoration of mains electricity supplies.

The tunnel lighting provides varying lighting levels controlled by photometers on each approach to the tunnel, in accordance with ambient lighting levels. The lights at each end of the tunnel are arranged in four lines along each cell, with a variety of luminaires in each line. The arrangement at each tunnel threshold is different from that in the central section which has two lines of luminaires. Six stages of illumination are provided to allow for all levels of ambient lighting in the transition between day and night, with automatic switching between the stages controlled by the photometers and monitored in the tunnel control building. In the event of a failure of the mains supply a reduced level of overhead lighting and an additional set of emergency lights at low level will be fed from the UPS supply.

Four full-colour pan tilt and zoom closed circuit television cameras, with a zoom ratio of 10:1, are located in the tunnel. Additional ones cover the approach roads. All are linked via the tunnel control building to the Stoke City Monitoring Centre. In the event of an emergency or an incident, control of the monitoring and recording operation can be assumed at either the tunnel control building or at the police control centre in Hanley Police Station.

Eighteen Motorway Standard emergency telephones are provided in the area of the tunnel - seven in each cell with four more on the tunnel approaches. Each is linked to the tunnel control building and to police headquarters. A radio re-broadcast system is installed to allow the use of radios by the emergency services within the tunnel.

When it is necessary to close the tunnel for an emergency, road traffic accident or for general maintenance work, variable message signs are provided on the approaches to the tunnel to divert traffic onto the slip roads and across the roundabout in the centre of Meir. A total of fourteen traffic queue loops are installed in the road surface within the tunnel to detect standing traffic. Visibility sensors are situated on the tunnel walls to warn of low visibility caused by exhaust fumes etc.. A series of signs warn drivers of stationary vehicles to switch off their engines to avoid a build-up of exhaust fumes.

Sensors are installed in the drainage system within the tunnel to detect any significant build-up of oil, diesel etc. and a valve is provided to prevent the discharge of these liquids into the public sewers. Fire extinguishers are located in separate cabinets throughout the tunnel adjacent to the emergency telephones and near the emergency crossover doors. Fire hydrants are provided for the use of the fire and rescue services at each end of each cell of the tunnel.

3.6 Roadworks

A 150 mm thick layer of cement bound sub-base material is placed on compacted ground through the tunnel area and the approach ramps. This is overlain by a 250 mm thick layer of continuously reinforced concrete roadbase.

Two layers of bituminous material are laid on top of the concrete roadbase. The lower layer is 60 mm thick rolled asphalt, which forms an impermeable barrier to protect the concrete roadbase from the effects of water and salt. The final surface comprises 50 mm of porous asphalt, which has been selected for its environmental and safety benefits. This type of surfacing not only lowers noise from the road, but reduces the effects of spray in wet weather.

Actual construction details for the road through the tunnel are:

Bituminous Surfacing (porous asphalt)	50 mm
Bituminous Basecourse	60 mm
Concrete Roadbase	250 mm
Cement Bound Sub-Base	150 mm

4 Tunnel Construction

The contract, at a tender cost of £21.3 million, was awarded to Amey Construction Ltd, under the ICE 5th Edition Conditions of Contract, and construction commenced in April 1995 for a planned completion in spring 1998. Construction of the tunnel itself started in July 1996 once the area had been cleared of all service cables and pipes. Three rows of contiguous bored piles were bored and concreted to form the central division and two outside walls. In December 1996 the first of the tunnel roof slabs was cast in a 20 metre section, and this was followed on a regular basis by other sections of roof. (Figure 2) Soil was excavated from both halves of the tunnel by a combination of a tracked excavator and a rubber tyred shovel. Special precautions were taken to ventilate the air inside the tunnel and to keep it free from obnoxious exhaust fumes. Some of the excavated material was used on another local road scheme in Stoke, while the rest was disposed of at local tips.

Figure 2: Road diversion during tunnel construction

Two sections of the tunnel which could not be constructed at the same time were those under Broadway and Weston Road where these crossed the construction area. Following the casting of adjacent roof slabs, both roads were diverted across the new tunnel roof in January 1997, allowing access to the remaining two sections of tunnel construction which were completed in mid March 1997. Excavation was completed in mid April 1997.

The piles exposed within the tunnel were then cleaned and the casting of concrete plinths etc. was commenced. (Figure 3) At the same time the road slab was cast and this was followed by installation of the tunnel linings, lighting and control systems.

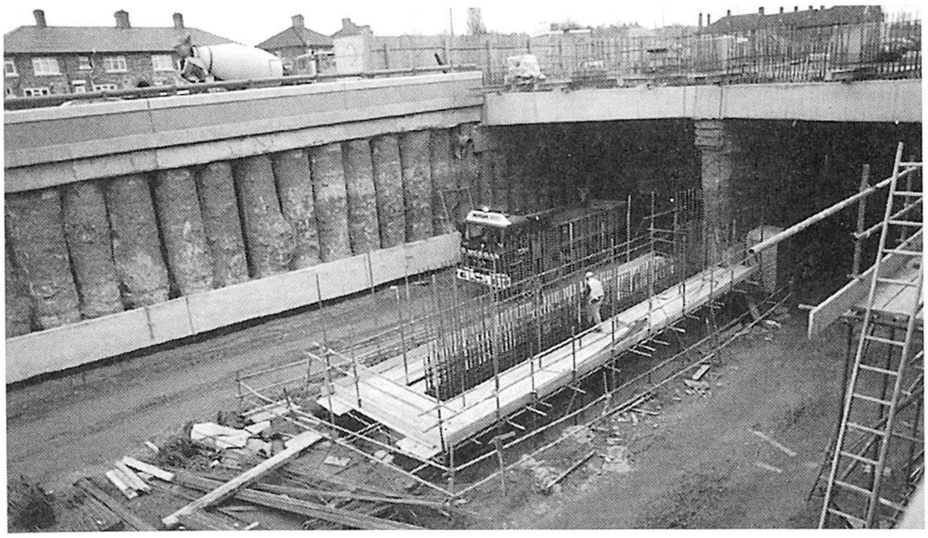

Figure 3: Tunnel construction

The tunnel is due to open by the end of 1997, some four months ahead of programme.