

A new lease of life: Drewstead Bridge, London

Figure 1 far right: View of southern substructure showing typical cross head beam and four circular columns.

Drewstead Road Bridge in Streatham Hill, London Borough of Lambeth, carries the B221 across the main railway line just west of Streatham Hill Station. It is a significant transport route for Lambeth with bus routes, commuting pedestrians, heavy goods and light vehicles constantly crossing the bridge. The current bridge, which was built in 1968, comprises precast, prestressed concrete bridge beams spanning the railway lines supported by two sets of four circular columns and a crosshead beam (see Figure 1). In 2012, after a thorough investigation and testing of the bridge structure, it became evident that repairs to the superstructure and the supporting columns and crosshead beams were required. After extensive planning and organisation of Network Rail possessions, in 2014 the bridge underwent a large-scale refurbishment to extend the life of the structure by at least another 25 years. **Michael Balletta of Concrete Repairs Limited (CRL) and Tony Parasram of Free4m Consulting report.**

Figure 2 far right: Typical area of spalled concrete on top edge of crosshead beam.



At the time of the inspection, carried out from the railway corridor, a number of the circular columns exhibited significant cracking along their height with some concrete spalling to the crossheads. Water staining on the elevations of the crossheads was evident, with a pattern of staining, cracking and spalling commensurate with the likely path of stormwater percolating past the bridge joints.

Observations made at top-deck level noted cracking in the carriageway surfacing in line with each buried joint, allowing chlorides from the de-icing salts used during winter to saturate areas of the crosshead beams and penetrate into the concrete, thereby increasing the likelihood of reinforcement corrosion.

Large areas of spalling had also begun to take place, indicating that the chlorides had reached the depth of the steel and destroyed the passivity around the reinforcing normally found in good concrete (see Figure 2).

Upon completion of the special inspection, the decision was taken to immediately design and install 'interim' measures to structurally support the distressed columns. Circular steel banding was fitted during engineering hours as a temporary support measure allowing further investigation to be safely carried out.

Condition survey and investigation works

In December 2012, Free4m Consulting commissioned CRL Surveys to carry out a limited programme of testing works to the supporting structure of the bridge. The survey consisted of hammer testing and making safe,

cover meter surveys to selected areas, screening for chlorides and checking for depth of carbonation.

Findings

The results of the testing works confirmed that concrete cover levels and carbonation depths were generally satisfactory, with cover ranging between 33 and 93mm (except for some localised low-cover areas). However, the nature and extent of the chloride values, ranging from 0.1% up to a maximum of 2.7% at the steel, suggested that chloride-laden water, percolating through the deck, had contaminated a substantial part of the portal crossheads. As was to be expected, the highest chloride contamination predominated in the areas with the most water staining, namely the crossheads, with localised chloride high spots at the tops of the columns. The results were borne out by the visual observations (see Table 1).

Decision on methodology

A number of options were presented to the client outlining varying costs and benefits. The minimum works recommended comprised conventional concrete repairs only, to BS EN 1504⁽¹⁾, designed to restore the structure to present-day load-carrying capacity but with no improvement. The final option ultimately agreed on consisted of a combination of concrete repairs with an impressed current cathodic protection (ICCP) system to the portal crossheads.

The client considered the implementation of the ICCP

system best value in not only arresting corrosion but also providing ongoing protection into the future, given that large areas of the reinforcing in the crosshead beams were in the 'high-risk depth' as per BRE Digest 444: Part 2⁽²⁾ (see Tables 2 and 3).

Cathodic protection is simply an electrochemical means of corrosion control in which the oxidation reaction in a galvanic cell is concentrated at the anode and suppresses corrosion of the cathode in the same cell. This can be achieved in two ways: ICCP and galvanic/sacrificial cathodic protection.

An outline design of the concrete repairs and ICCP system was prepared for initial costing in conjunction with proposals for new bridge deck waterproofing, bridge joints, highway and footway resurfacing. This package

was considered best value by the client who successfully obtained TfL grant funding awarded through the London Bridges Engineering Group.

The works

Detailed design followed with the final works methodology developed through close collaboration between CRL, FM Conway and Free4m. It was agreed that all works within the railway corridor were achievable within a fully enclosed hoarding situated at railway platform level, thus establishing a 'green zone' and effectively removing all risk associated with possessions, cancelled possessions, etc (see Figure 3).

The fully enclosed hoarding also ensured that the works could be carried out over the winter months

Table 1 – Cover, depth of carbonation and the percentage of chloride at the depth of reinforcement

Element	Minimum depth of cover (mm)	Maximum depth of carbonation (mm)	Chloride (% by weight of cement)
Southern portal	33–93	5–10	0.1–2.7
Northern portal	43–79	5–15	0.4–1.8
Column	77	10	0.9

Table 2 – Showing the risk category as extremely high for 'ingressed chlorides' over 1%

BRE Digest 444 risk category	Description	
	For cast-in chloride	For ingressed chloride
'Negligible'	No corrosion expected	Little or no risk of corrosion under current conditions over the lifetime of the structure
'Low'	With normal maintenance no significant corrosion likely to occur. Some minor corrosion may be identified	Some corrosion possible under current conditions. Rate of corrosion likely to be low
'Moderate'	Some corrosion likely to occur. Rate of corrosion likely to be slow	
'High'	Significant corrosion likely, particularly towards the end of the selected age	Significant corrosion likely, increasing with exposure period. Rate of corrosion could be high in parts
'Very High'	Significant corrosion likely over considerable area	Not applicable
'Extremely High'	Severe corrosion inevitable. Significant area likely to be affected	Severe corrosion inevitable. Significant area likely to be affected

■ Risk categories appropriate for the concrete under discussion here

* Extracted from Figure 6 Interpretation of steel reinforcement corrosion risk and prognosis – BRE Digest 444: Part 2: 2000

Table 3 – Likelihood of corrosion taking place where steel is in the 'Extremely High' category

Risk category	For cast-in chloride												For 'ingressed' chloride
	25 years old				40 years old				60 years old				
	Dry		Damp		Dry		Damp		Dry		Damp		
	A	B	A	B	A	B	A	B	A	B	A	B	
'Negligible'	0	–	0	–	0	–	–	–	0	–	–	–	0.15–0.35
'Low'	0.4	0	0.4	–	0.4	0	0	–	0.4	0	0	–	0.2–0.6
'Moderate'	1.0	0.4	0.7	0	0.7	0.3	0.45	0	0.6	0.2	0.4	0	
'High'	1.5	0.7	1.0	0.6	1.0	0.6	0.7	0.4	0.8	0.6	0.6	0.4	0.5–1.35
'Very High'		1.0	1.5	1.0	1.5	1.0	1.0	0.7	1.5	0.8	0.8	0.6	Not applicable
'Extremely High'		1.0	1.5	1.0	1.5	1.5	1.5	1.0		1.5	1.5	0.8	1.0–1.95

■ Risk categories appropriate for the concrete under discussion here

Note: A = where the carbonation front HAS NOT YET extended down to the reinforcement, whereas B = where the carbonation front HAS extended down to the reinforcement

* Extracted from BRE Digest 444: Part 2: 2000 – Figures 4 and 5 Very approximate minimum chloride content, % by weight of cement

Figure 3 right: North substructure showing the hoarding/enclosure of the work.



Figure 5 far right: Testing for shorts in the CP system prior to applying overlay with the spalled areas repaired and the beam prepared with the MMO titanium fabric and wiring ready to receive the overlay.



of 2014. All activities could carry on regardless of the weather, with all noise, debris and dust contained within the 'green zone' and the station remaining fully operational throughout the project.

The column repairs

All loose, cracked, delaminated and substandard concrete was removed using hydro-demolition, as opposed to mechanical breakout, and carried out within the 'green zone' at 10,000–12,000psi (690–827 bar) to remove the defective concrete off the structure, while maintaining sound parent material. Concrete removal was specified to a depth of approximately 30mm behind the existing column reinforcement to ensure existing reinforcement was fully enclosed in the repair material (see Figure 4).

Repair of the column sections was then carried out in 900mm lifts to the full circumference of the column. The design team established that, with live load relief, a full circumferential repair was achievable in one go.

To ensure that the design assumptions facilitating the full circumferential repair were sound, a window sample of concrete was removed at the top of the worst column to observe the condition of the reinforcement. The condition was as expected and the designed methodology employed. Each lift was reinstated using a proprietary flowable micro-repair concrete.

Cathodic protection was not specified for the columns as the extent of the repair varied widely from column to column and the likelihood of active corrosion was deemed to be low given the very low chloride results.

In reality, the condition of the column reinforcement was very good, with the most significant deterioration located at the top, as expected.

The crosshead beam repairs

Hydro-demolition was again used to remove the defective concrete, with crosshead repairs limited to localised sites. Removal of defective concrete again was specified to behind the existing reinforcement with reinstatement carried out using either a flowable micro-repair concrete, or a proprietary repair mortar as appropriate.

To ensure that present-day load capacity was achieved, a design check on the minimum diameter of reinforcement required was carried out. The conclusion was that the vast majority of the existing reinforcement could be retained, as even though pitted in some instances, the remaining reinforcement was sufficient. Only in the areas where the worst of the decayed reinforcement was situated was additional steel required to be added in.

Given that both the north and south portal crossheads exhibited both high chloride levels and spalled concrete, they were targeted with the ICCP system.

Split into two zones, the ICCP comprised mixed metal oxide coated titanium (MMO/Ti) expanded mesh anode encapsulated within a sprayed concrete overlay for Zone

1 (the majority of the crosshead elevation, underside and ends) and 19mm-diameter discrete anodes of MMO/Ti along Zone 2 (top of the crosshead) drilled into the crossbeam for the protection of the bearing shelf (see Figure 5).

All cabling was taken along the crossheads to the portal ends, up through the parapet, discreetly to a cabinet located at bridge deck level prior to the mesh and wiring being overlaid with a special CP spray-applied mortar (see Figure 6).

Power supply and telecommunications, for remote monitoring, were all provided to the cabinet so as to ensure safe access without the need for possession or 'engineering hours' working in the future.

Project success

The refurbishment and repair of the Drewstead Road Bridge, over an operational mainline railway station, within a residential community and on a main trunk route was, in the main, a conventional and run-of-the-mill repair project. The success of the project lay primarily in the collaborative working between London Borough of Lambeth, CRL, FM Conway and Free4m. This meant establishing a methodology, which substantially mitigated the risk of working in a highly controlled and restrictive environment, enabling the refurbishment works to be completed in 4½ months without incident, within budget and to programme. Early contractor involvement, a proactive client and a forward-thinking engineer also contributed to the ensuring that the structure will withstand the ravages of time and the elements for a further 25 years (see Figure 7). ●

Figure 4: Column with defective concrete removed awaiting recasting.



Figure 6 below: The completed crosshead beam with the overlay applied.

Figure 7 far right: The completed superstructure with new joints in place and re-asphalted.



References

1. 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.* BSI, London, 2005.
2. BUILDING RESEARCH ESTABLISHMENT, BRE Digest 444. *Corrosion of steel in concrete. Part 2 - Investigation and assessment.* BRE, Watford, 2000.