CASE STUDY

Car Park Refurbishment

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PROJECT

Omni Centre MSCP

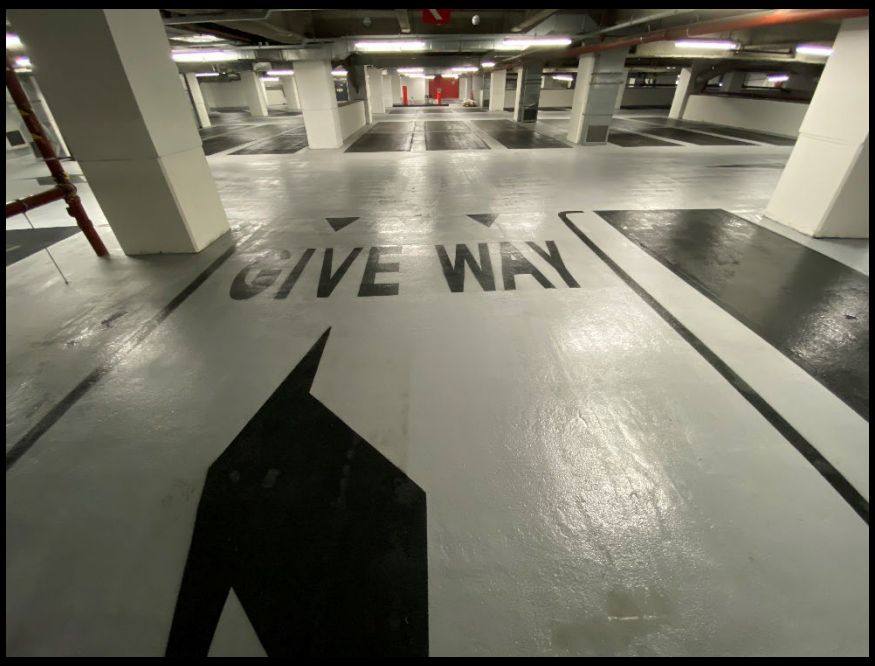
STRUCTURE

Basement Car Park

CLIENT

Avison Young

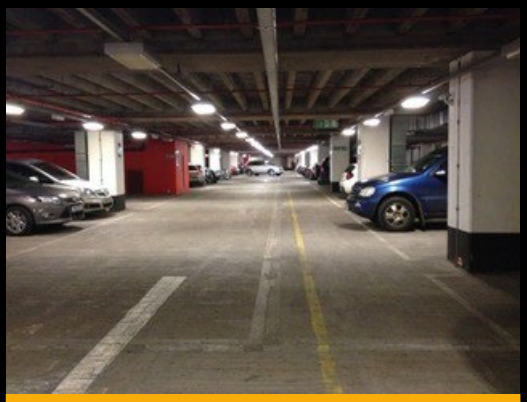
CONTRACT



In 2019 Makers were approached by the owners of the Omni multi storey car park via their agents to help and assist with issues being experienced with the structure. The Centre together with the car park was constructed and completed in 2002 comprising of a development from a waste ground and surface car park of Greenside Row. The site which was formerly to provide the home to BBC Scotland never got past the development phase but after a failed development it was finally completed comprising of Offices, retail units, a 12-screen cinema and a 990-space underground basement car park ideally positioned to service local tourists' attractions and landmarks in the City of Edinburgh.

Since its construction the car park had been the recipient of a number of maintenance and repair schemes and recently had undergone a modernisation and repair programme however shortly after this work had been undertaken by the resident car park operator the works began to fail in a very short period of time. Concern by the owner as the condition of the structure lead to further investigation by Makers and a delivery plan devised to provide a safe structure asset.

The first step was to ascertain the issues facing the car park and the underlying cause that accelerated the mode of failure. This required gathering evidence through testing, analysing the data and then devising a repair design that would overcome the issue and provide longevity to the structure. Over recent years the car park had experienced flooding due to the poor water management controls from the public highway. The steep topography of the access road meant that large water volumes could accelerate and bypass the small Acco channels located at the car park entrance. Large volumes of water passed over the channels flooding 2 of the 4 basement levels.



Existing Environment

Multiple Failed Repairs

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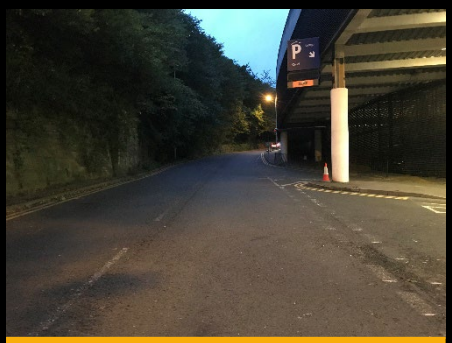
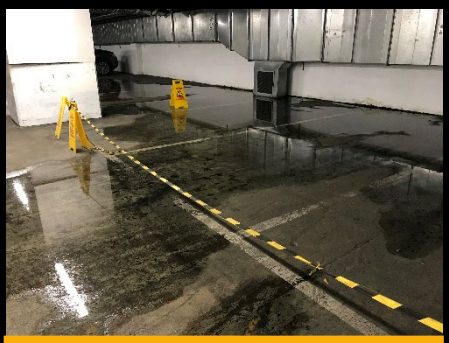


Street View

Entrance Acco Channel



Flooding

The car park sits beneath street level with vehicular access at level -3 and through a series of interconnecting ramps allows upper access to levels -2 & -1 and lower access to -4. The car park is popular due to the number of car hire specialists that operate from the car park and that it services the cinema directly and the Playhouse Theatre when open. Lewis's has a store directly opposite the car park at street level but also operates a click and collect service within the car park footprint.

Visual inspection clearly identified a pattern of failed repairs over a number of years with evidence of anodic reactions taking place causing new repairs to fail. The number of different repair products closely placed together was a strong indication that a number of failed repairs had merely been carried out to improve the driving surface and not actually tackle the root cause of the initial repair.

Deck level -3 had the most recent tranche of work incorporating both repairs to the deck and application of membrane coatings improving the overall aesthetics however again they failed to deal with the underlying root cause which led to premature failure. It appears that the strategy was to reduce the chloride risk by encapsulating the chlorides and reduce the rate of corrosion by removing the active ingredients of oxygen and moisture however unfortunately this merely accelerated the process resulting in repairs occurring beneath the membrane surface.

In order to design any repair systems, it is imperative that a series of tests measures be undertaken to provide a platform of data to more fully understand the behaviour of the car park and the severity of the issues and processes it is facing. Alongside the test data further, invasive information is also required to establish steel density and distribution together with concrete sampling and adhesion tests. Any system of repair will require as much data as is possible to collect together with visual and hammer surveys to measure the extent of work to be undertaken. For areas that are not exhibiting spalling or repairs a full half-cell potential survey will map those areas potentially at risk but not yet showing signs of degradation.

Adhesion test

Dolly

Original Coating

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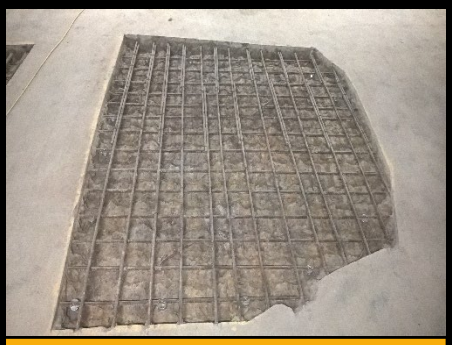
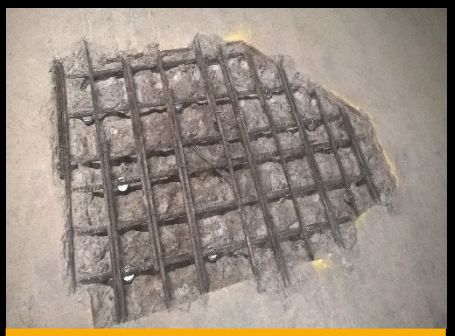


Excavated Repair

Replacement Reinforcement



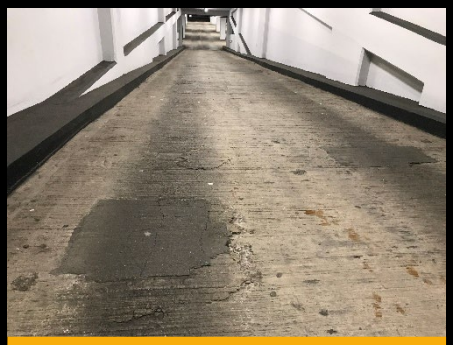
Installed Perimeter Anodes

It is important to establish a baseline of information to map the current position of the car park which will assist and develop alternative strategies depending on budget and severity, what is essential and what can be attended to at a later juncture.

The testing evidence provided the blueprint data to investigate the market for latest technologies and approach to repair with specific designs to meet the issues outlined and provide a comprehensive strategy for repair. Repair strategies are designed to incorporate a combination of measures that are cost effective but deal with the issues. This was the case at Omni and after careful consideration a suite of measures was proposed to deal with the Chloride issues uncovered within the car park.

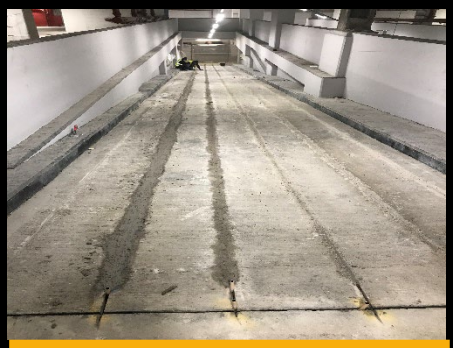
Chloride attack is particularly damaging to reinforced concrete and is both expensive and difficult to deal with depending on the Chloride levels being experienced within the car park. The Chloride ions attack the passive layer around the steel making it more acidic and causing the steel to corrode and expand resulting in the eruptions (spalling) within the deck surface. As well as causing corrosion it can also cause loss of section and heavy pitting to the steel.

The data gathered provided a picture that meant a series of measures would need to be designed to encounter the different levels of chlorides being experienced through the car park. New repair sites would require sacrificial anodes to the perimeter of the repair sites at the required designed spacings. Areas at risk but with levels below 1% would receive MCI's, Migratory Corrosion Inhibitors, these are applied to the surface and as the name suggest migrate through the porous concrete toward the reinforcing steel creating a passive layer around the steel. The ability to migrate to the steel again depends on the matrix of the concrete and density of the steel. To areas of high risk and suffering high chloride levels a fully designed ICCP (Impressed Current Corrosion Protection) system would be needed.



Existing Ramp Surface

Channels for Titanium Wires



Conductive Mortar Anode

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Exposed Surface Steel

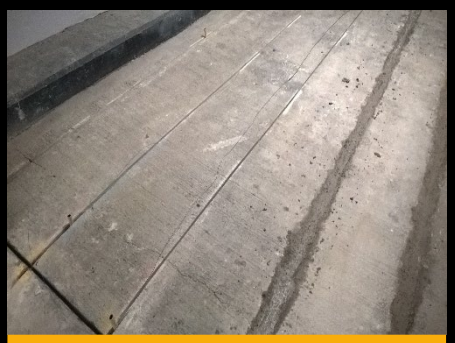
Anodic Reaction

Debonded Concrete

ICCP systems are fully powered systems and to be successful require a fully powered direct electric supply, continuity of the reinforcement within the concrete structure and the installation of an anode system that can be installed close to influence the affected steel. The logic behind the system is that it works on the basis of ion exchange by encouraging chloride ions to migrate towards the anode whilst at the same time exporting electrons to the reinforcement so that over time the layer around the steel becomes more passivated. As the chloride ions become more diluted as the system works the system can over time be turned down or managed to meet the corrosion rate potentials.

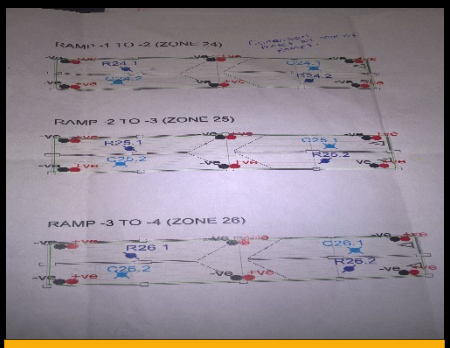
In order for system to protect the steel the system has to be powered at all times, for it to be managed it requires measurement probes to be installed within zones and that the created anode has the power or “throw” to deal with the volume of steel it has to protect. The siting of the anode is critical, too far away and it won’t protect the steel, too close and there is a risk that the anode will come into contact with the steel creating a short in the circuit. The system is based on the introduction of an acid resistant coated titanium wire measuring 0.79mm in diameter and embedded in a chase measuring 10mm wide 20mm deep and infilled with a specially designed conductive mortar. The conductive mortar is critical to the creation of the anode.

The anode requires to be powered at all times with a direct current supply to create the battery cell of cathode and anode to allow for the exchange of electrons and chloride ions. This also requires the reinforcement to be continuous and adequate and any missing or damaged steel was replaced in Omni case some 1200m. The car park consisted of over 32,000m2 of surface area and the amount of ICCP was dictated by the half-cell potential survey. Just over 11,000m2 of the deck surface was required to be treated by the ICCP design which would involve over 27,000m of chasing and titanium wire so prior to the full-scale installation a preliminary study was undertaken to assess the performance of the design to establish that it could be installed and that it would deal with the issues.



ICCP Runs

Monitoring Probes



ICCP Zones

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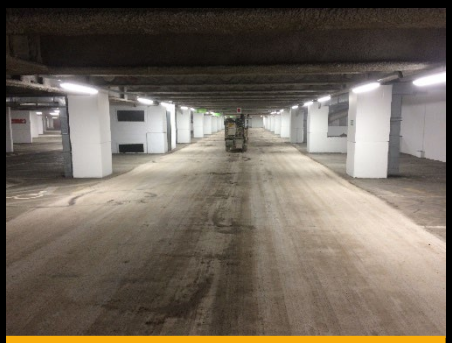
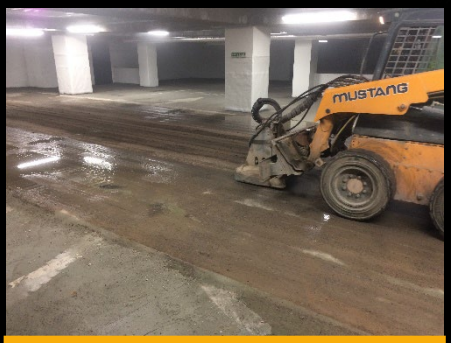


Existing Coating Removal



Deck Preparation

Surface Profile

The preliminary study underlined to desk top design however it did throw up installation issues particularly where there wasn't enough cover to the steel to create the chase. Alternative designs were examined on site settling on drilled pockets at 45 degrees to the steel and creating an anode with pieces of titanium wire embedded in series and fed via a sheathed electric cable. Once the preliminary system data was verified and processed the design was rolled out.

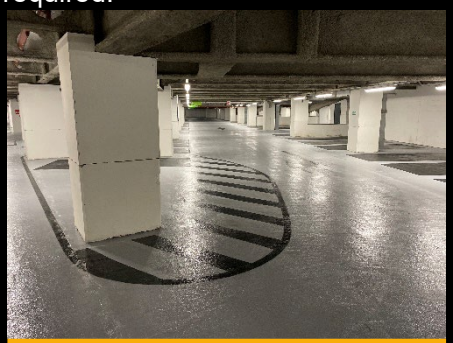
The system is a managed system and as such has the capability of being monitored remotely requiring the areas to be broken down into effective zones 34 in total. Each zone contains reference probes which constantly monitor the zones and these reference probes were extended to monitor the 15,000m2 of car park surface treated by MCI's.

Concrete repairs also occurred within the ICCP areas but these were first repaired and then chases created but to areas outside these areas' repairs received sacrificial anodes to the perimeter with over 1700m2 of repair being undertaken throughout the car park.

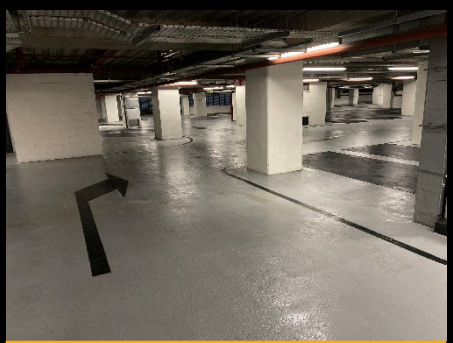
Specialist trained teams were responsible for the installation of the ICCP system with the installation process being overseen and signed off by an independent third-party engineer. Testing and evaluation of the systems capability was assessed to meet the needs of the structure and the method of installation constantly inspected to ensure it complied with the designs criteria.

Corrosion engineers were employed to test individual zones and ensure steel continuity and anode performance including all required connections and zonal mapping. Data logging and data transfer were also tested to ensure remote system monitoring. The whole network had a network throughout the car park traced back to a Network Access Unit which then was transferred to an ariel converter over the internet. The system comes with a full year monitoring and maintenance after which the client has the ability to extend the service for as long as necessary.

The remote monitoring of the installed system allows the corrosion engineer to adjust the power output as and when required.



Triflex Epoxy System



Directional Arrows

Management Signage

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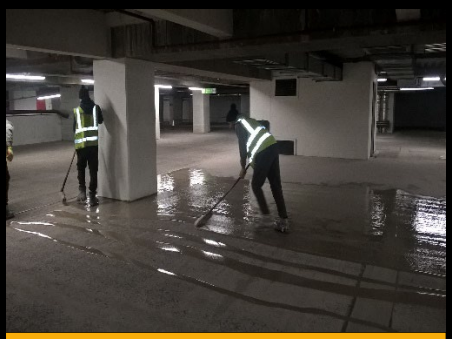
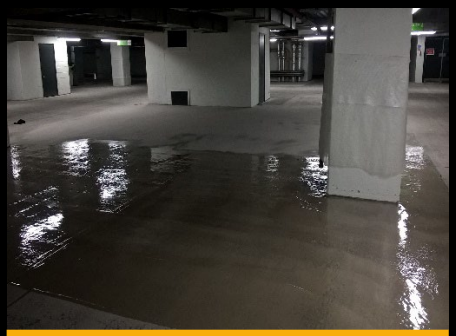


Base Layer Application



Sand Coat

Seal Coat

The car park also had the added protection of 32,000m2 of Triflex coatings which would reduce water penetration and salt laden water being brought into the car park from public vehicles using the car park. The repair and coating works had to be carried out in a live car park which meant that areas were broken into a number of phases but always allowing for access and egress via level -3. The project was executed over a 2-year period having a considerable amount of time off site due to covid and the Scottish Government regulations.

A two coat Triflex epoxy filled system was installed after the installation of repairs and corrosion measures. This was selected given the lack of air movement experienced at the lower basement levels. The system colours were adopted to meet the current Q-Park brand and their bay and demarcation preferences installed to match their car park branding.

Civil works were executed to the entrance of the car park to improve the water catchment of surface rain run-off and prevent it entering the car park. This consisted of replacing the small Acco channels and creating a big sump channel and installing an additional outlet to increase the volume of water capable of being dealt with.

Fully Installed System

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