

## RAIL: SCOUR PROTECTION

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# SHIELD OF STEEL

Protecting bridges from scour is one of a wide range of repairs and upgrades that London Underground is carrying out on its structures this year. **Margo Cole** reports.

**L**ondon Underground (LU) is in the process of installing protection for four of the bridges on its network that have been identified as being at the highest risk of scour.



The first in the programme – and the first scour remediation scheme ever undertaken by the organisation – was a Victorian brick arch structure, known as underbridge MR80, which carries the Metropolitan Line over the River Gade in north London.

Underbridge MR80, located





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between Moor Park and Rickmansworth stations near Watford, was originally constructed in 1887. It has four brick arches, all with a 6.2m span, supported on 900mm wide, 18.4m long brick and concrete piers founded on 450mm deep concrete strip footings. The western side of the bridge was widened during the 1940s and its eastern side was partly reconstructed in 1961.

Under normal conditions the River Gade only flows through one of the arches but, when the river floods, it flows through the adjacent ones as well.

Once the bridge had been identified as being at risk, LU's capital projects directorate (CPD) civil engineering team carried out a feasibility study to consider various scour prevention options.

That study included

- whole life cost
- impact on rail services during construction
- ease of handling and transporting materials to site
- speed and ease of construction
- the effect of a 200-year return period flood event
- risk reduction as a result of the mitigation measures
- the environmental impact of the mitigation measures
- changes in flow profiles caused by the mitigation measures
- impact on scour

The preferred solution was to install steel sheet piles



**Temporary works:** Water was diverted through flume pipes

upstream and downstream of the bridge, construct a concrete invert in the river between them, and place precast concrete blocks downstream of the concrete invert to prevent scour holes forming.

LU commissioned an intrusive survey to get a clear understanding of the geotechnical parameters of the existing ground conditions and

accurate data on the bridge foundations.

The ground conditions were found to be made ground for the first 600mm, alluvium to a depth of 2.5m, and river terrace deposits down to about 6m, with weak low density chalk underlying the river terrace deposits.

The organisation also undertook an ecological survey of the surrounding area, as one of the key considerations of the project was the potential impact of the work on the surrounding environment. The bridge is located within Croxley Common Moor, which is a site of special scientific interest (SSSI), so the project was going to involve close liaison with Natural England, as well as the local authority, Three Rivers District Council, and the



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Adriaan Wolhuter,  
London Underground





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Environment Agency.

The scheme was designed by LU's in-house civil engineering design team, and then competitively tendered to contractors on the organisation's approved supplier list. The job was won by Dyer & Butler.

The permanent works design consists of Larsen 605-05 sheet piles, embedded to a depth of 6.5m upstream and downstream of the bridge foundations, with a 300mm concrete slab cast between the sheet piles and covered with 200mm of clean gravel. Dycell 150 precast blocks were placed downstream of the newly installed sheet piles.

To build the permanent works, the contractor had to undertake some complex temporary works to divert the River Gade through flume pipes in one of the adjacent arches. This involved installing a temporary sheet piled cofferdam.

One important consideration was the requirement to use non-impact piling techniques close to the existing bridge as, according to LU project manager Adriaan Wolhuter, "brick arch structures of this age are quite vulnerable to vibration and structural movement".

Dyer & Butler's piling subcontractor Suttle opted for a Movax vibratory pile driver mounted on a Doosan excavator (*see box*) to meet

## THE MACHINE



**Doosan:** Low emission machine

**Sheet piling for the MR80 scour prevention scheme was carried out by Dyer & Butler's specialist subcontractor Suttle Projects.**

It used a Movax side-grip vibratory pile driver mounted on its brand new Doosan DX255LC-3 25t crawler excavator.

The machine was used for the temporary cofferdam created to enable water to be diverted through a side arch in the bridge, as well as for the permanent scour prevention solution.

The Stage IIIB-compliant excavator meets emission regulations through the use of cooled exhaust gas recirculation, diesel oxidation catalyst and diesel particulate filter after-treatment technologies.

Suttle managing director Joe Paine says its investment in the Doosan machine "demonstrates our belief that only the most modern and up-to-date technology should be used for our sheet piling work, a view that

is not shared in every part of our industry. The fact that we carried out this work in an especially sensitive area such as the River Gade reinforces the point about using only state-of-the-art, environmentally acceptable equipment," he adds.



Paine says that, as environmental concerns increase, he expects "new generation" machines like the Doosan excavator, with greatly reduced emissions and clean technology, to be "a prerequisite for work on projects of this type".

Doosan says that, with the new DX255LC-3, the company "has gone much further than just meeting the Stage IIIB regulations", and the new design has improved productivity, fuel efficiency, controllability, operator comfort, reliability, durability and serviceability.

The excavator – in common with all the construction equipment used on the River Gade project – was operated with biodegradable oil.



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this requirement, while LU organised extensive vibration and structural movement monitoring to ensure the piling – and any of the other construction activities – were not having a detrimental effect on the structure.

One of the more unusual stakeholders in the project was a local fishing club, The Watford Piscators.

“Initially, when the club was made aware of the proposed works, they were extremely concerned regarding the potential impact the project could have on their fishing club, as their main fishing lake is only 12m from the actual worksite and contains at least £250,000 worth of fish,” says Wolhuter.

“The main concern was that the vibration from the piling could trigger a release of methane from the bed of the fishing lake, which could have a catastrophic impact on the fish,” he continues.

“Very few studies have been conducted on the effect of piling on fish in the UK, and those studies which have been carried out have mostly been done on salmonids [the salmon family] and not cyprinids [carp].”

## REPAIRS, UPGRADES AND IMPROVEMENTS

**LU’s scour protection schemes are part of a programme of repairs, upgrades and improvements that the organisation carries out every year on its 12,000 bridges and structures.**

That programme is valued at around £25M a year, with a further £15M being spent remediating cuttings and embankments.

The programme is made up of individual projects, most valued at around £2M or £3M, with the largest being around £8M.

Design is usually done in house, according to LU civils

sponsor James Andrews, who is responsible for deciding what goes into the programme.

“The majority are designed in house – especially where they are more complex and more specialist, because you need to understand the impact on other assets,” he explains.

The programme includes a wide range of structures – LU estimates it owns more than 50 different types of structures, from major bridges and culverts to platforms and pipes – and a variety of repairs. Recent jobs include strengthening a major cast iron sewer and protecting bridges against vehicle incursion.

LU, Dyer & Butler and the Watford Piscators agreed a range of measures to avoid detrimental impacts, including increasing the oxygen supply in the lake through a wind aerator; vibration monitoring at the lake before work started, as well as during the piling; and employing an external fisheries expert to monitor the oxygen and methane levels in the lake. The measures were so successful that the team was able to reassure the owner of

a similar fishery close to the location of the second scheme.

That job – underbridge MR85 carrying the Met Line over the River Chess – has just been completed. It was also done by Dyer & Butler, but was not part of the original contract.

“We didn’t package them together initially because we wanted to see how it [MR80] went,” explains Wolhuter. “It went very well, so we awarded the second job as a variation to that contract.”