Concrete Repair – Ensuring Durability

Willie Kay
Managing Director, WAK Consultants, WAK Technologies, MC Bauchemie Muller GmbH & Co

This paper will look at the key areas of concern that must be addressed to produce long lasting repairs. New and old structures are considered and various charts and methods highlighted. Civil structures will be compared with buildings and the different approaches will be compared and explained. Material Technology will be examined and some of the newer emerging technologies discussed.

Concrete when correctly mixed placed and cured is a very durable material. One then wonders how there are such a huge ever growing concrete repair business. The reality is that new structures are not being built correctly and old structures have not been maintained.

The repair of concrete structures is well documented and researched and many solutions offered. Herein lays the problem that often a little knowledge is a dangerous thing and many half truths exist in our concrete repair industry.

The basis of long lasting concrete repair must be based on a natural progression of the problem. If we know the cause we can then start formulating the cure.

The flow chart in Figure One starts to highlight the complexity of a repair.

Many key concerns are shown in the table but for me the practicality of repair is very important.

When repairing new or old structures it is important to differentiate they key approaches and define them carefully. In old structure assessment of deterioration is critical and often dictates the repair method or procedures. A good example of this is in wastewater plants where biogenic acid attack can totally destroy cover concrete in less than five years. What is less understood is the mechanics of this attack which unlike carbonisation actually causes an ettringite attack as the acid gas penetrates the concrete. When the surface is prepared and repaired with conventional cementitious repair products failure of the repair will normally occur within months not years. The acid gas is still in the existing concrete and quickly destroys the new repair mortar which is rich in C3A content. To carry out successful repairs the understanding of the mode of deterioration is critical.

In repairing structures in a marine environment again chloride attack is more complex and localised. Ensuring removal of all contaminated concrete is difficult particularly. In many cases electro chemical solutions are of value in finding long term solutions.

However our industry is not all doom and gloom and we have carried out some very demanding repairs in both new and old structures.

The World Trade Centre originally Echelon Square in Colombo is an excellent example of careful specification of material and a well trained applicator with external supervision.

On October 15th 1997 a bomb was exploded at the back of the World Trade Centre in the basement. Damage was extensive but due to the design and extensive block walls which absorbed the bomb pressures damages was repairable.

A team was set up by the owner ORCC and a detail repair plan formalised. Damages included cracked concrete facing...
panels, cracks to beams and columns soffit cracks in the car park and window blown out.

The repairs all had to be agreed and signed off by the American Structural Engineer, the architect in Hong Kong and WAK Consultants in Singapore. There were some interesting challenges in this repair as the damage precast units had to be repaired in situ.

These panels had a total thickness of 125 mm including the architectural facing and were bent, bowed and cracked.

To repair these units, steel box sections were anchored to the inside of the panel and slowly tightened to strengthen the panel. The outside cracks were then injected and a reactive silane applied.

There was extensive cracking on the soffit which needed repairing but there was no budget for crack injection so alternate solutions were developed. The columns and beams were repaired by either hacking or pressure grouting or epoxy injection depending on the type of repair.

The soffit was coated with an elastic crack bridging membrane and then surveyed every week and where water leaked then the area was injected. This cut down the length of crack injection from over three thousand linear metres to something less than five hundred linear metres.

Changi Water Reclamation Plant is the largest covered waste water plant in the world. As 80% is underground the concrete had a very high performance specification.

Figure Two - The performance requirements for the concrete designs are reproduced below.

The Engineer and owner had specified and paid for this High Performance concrete as one the building had a design life of more than 100 years and it was built in aggressive reclaimed land full of chloride. As in any concrete structure there were areas of honeycomb and other repairs. The repair materials had to comply with the concrete performance specification on water absorption, water penetration and in chloride diffusion. We developed repair products grouts and mortar to fully comply with the specification and were able to repair through trained applicators all damages.

<table>
<thead>
<tr>
<th>Grade</th>
<th>C55</th>
<th>C50</th>
<th>C45</th>
<th>C40</th>
<th>C35</th>
<th>C20</th>
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<tbody>
<tr>
<td>Characteristic Strength N/mm² at 28 days</td>
<td>55</td>
<td>50</td>
<td>45</td>
<td>40</td>
<td>35</td>
<td>20</td>
</tr>
<tr>
<td>Minimum Cement Content in kg/m³ of fully compacted concrete</td>
<td>420</td>
<td>400</td>
<td>375</td>
<td>350</td>
<td>350</td>
<td>270</td>
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<tr>
<td>Silica Fume as percent of cement by weight</td>
<td>7-10%</td>
<td>7-10%</td>
<td>7-10%</td>
<td>7-10%</td>
<td>7-10%</td>
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</tr>
<tr>
<td>Maximum water / cement ratio for concrete containing high range water reducer (superplasticiser)</td>
<td>0.35</td>
<td>0.35</td>
<td>0.40</td>
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<tr>
<td>Maximum Air Content</td>
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<td>&lt;2%</td>
<td>&lt;2%</td>
<td>&lt;2%</td>
<td>&lt;2%</td>
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<tr>
<td>Absorption (BS1881 : Pt 122)</td>
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<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
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<tr>
<td>Permeability (ASTM C1202)</td>
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<td>&lt;1000 Coulombs</td>
<td>&lt;1000 Coulombs</td>
<td>&lt;1000 Coulombs</td>
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<tr>
<td>Water Penetration (DIN 1048)</td>
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<td>&lt;10mm</td>
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<tr>
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<td>&lt;4%</td>
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<tr>
<td>Permeable Voids</td>
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<td>&lt;10%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Conclusion

Concrete repair has many aspects and different projects have differing needs in Colombo external aesthetics and ability to repair whilst the building was occupied were the key factors. At Changi matching high performance specifications and ensuring design life durability was the key. Repairing concrete is not just the material selection but the repair process which often involves many parties. Consultation is the key and at the earliest opportunity to develop long lasting durable repairs.

Sri Lanka plans for the world’s tallest plant-covered building

Sri Lanka will be the next country to vie for the title of the “world’s tallest plant-covered building,” if the proposal by Clearpoint Residences by Milroy Perera and Maga Engineering is executed as planned. The 46-story, 164-unit tower would give each apartment its own garden terrace, such that residents can still get the advantage of ground-floor living in proximity to greenery. Each garden is meant to be self-sustaining, with an in-built automatic drip irrigation system delivering nutrients to the vegetation.

Grey water is recycled and reused for irrigation and sanitation, with an aim to reduce water use by 45% when compared to a conventional building of the same size. The tower is expected to come up in Kotte, overlooking the tributaries of Diyawanna Lake and the newly built Diyatha Uyana district, a precinct offering entertainment, markets, food outlets and an aquarium.

Kotte is located southeast of the capital city Colombo, and contains the nation’s parliament, which is built on an island in the ceter of Diyawanna Lake. The tower when completed in 2016 would join an elite but growing club of tall vegetation-covered buildings, including the Bosco Verticale in Italy, Parkroyal on Pickering and Newton Suites in Singapore, and One Central Park in Australia.