Figure 1: South terminal – general view.

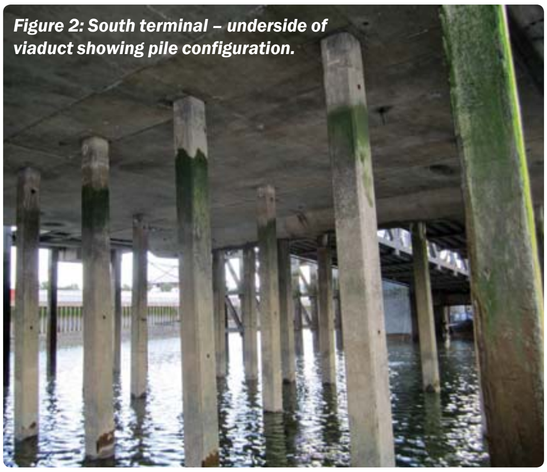

Figure 2: South terminal – underside of viaduct showing pile configuration.

Protecting our assets: the Woolwich Ferry jetties

The Woolwich Ferry is a free service operating between Woolwich and North Woolwich, linking the north and south circular roads across the Thames. It is a vital, heavily used service that relies on the concrete approach viaducts (jetties) for the loading and unloading of the cars and trucks using the ferries. In 2013, a contract was awarded to Concrete Repairs Limited (CRL) to carry out the repairs to the 'spalling' concrete on the columns and soffits of the north and south approach viaducts. Michael Balletta of CRL reports.

Anecdotal evidence suggests that the same crossing points that the current ferry now operates from were used by the Romans to travel between Colchester in the north to Dover in the south. However, hard evidence is available that some sort of ferry service was run from these same points as early as 1308. The ferry service as we know it today, called the Woolwich Free Ferry, was opened on 23 March 1889, when the Metropolitan Board of Works (the forerunner of the GLC) obtained statutory authority to ferry passengers, animals, vehicles and goods across the Thames at Woolwich, free of all tolls, rates or charges.

Initial construction

From records still available, it appears that there have been three sets of access ramps (or jetties) on the site of the existing loading platforms. The earliest ones were constructed of timber, with the current jetties being built in 1966. This was necessitated when the ferries became end loading instead of side loading, as well as the fact that the condition of the existing timber platforms was so bad that they needed to be replaced.

As was appropriate and the norm at the time, both the north and south jetties were built from reinforced concrete and consisted of an approach viaduct and a tower, which houses the lifting equipment for two structural steel linkspans that provide the means of access from the piled roadway onto the ferry. The approach viaducts are supported on vertical precast concrete piles (457mm square) and carry four lanes of traffic, two lanes in each direction. There is a raised footpath on each side, with edge protection provided in the form of reinforced concrete parapets. The viaduct on the north terminal is a 20-span structure with six piles per span and that at the south terminal is an 18-span structure, also with six piles per span (see Figures 1 and 2).

Investigation/condition survey

Method

Following a previous inspection in 2003, and in line with principal inspection policy, Royal Haskoning was again commissioned in 2010 to carry out an inspection and survey of the various structures making up the ferry loading system, namely the linkspans, dolphins, walkways and approach viaducts, and lifting towers. The inspection of the approach viaducts took place on foot and by boat, and was purely visual. No intrusive investigation or testing was undertaken at this stage. The primary objective was to identify apparent defects and highlight those that could be structurally significant, or have safety implications.

Principal inspections carried out in accordance with BD 63/07[1] require all inspectable parts of the structures to be accessed 'within touching distance'. For the underside of the approach viaducts and piles, this would have required 'under-bridge' type mobile access platforms, which would have been very costly. This requirement was therefore relaxed and the inspection was instead carried out from a work boat during spring tides but withdrawing from beneath the structure before the tide rose to a level where the risk due to wash from passing vessels became too great.

Findings

The main finding pertinent to this case study was the large amount of vertical cracks to the pile corners/

Figure 3 far left: Cracks to pile arrises along vertical reinforcement bars due to the expansive forces caused by the corrosion of the reinforcement.

Figure 4 left: Spalled area of pile showing chloride-induced corrosion to main reinforcement bars.

arrises (see Figure 3). Some of these cracks had been noted in the 2003 survey, with the majority having increased in length, but not in width. However, a few of the larger cracks noted in the 2003 survey had increased in width to approximately 7mm. This was to be expected taking into account the severe conditions to which the piles were subjected and the fact that corrosion had probably already been initiated in 2003. A number of the cracks also exhibited signs of rust staining, indicating that the reinforcement was corroding (see Figure 4).

Numerous hairline cracks were found on the soffits, including a number not noted in 2003. Leaching was visible from the majority of these cracks.

As there is no record of condition testing of the concrete being carried out in both the 2003 and the 2010 surveys, it was difficult to ascertain whether the cracking to the arrises was due to the impact on the piles when they were driven in originally, whether an accelerator such as calcium chloride was used when the piles were cast (as was the norm in those days), or whether the salt water had finally worked its way through the concrete cover, destroying the passive layer around the reinforcing and allowing the corrosion process to commence.

Once the access works were in place, CRL was instructed to carry out full close-up visual inspections of the piles, as well as hammer testing of all the accessible concrete surfaces. CRL Surveys, a division of CRL, also carried out a condition survey of the piles comprising half-cell potential surveying, screening for chlorides, cover-meter surveys and the preparation and testing of concrete core samples for compressive strength and density. The results confirmed that a chloride-based accelerator had not been used at manufacturing stage; however, chloride levels of up to 3% by weight of cement were found at the depth of the reinforcement.

Repair methodology and materials

In July 2012, a tender was issued to carry out the repairs as recommended by Royal Haskoning and as per its Bill of Quantities. After extensive discussions and revision of the works to be carried out, CRL was awarded the contract. The specification priced on was a standard prescriptive concrete repair specification, allowing for a choice of two types of material systems (or similar approved). The contract period was six months. Work has only taken place on the southern approach viaduct at this stage.

Breaking out

The specification, however, was not entirely prescriptive on the method of breaking out the loose, cracked, sub-standard concrete and getting behind the reinforcing. After carefully considering the advantages and disadvantages of mechanical methods, CRL decided to go with hydro-demolition. Its main advantages over mechanical breakout were the easier mobilisation of the plant and equipment, resulting in more concrete being able to be broken out in a shift. The cost advantage of this method of breaking out became more evident when high tide fell in the middle of a 'daylight' shift, necessitating a mobilisation in the morning and another late in the afternoon (see Figure 5).

Figure 5 left: Areas of piles where loose, cracked, spalling concrete has been removed with hydro-demolition.

Materials

Due to the tidal fluctuations, up to 7m, the material required to carry out the repairs needed to be fast setting, as well as gaining strength rapidly. After a thorough analysis of the materials specified, and what other materials were available, the decision was made to use Natural Cement's Shotcrete 530 dry spray concrete. Not only was this material fast setting and fast curing but its rapid strength gain allowed CRL to confidently reinstate the broken-out areas between tides with no possibility of the material being washed out, or in any way being compromised (Figure 6).

To slow down the rate of corrosion, and ensure the longevity of the repairs by negating the 'incipient anode effect', discussions are now being held regarding the inclusion of sacrificial galvanic anodes within the repairs, and/or the attachment of large zinc anodes externally.

Figure 6 below: Repaired pile showing reinstatement of a patch using Natural Cement's Shotcrete 530 dry spray concrete.

Access

The costs of the access to the areas to be repaired constituted close to 60% of the total tendered price and required some innovative thinking to overcome some of the difficulties that would be encountered. The jetties had to remain operational at all times, the work had to be carried out as and when the tide allowed, and no debris or materials were allowed to fall into the river or the foreshore. Two options were considered: either to erect from the bottom up using a pontoon; or top down, handed from the approach road above. The top-down approach was finally used, mainly from a mobilisation, cost and safety point of view (see Figure 7). In addition

Figure 7: Initial access configuration from top of approach viaduct.

Figure 9 above: Clearing up debris after hydro-demolition and before tide rises.

Figure 8 above: Typical access to piles (note the three lifts required to access the full height of the pile).

Figures 10 far right: View of cleared scaffolding/access prior to rising tide.

to normal access requirements (Figure 8), the area where hydro-demolition was taking place had to be fully enclosed with debris netting and plywood to contain any flying debris (see Figure 9). The scaffold also had to be cleared before every rising tide, and the additional protection removed so as not to overload the scaffolding (Figure 10).

Deliver innovation

The current economic climate, as well as sustainability issues, has put owners of infrastructure assets under considerable pressure to deliver innovation and reduce costs in the repair and maintenance of their assets. BS EN 1504[2] states that there must be a survey and interpretation of the results before embarking on a concrete repair project. The results of this survey and the correct interpretation of the results, as well as the early involvement of marine specialist repair contractors experienced in the type of work being carried out will go a long way to ensuring that the client gets value for their money. ●

References

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