CASE STUDY

Ground investigation for Creswell Viaducts widening on M6 motorway

STRUCTURAL SOILS LTD

Background

Highways England's smart motorways programme includes widening sections of the M6 motorway. Smart motorways use the hard shoulder for traffic, either permanently or at peak times, to provide extra capacity.

Close to Junction 14 of the M6 motorway, the carriageway is carried over a low-lying flood plain, a river and a railway line by a series of three viaducts known as the Creswell Viaducts.

Highways England proposes to widen viaducts 2 and 3 and their associated embankments to accommodate a change in layout at Junction 14 where the M6 southbound carriageway is to be widened by about 6 m.

Site setting and constraints

The viaducts and embankments carry the motorway about 8 m above the flood plain. A narrow access track running alongside the eastern side of the motorway at the foot of the embankments is accessed from a busy roundabout for the Junction 14 entry and exit slip roads, the B5013 and the A34. A public footpath and farm access crosses the site. Although the access track and viaducts are not formally open to the public, local dog walkers and others use them. Parts of the site are prone to flooding during winter storm events.

Historical records show viaducts 2 and 3 to be founded on raking piles that appear to be driven into the underlying bedrock. The embankment foundations are shown to be reinforced concrete slabs supported by pile foundations and the shoulders are shown to be constructed from stabilised soil. Tensioned vertical restraint barriers separate the motorway hard shoulder from the top of the embankments with a narrow verge between in places.

British Geological Survey records and records of past ground investigations show the site to be underlain by thick alluvial, glaciofluvial and glaciofluvial sheet deposits over bedrock of the Mercia Mudstone Group, with groundwater standing at less than 1 m deep.

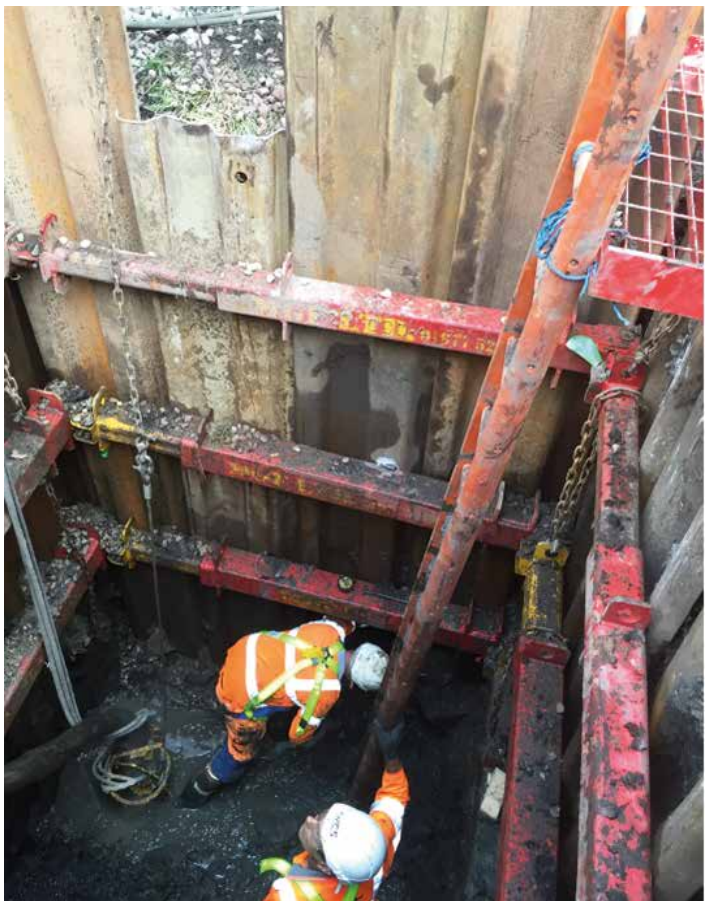
Main ground investigation

The Carillion–Kier joint venture initially employed Structural Soils, an RSK company, in August 2016 under an NEC3 form of contract to carry out a ground investigation to inform the project design on behalf of Highways England. The investigation supervisor was the Jacobs–Atkins joint venture. The main investigation had many different elements of work, including

- cable percussion boreholes to depths up to 50 m, most of which were extended by rotary coring
- boreholes drilled from narrow sections of motorway grass verge at night (with sections of temporary barrier restraint system being removed) to investigate the stabilised soil embankments
- pavement coring in the hard shoulder
- conventional machine-excavated trial pits plus embankment slit trenches completed using a long-reach excavator
- in-situ testing, including high-pressure dialatometer and lorry-mounted, static cone penetrometer testing
- the construction of sheet-pile-shored trial pits, excavations beneath pile caps within header boxes and testing of piles using acoustic techniques
- geotechnical and geoenvironmental laboratory analysis.

The investigation proved challenging, as the linear and mostly narrow nature of the site made it difficult to programme and complete different activities while maintaining the access needed by the investigation plant. The ground conditions encountered also posed some problems. The glaciofluvial deposits, typically sand with varying amounts of gravel, were locally much thicker than expected (more than 50 m), so Structural Soils mobilised additional larger-diameter drilling equipment to deal with this.

The shallower peat deposits were locally more than 10 m thick. The weak peat soil was incapable of providing adequate support for the 6- and 9-m-long sheet piles employed for the shored trial pits where embankment self-weight and groundwater surcharge pressures were present. Therefore, not the all planned pits to expose the existing pile foundations could be completed.



During the course of the work, a bat roost was identified in one of the viaduct structures, which resulted in some changes to the sequence and scope of work. Structural Soils, as part of multidisciplinary environmental consultancy RSK, was able to support the client by arranging for RSK specialists to perform a noise and vibration monitoring survey. Other RSK services used for the ground investigation were utility detection surveys by RSK SafeGround and chemical contamination testing of soil samples by Envirolab.

Additional ground investigation

Following completion of the main investigation, Structural Soils was asked to undertake further specialist investigation of the embankment and pile foundation structures:

- dynamic probe penetrometer testing around the viaduct abutment foundations with the aim of proving the presence or absence of raking pile foundations
- dynamic probing through the embankment slopes to prove the extent of the underlying piled concrete slab
- inclined dynamic sampling and rotary cored boreholes through the stabilised soil walls within the embankment.

The first element of work was routine and more than 160 dynamic probe tests were completed. The other two elements were more difficult owing to the need to conduct investigations on and through the embankment slope, which required specialist access equipment.

A long-reach, 20-t, Komatsu PC 220 LC tracked excavator specially modified to enable different investigation apparatus and working platforms to be connected to the boom was used to provide access for plant and personnel to work on the embankment slopes. The slopes were of variable inclination and height, but were estimated to be more than 40° at their steepest and at or beyond the practical limit of most slope-climbing equipment.

Dynamic probing was carried out on the slope from a working platform fitted to the boom. Using the long-reach excavator enabled probing to be undertaken at most points on the embankment slopes and made relocating the equipment along a line for each successive test simple. It also removed the stability risks and anchoring requirements inherent to slope-climbing drilling rigs and avoided the need to access the work areas from above via the motorway carriageway.

The same excavator boom was then fitted with a modified rotary drilling rig mast to enable the inclined boreholes to be progressed by dynamic sampling and rotary coring techniques through the embankments and stabilised soil walls within. Working platforms were lifted onto the slopes by the excavator and anchored in position at each hole location to provide access for the drilling team and to hold the equipment and materials required. The borehole lengths ranged from 4 to 8.8 m at inclinations ranging from 18.9 to 43° from the horizontal.

Safe systems of work

The Carillion–Kier joint venture employed Structural Soils as a contractor under the CDM Regulations 2015. Structural Soils undertook a site walkover to inform the development of a site-specific risk assessment and method statement.

The site access was via a Highways England access gate alongside a busy roundabout at the intersection of motorway slip roads and A and B roads, which created a high risk of collision between site traffic entering and leaving the site and other road users. Structural Soils mitigated this by repositioning the gate further from the road to provide adequate space for delivery vehicles to enter and exit the verge safely, and by operating a site access plan that included timed deliveries for large loads and supplemented by staff briefings and simple signage on the approach to the entry point. The gate and fencing were removed temporarily to provide access for the widest deliveries.

The shored trial pits requiring man entry presented another significant risk on this project. Consequently, specialist subcontractors were employed for the design and construction of the piling, confined spaces trained personnel were employed and an emergency rescue plant was put in place as part of the safe system of work. Groundwater pumped from the excavations was run through a silt removal system then discharged to ground with the approval of the local environment officer and others.

Where the scope of work was altered, management of change procedures were followed, new tasks or hazards were assessed and site-specific safe systems of work were developed. For example, a new requirement to carry out utility location excavations at the top of the embankment slope led to the use of harnesses to mitigate the risk of falling down slope. Site operatives invoked stop-work authority when dangerous concentrations of hydrogen sulphide gas arising from the peat deposits were detected while excavating one of the shored trial pits. The risks were assessed and a forced ventilation system was used to enable work to proceed safely.

Before supervising the work on-site, Structural Soils site supervisors completed a ‘Supervisors working with Carillion’ training course to bolster their existing CITB or IOSH site supervisor or manager qualifications.

Outcome

On completion of each phase of the work, factual reports and AGS data were provided. The work, which presented several challenges owing to the site constraints and investigation locations, was delivered safely and without significant incident.

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