2006 Project of the Year

Parking Structures Category

Mayorhold MSCP Renovation

Northampton, United Kingdom

Submitted by C-Probe Systems, Ltd.

Completed project

Built in 1973, Mayorhold MSCP (multi-story car park) is an important Town Center parking facility, a key service provision from the client owner to shoppers and businesses alike. It underpins the livelihood of the town.

The complex consists of five parking levels—designated A (basement) through E (roof)—with entry to the facility at Level B. Access between levels is via upward flat ramps/decks and downward spiral ramps.

The structure is a trough slab construction, conventionally reinforced through deck and within support downstand beams. Light mesh reinforcement exists between downstand beams.

Problems that Prompted Repair

During various projects prior to 1999, the structure was subject to localized repairs that were continuing to fail as a result of the corrosion process progressing. On an annual basis, new areas were also identified that required repairing. It was clear that the structure was deteriorating and that failure would ultimately occur.

The repair areas, however, were observed to be emerging mainly from leaking expansion joints/day joints. The downstand beams associated with these areas were in more serious condition than other midspan beams. There were also corrosion and spalling issues associated with the reinforcement in the deck surface over the beams.

Moreover, the areas of heavy traffic associated with Entry Level B, Ramp B-C, and Level C itself were worse than those of Basement Level A, where traffic rarely descended, and Levels D and E, where traffic was much lighter. In addition, Roof Level E was also protected over time with a deck waterproofing system.

The evidence of deterioration was therefore more specific than general (although growing in scope). This led to the owner instigating testing to assess the feasibility of designing a corrosion management strategy that could meet the technical and economic needs of the parking structure.

Expansion and day joints were the focal point for growth of the corrosion issues

Heavy corrosion was found in some areas

Corrosion of the structure

Inspection and evaluation of the structure

Inspection and Evaluation Methods

In 1999, the first phase of investigation began on Levels B and C and revealed high levels of chloride and corrosion to the reinforcement over a significant portion of these levels. This investigation was repeated in 2003; and over a 4-year period, it was determined that the problem was accelerating in the high chloride areas.

The principle techniques employed to determine the condition, as well as to determine the acceleration effects, were:

- Chloride depth analysis at 1 in. (25 mm) increments to three depths;
- Carbonation testing with phenolphthalein to fresh concrete surfaces;
- Full half-cell potential contour mapping and interpretation to ASTM C 876;
- Delamination sounding; and
- Visual records.

The data in Table 1 was taken at the same test location on the Level B driving lane and is representative of the corrosion condition to that level. The condition was also typical extending to Level C.

The data clearly demonstrates the extent to which deterioration was accelerating given the increasing chloride at all depths as well as the more negative shift in corrosion potential. This acted as the basis for the type of corrosion mitigation techniques employed.

Typically, other levels demonstrated chloride content less than 1 wt% for Levels A and E with Level D showing chloride levels varying from very low (<0.1 wt%) to medium at less than 2 wt% with corrosion potentials reflecting this lower activity.

Carbonation levels were low throughout with the deterioration mainly attributed chloride attack.

Table 1

Year of testing	Chloride to 1 in. (25 mm)	Chloride to 2 in. (51 mm)	Chloride to 3 in. (76 mm)	Most –ve potential	Most +ve potential
1999	1.82	2.32	1.28	–396	–206
2003	4.48	4.85	3.96	–560	–285

Chloride content is expressed as percentage by weight of cement
Corrosion potential is expressed as mVCSE (copper/copper sulphate electrode)

Repair and Protection System Selection

The corrosion management strategy was designed to arrest corrosion immediately with important control considerations that would avoid deterioration in the future.

Concrete repairs were defined and carried out together with the significant use of electrochemical corrosion mitigation techniques, namely, surface-applied corrosion inhibitors and impressed current cathodic protection methods to control the effects of corrosion. The repairs were to the deck surfaces above the rib positions and at every 5th rib soffit position (including downstand beam) arising from the leaking of day joints.

Armed with the visual and electrochemical inspection results from the two test regimes in 1999 and 2003, criteria were developed to identify the most appropriate corrosion mitigation techniques in specific circumstances. This had the intention of targeting the most appropriate technical solution while still being acutely aware of the most appropriate economic solution for the owner.

The criteria were based in principle on the chloride depth and corrosion potential contour mapping information, but with the underlying intention not to mix and match solutions on the same parking level but to use the most appropriate technique to achieve the 25-year life extension desired by the owner.

The criteria and system package solutions applied were:

- Half-cell potentials more positive than –200mVCSE and chloride content less than 1 wt% of cement would receive no corrosion mitigation treatment;
- Half-cell potentials more negative than –200mVCSE and chloride content less than 1 wt% of cement would receive surface-applied corrosion inhibitor throughout. This was also applied to support columns;
- Half-cell potentials more negative than –200mVCSE and chloride content greater than 1 wt% of cement would receive MMO titanium ribbon impressed current cathodic protection system;
- In addition to the first three items, the top deck (Level E) would receive a decking system (solvent-free elastic polyurethane overcoated with a flexible epoxy seal coat) on all top surfaces to provide a tough, crack-bridging, waterproof but flexible surface to the deck with good color stability and weather, abrasion, and slip resistance;
- Intermediate decks exposed to less weathering received a solvent-free epoxy resin decking system with all the stated exposure durability characteristics; and
- A decorative and anti-carbonation coating system was applied to soffits and downstand beams.

This yielded the following strategy on a level-by-level basis:

- Level A: Limited concrete repairs and deck waterproof coating;
- Level B: Extensive concrete repairs, ICCP system, and deck waterproof coating;
- Level C: Same as Level B;
- Level D: Limited concrete repairs, surface applied corrosion inhibitor and deck waterproof coating; and
- Level E: No concrete repairs but new deck waterproof coating.

Levels B through D are monitored for performance, as well as various early detection points to the downward spiral ramps.

Preview of Corrosion Management Scheme

Prior to proceeding with the full corrosion mitigation scheme, a preview was conducted to provide assurance that the use of the various techniques would likely provide the desired level of protection to the structure.

In the main, this was a concern for the ICCP system design, as the ribbon anode was primarily intended to protect the steel in the deck and downstand beams with the light reinforcing mesh between beams needing definition with respect to the throwing power of the anode system.

An area was chosen that reflected "best case," that is, the chlorides were low as this was likely to reflect the worst case for conductance of the protection current.

It was shown that not only did the ICCP protect the deck and downstand beam, but that the mid-point of the trough mesh was also polarizing and at low driving voltage.

Project Installation

Concrete repairs used a proprietary prebagged rapid-setting mortar with high early-strength

characteristics. The consideration of repair material resistivity was made with the decision to provide robust concrete repairs and allow the ICCP to provide its protection to the unrepaired areas. Over time, as the steel within the repair patch requires additional protection, the resistivity change would allow passage of current and allow protection to proceed. The MMO titanium ribbon anode, however, was set into slots in the deck with a non-polymer modified but rapid-setting mortar to allow the flow of current to occur from initial energization.

A policy of using embedded monitoring of all system packages in a representative manner for the structure was also adopted. To achieve this, the half-cell contour plots were used to place corrosion potential and corrosion rate devices to provide performance data for deck, downstand beam, and trough steel on the levels that received direct corrosion mitigation treatments.

All wiring associated with the ICCP and monitoring systems was hidden within the deck either in the anode slots or sawcut into the deck and dropped through the termination boxes on the soffits. These were then transferred to zonal enclosures in two-compartment trunking that was also used to house the lighting cabling.

The system installed integrates all corrosion mitigation choices in a single controllable network management system. Boxes containing specific electronics for ICCP power, control, and monitoring as well as SACI and early detection monitoring were discreetly hidden within the trough ends.

A single network management access unit controls the whole installation and is conveniently sited in the parking management suite. Access and control are remote and accessible from a secure Internet facility that will allow not only growth of the client's infrastructure management but integration of other features, such as lighting and security on the same network.

Special Features

Having established the structural integrity and future condition of the parking facility, the functionality and aesthetic end product was also a main consideration. Expansion joints were upgraded on

External appearance before (top) and after (bottom) refurbishment

Top deck appearance before (top) and after (bottom) refurbishment

Disabled parking area clearly delineated

Internal appearance before (top) and after (bottom) refurbishment

Mayorhold MSCP

Owner
Northampton Borough Council
Parking & Security Operations
Northampton, United Kingdom

Project Engineer/Designer
Structural Healthcare Associates
Manchester, United Kingdom

Repair Contractor
Makers UK Limited
Coventry, United Kingdom

Material Suppliers/Manufacturers
Sika Limited
Hertfordshire, United Kingdom

C-Probe Systems, Ltd.
Cheshire, United Kingdom

both the top deck and intermediate decks with state-of-the-art technology with attention to finishing and sealing details.

The deck coating systems were chosen not only for their durability and mechanical features but also for their aesthetic and safety features. The parking garage was originally a dark and dismal structure; but with the ability to enhance the color scheme within the structure and upgrade the lighting system, the appearance of the structure has been transformed.

Color-coding of the deck has allowed feature enhancement to demark disabled parking, driving aisles, and parking bays as well as entry/exit clarity. Disabled features were added in the form of additional ramps to facilitate access to elevators.

New lighting designed to fully illuminate the drive lane and parking bays was installed with new automated emergency lighting added. The combination of an aesthetically pleasing new deck coating system and enhanced lighting has especially transformed the parking facility.

The addition of new roller shutters secures the parking facility at nights. Moreover, fully interactive help points linked to a help desk have been added to newly installed pay-on-foot machines. CCTV has also been installed and the parking facility patrolled to augment security.

Following completion of the refurbishment, the facility was assessed and was accredited with Park®Mark secure parking status.

The Internet corrosion management facility is especially comforting to the owner as it offers the opportunity to continually assess the performance of the parking facility and reinforce the wisdom of his investment in a structure that looked initially to be more likely to be a candidate for demolition than a structure ready to face the next 25 years as a working and profitable asset to the town.