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Intrusive Testing Results Synopsis

Intrusive testing has been carried out to the car park in February 2016 and previously in 2005 and 2012. These results allow for the current state of the car park to be assessed and give an indication of the deterioration of the concrete and reinforcement over the medium term. The testing has comprised the in-situ measurement of the depth of concrete carbonation, laboratory testing of recovered samples for chloride ion concentration and most recently the measurements of half-cell potential to give an indication of the extent of the actual corrosion of the embedded reinforcement.

Over the last 10 year period an increase in the levels of chlorides can be seen with the maximum recorded levels of chlorides within the concrete being 1.4% in 2005 rising to 2.36% in 2012 and 3.3% in 2016. Over the same period the depth of carbonation has remained more static and an increasing trend is not so evident. The half-cell potential results obtained within the 2016 testing show readings up to -530mV. These show that corrosion is actively occurring across a significant area of the top reinforcement to the carpark decks. The test results together with the observed deterioration show that the conditions of the concrete structure are such that corrosion of the embedded steel has been initiated in large areas of the car park.

The life span of the building is determined by the corrosion rate of the embedded steel, therefore it is crucial that the planning of refurbishment and repair works considers the effect of the proposed works on the corrosion rates of the embedded reinforcement. The aim of the repair and maintenance is, if possible, to prevent the occurrence of conditions where corrosion of the embedded reinforcement can commence, and where corrosion has commenced minimise the rate of corrosion and if, possible, create conditions where corrosion can be stopped. The reduction of the corrosion rate due to any proposed works should therefore be considered in determining the cost effectiveness of such works.

Various repair techniques are available for deteriorating concrete structures but in this case five primary methods are suitable;

1 The addition of painted sealant coatings (paints) to the top surface of the deck to resist future chloride ingress into the concrete deck.
2 The application of migrating corrosion inhibitors to assist the reinforcement in resisting corrosion.
3 The installation of an anodic protective system (sacrificial anodes constructed from zinc) to the top level of reinforcement.
4 The application of a painted anti-carbonation treatment to the slab soffits, columns and parapet upstand.
5 Impressed current cathodic protection to the entire concrete structure to suppress corrosion rates.

The report by CRL has suggested four repair options;

Option 1 – Do nothing. The reinforcement will continue to corrode and will accelerate with repair works needed on an annual basis and a future serviceable life of say 5 years.

Option 2 – Patch repairs and coatings. If repairs are undertaken to current areas of defects and then protective coatings are applied, a life to first maintenance may be achieved of between 5 to 10 years. Future maintenance can be expected to be extensive.

Option 3 – Patch repair coatings with corrosion inhibitors and/or sacrificial anodes. The additional works provide methods to slow the rate of corrosion. A life to first maintenance of 10 to 15 years may be achieved (although with maintenance to the surface coatings within a 5 to 10 year period).

Option 4 – Patch repairs with cathodic protection. If an impressed current cathodic protection system was applied, the rate of corrosion would be reduced further. A life to first maintenance of the concrete may exceed 15 years (although with maintenance to the surface coatings within a 5 to 10 year period).

Where corrosion of the embedded steel has been initiated, only the installation of sacrificial anodes or cathodic protection from the methods listed above can achieve the prevention of corrosion. Corrosion inhibitors and coatings could be utilized to slow the rates of corrosion, but will not prevent corrosion.

If no action is taken the currently active corrosion will become more extensive and will accelerate with time. This will rapidly result in structural weakening of the decks and will soon affect the safety of the car park. A future serviceable life of say 5 years could be considered.

The coatings of the structure will help prevent the extent of corrosion progressing so rapidly although some corrosion will continue at the current rates.

The addition of sacrificial anodes to the structure in areas currently at risk of corrosion will stop corrosion from occurring and if correctly designed will have a design life of 20 to 25 years with a life first maintenance of about 15 years. Surface coatings will require maintenance within about 5 to 10 years.

The application of a full impressed current cathodic protection is beyond the scope of the available budgets for the repair works, and therefore has not been further considered.

Previously we recommended that the implementation of a repair regime broadly as Option 3 of the CRL Report. Since this recommendation we have been advised with regard to the available budget and understand the desired projected life span of the structure at this stage is about 10 years. Following this advice and further discussion with Daniel Connal Partnership regarding the budget costs of the proposed works we recommend a reduced scope of repairs with the specification of the scheme reduced to suit the available budget and the future serviceable life of the structure of only 10 years.

To suit the budget we recommend that the repair regime is to include;

- Patch repairs to damaged areas of the structure.
- The application of a migrating corrosion inhibitor to the top of the decks
- The application of sealant coatings to the decks.
- The targeted introduction of sacrificial anodes to areas currently at greatest risk of corrosion, with the lower decks nearer to the entrance being the priority and the extent tailored to the budget.

To suit the available budget the installation of the sacrificial anodes will be very limited. Detailed assessment of the areas where the installation the anodes is most required and will have greatest affect will need to be carried out during the design phase to ensure the limited installation is carried out effectively.

Based on our understanding of the current condition and rate of deterioration of the concrete structure, we expect that if the recommended repairs are undertaken, the serviceable life of the car park will be usefully extended and a target life of 10 years can be expected to be achievable.

Future maintenance to the deck surface coatings will be required during the remaining life of the car park and repairs are likely to be first required after about 5 years, together with some patch repairs to the deck surface below. More extensive repairs are likely to be required within the 5-10 year period to the more severely chloride contaminated areas of the structure.

The future serviceable life beyond a 10 year period is uncertain at this stage but can be assessed on say a 5 yearly basis when the effectiveness of the repairs and preventative works can be determined.

We therefore suggest that following this scheme of repair works, visual inspections are carried out on an annual basis to review the serviceable condition of the concrete with a comprehensive engineering review carried out at year 5 and again at year 10.