Oldbury Viaduct major renewal scheme

The £100m+ Oldbury Viaduct project, located between M5 junctions 1 and 2 in Sandwell in the West Midlands is, the largest concrete repair project (by value) ever carried out in the UK. This project began in April 2017. ***Matt Cain*** *and* ***Michael Balletta*** *of* ***Concrete Repairs Limited (CRL)*** *report.*

Above: Ready-mixed concrete being poured in a 200m^2 repair.

The M5 is one of the busiest motorways in the country, carrying traffic through the Midlands and on towards routes in both the north and south. Oldbury Viaduct on the M5 is exceptionally busy, with traffic joining with the M6 and other major routes into and out of the Birmingham and Sandwell conurbations. Up to 120,000 vehicles use the viaduct each day and it has several interfaces with local roads, canals, railways and tram lines.

Formerly part of what was known as the Midland Links Motorway, the viaduct, which was constructed in the late 1960s and opened in 1970, is a 3.2km-long elevated section to the west of Birmingham. Although the viaduct was considered structurally sound, Highways England realised the need to carry out essential repair work to the concrete decks, deck ends and cross-head beams as the waterproofing system and expansion joints on the motorway deck had degraded over the years, causing extensive deterioration.

The decision to repair this section of motorway at this time was based on the current condition of the viaduct and to avoid large-scale projects occurring at the same time around the 'Birmingham Box' – the M5/M42/M6 – over the next few years. The work formed part of the Government's long-term Road Investment Strategy to build a modern and resilient road network that would last well into the future.

The viaduct is split into 165 separate steel reinforced concrete deck sections (slabs) linked by expansion joints in the gap between the ends of each section. A waterproofing layer then protected the deck, but this had deteriorated over time, resulting in chloride-contaminated water ingress and causing the reinforcing steel to corrode and concrete to spall.

Three stages

The concrete repair work was carried out in three stages to allow for the continued two-way traffic flow of this strategic route. The first was the southbound carriageway, followed by the northbound section and finally the central reservation. CRL was appointed as the concrete repair contractor alongside VolkerLaser. The principal contractor was a joint venture between BAM Nuttall, Morgan Sindall and VolkerFitzpatrick, known as BMV.

The concrete repair work carried out here involved the northern section of the viaduct closest to junction 1, comprising a 1.5km stretch of deck, covering 50,000m^2 (essentially half the viaduct). From CRL's perspective, even though the nature of the contract was typical of work commonly undertaken – involving hydro-demolition, continuity testing, installation of sacrificial anodes and then reinstatement with a pre-bagged flowable micro-concrete – the scale of the work was unprecedented.

In total, CRL carried out full repairs to its allocated section: 125 deck ends, over 4500 individual mid-span areas and the replacement of half a deck as part of a single repair covering 200m^2. To achieve this, 10 million litres of water was used during the hydro-demolition works, 1.5 million kilograms of concrete repair material was used, 21,000 sacrificial anodes were installed and almost 350 individuals contributed to the project's success in this section alone.

The southbound (first) phase was carried out over a period of 13 months, during which time the four-lane carriageway was closed to traffic for the entire duration. Both northbound and southbound traffic used the northbound carriageway via a contra-flow system, which enabled operatives to work two full shifts a day, six days per week. Some areas of the motorway had other roads passing directly underneath, which required completion of the concrete repairs during full weekend closures of the road underneath from 8pm on Friday until 6am the following Monday.

The work process started with BMV removing the existing surfacing and taking off the failed waterproofing system. A third party – Socotec – then tested the deck to identify where concrete repairs were needed. Hammer testing identified where the concrete had delaminated, half-cell testing pinpointed areas of potentially corroded steel and surface defects were identified via visual inspections. Chloride testing was also carried out to identify where chloride salts had penetrated the deck to the depth of the reinforcing steel.

Once the areas requiring repair were identified, operatives were able to saw cut around the patches that needed repairing and proceed with the hydro-demolition. A 3 × 3m enclosure was created and surrounded with two layers of debris netting to contain flying debris.

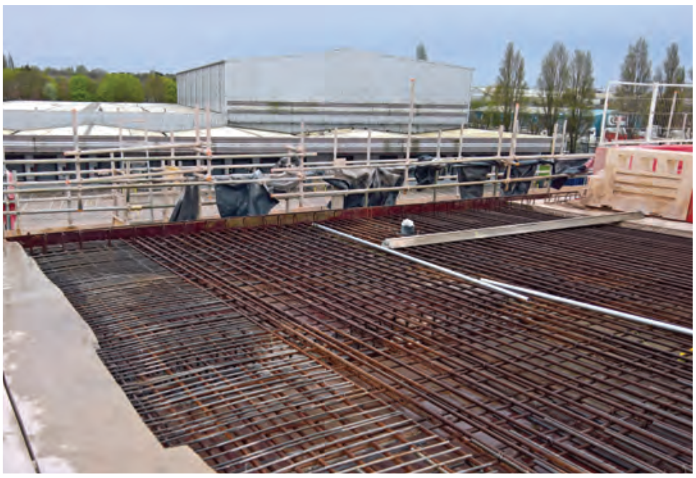
Hydro-demolition was selected as the most suitable preparatory method for both safety and efficiency, as the high-pressure water process used to remove the old concrete and prepare the patch, exposes and cleans the existing steel reinforcement without damaging it. If traditional pneumatic breakers had been used, the reinforcing steel and surrounding concrete would have been susceptible to damage as a result of the impact and vibration created.

Blast water

An added issue that needed to be considered and dealt with during the works is that the hydro-demolition process creates concrete blast water, which, if released without treatment, would have polluted the Birmingham Canal Navigations that run beneath the M5. Concrete blast water typically has a pH of 12–13, which is the equivalent of domestic bleach and would have proved damaging to vegetation, ecosystems and aquatic life if left untreated.

Removal of the concrete blast water via tanker was not feasible, so a number of Siltbuster machines were used to neutralise the high pH water and remove suspended solids. The machines use carbon dioxide, instead of mineral acids, to neutralise the alkaline waters. The use of carbon dioxide not only brings numerous environmental advantages but also it removes the practical safety issues surrounding the storage and handling of acids. In addition, the use of carbon dioxide here allowed for significant cost savings to be made over the duration of the works.

In certain areas, the units were not only used to treat the hydro-demolition blast water but also the surface water runoff after heavy rainfall from the motorway deck, which tended to became alkaline due to the works being carried out.



Reinforcing steel install for part of a 200m^2 repair.

CRL's cathodic protection supervisor training an operative to carry out the continuity testing.

CRL's cathodic protection supervisor training an operative to install the anodes.

Hydro-demolition within the 3 × 3m enclosure.

The next stage

The next stage of the process involved replacing badly corroded steel reinforcement. A number of on-site welding devices/ systems were used to connect the new to the existing reinforcement. The welds were subsequently tested using non-destructive testing methods, including magnetic particle tests and ultrasonic testing. Continuity tests were also carried out on the reinforcing steel before installation of the sacrificial anodes, which were used to prevent potential future corrosion of the reinforcement and thereby significantly extend the life of the structure. Over the course of the contract, more than 21,000 sacrificial anodes were installed.

Once the patches had been prepared, the necessary reinforcement replaced and the sacrificial anodes installed, the broken out areas were then filled in with a high-performance, free-flowing repair micro-concrete conforming to the requirements of Highways England *Specification for Highways Works*[1] and EN 1504-3[2] *Structural and non-structural repair* Concrete Class 29F. Due to the scale of the repairs, large 500kg bags of repair material were used instead of standard 25kg bags. This eliminated manual handling, as the bags were lifted using telehandlers and an opening on the bottom allowed for the material to be discharged into large pan mixers. The mixed repair material was then transferred to the individual repair areas, placed and finished by hand using trowels and floats.

As repair work was required throughout winter months, a winter working procedure was implemented whereby an enclosure was constructed over the completed repair. In addition, warm water was added to the mix and blow heaters were used to keep the temperature above 5°C until the mortar had cured.

Once all the concrete repairs had been carried out on the southbound carriageway, the area was handed over for deck waterproofing before the team moved to the northbound carriageway for a period of ten months, replicating the processes used for the first phase.

The central reservation (final phase), carried out over a period of two months, was the shortest phase. During this period, operatives worked in lanes either side of the central reservation to carry out the required repairs to damaged/spalled concrete. CRL was appointed to carry out the concrete repairs to the central reservation across the full length of the viaduct.

The works carried out have ensured that the structure has been effectively and efficiently repaired, the concrete protected and the lifetime of the viaduct extended significantly, thus ensuring the ultimate Highways England objective of having a robust and resilient road network. ■

References:

1. HIGHWAYS ENGLAND. *Manual of Contract Documents for Highway Works. Volume 1 – Specification for Highway Works. Series 1700 – Structural Concrete (Clause 1770AR)*. Available at: *www.standardsforhighways.co.uk/ha/standards/mchw/vol1*, December 2014.
2. BRITISH STANDARDS INSTITUTION, BS EN 1504. *Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and evaluation of conformity. Part 3 – Structural and non-structural repair*. BSI, London, 2005.

Welding in replacement reinforcing bars.