Munna Point Bridge was built in Noosa Heads, Queensland in the late 1970s. Over 1.8 million trips in each direction are made across the 106 metre bridge every year, by tourists and locals. The bridge is one of only two routes across saltwater canals, to reach the primary tourism attractions of Hastings Street, Main Beach, and Noosa National Park. Accordingly, it is a critical piece of infrastructure to facilitate Noosa’s economy as a lifestyle and tourism destination.

In the 1990’s, large cracks appeared in the precast concrete piles and cast-in-situ pile caps. Engineers from Queensland’s Department of Transport and Main Roads identified the cause as chloride attack and alkali silica reaction (ASR).

ASR is a worldwide issue, because many gravels (aggregates) contain silica. When used in concrete, these react with alkalis in the cement. The resulting expansive gel causes concrete to expand and crack. ASR occurs in the presence of water. The ASR cracks allowed salt (chlorides) to reach prestressed steel strands in the piles and reinforced steel in the pile caps (chloride attack). There is no “silver bullet” to solve ASR problems in existing concrete. The Federal Highway Administration (FHWA) in the United States says, ‘the term “mitigation” is used in lieu of “repair”’.

Bridge owner, Noosa Shire Council (NSC) commissioned various consultants to monitor the bridge between 2001 and 2013.

Their test labs included chemical and mechanical tests of the concrete, such as compression strength, chloride content, carbonation, sulphate, and ASR potential.
The steel reinforcement condition was inferred from the crack width inspections and the lab tests.

The prognosis worsened with time. Later, consultants concluded the 106-metre-long bridge’s economic life would end in 2013, and planned for replacement of the full substructure for $6 to 8 million (see Option 1 in later table).

In 2014, NSC and TOD Consulting (TOD) investigated the steel reinforcement, with surprising results. We determined that remediation (Option 2) was viable, and prepared a reference design. Specialist Repair Contractor, MCM enhanced the solution in 2016, extending the bridge’s life by 50 years, for less than $3 million (50% less than Option 1 above).

**How did we do that?**
The previous consultants had relied on visual inspection of the exterior, and lab testing for ASR and chlorides. TOD’s bridge engineers took a different approach: We knew the critical structural components were the unseen prestressing strands and reinforcement.

**Investigation**
TOD is a member of the Australasian Corrosion Association and our directors are members of the IPWEAQ. When NSC approached TOD in 2014, we had reports showing that all of the previous investigations had relied on visual inspection of the exterior, and materials testing for ASR and chlorides in a laboratory.

We conducted a joint invasive investigation, by breaking out small volumes of concrete in the piles and pile caps to visually identify the condition of the strands and reinforcement. The observed reinforcement in the pile caps of Piers 3, 4 & 5 and piles (No. 3 & 8, Pier 1) were in better condition than we expected. TOD’s judgement was that macrocells had formed in the pile caps so that corroding bottom reinforcement was (temporarily) protecting the critical top reinforcement. In the piles, TOD determined that the reduced oxygen below tide level had resulted in much slower than expected corrosion rates. This meant the bridge was still safe for public use, giving NSC and TOD enough time to plan a solution properly, and with care, the bridge could remain open while the solution was implemented.

In summary, visual identification of the prestressing/reinforcing condition by a trained Bridge Engineer was a critical game-changer:

- The earlier materials testing (chloride levels, ASR potential, carbonation level and crack mapping) had given us valuable
information; but alone, could not give us a true idea of the bridge’s structural safety level. Most testing service organisations do not have bridge/structural engineers on staff. Nor do many Local Authorities.

- Without the visual identification, we would not have known that the pile strands and pile cap top reinforcement were less corroded than expected,

- Without the Bridge engineer, we would not have known the significantly corroded pile cap bottom reinforcement bars were less important than the top bars.

TOD summarised their report into a single drawing which visually identified the condition of each component by colour. This visual ‘model’ sped up everyone’s comprehension of the extent of the issues.

**Sustainability**

Possibly the largest environmental impact of a bridge is its carbon footprint – the carbon dioxide emitted to produce and operate it.

Australia is a signatory to the Paris Accord and therefore has binding targets to reduce greenhouse gas emissions. NSC is committed to custodianship of the Noosa environment, and is planning for an emissions target of 0%. It follows the principle that ‘resources are sustainably managed so that the lifestyle of the community is preserved without compromising the ability of future generations to meet their own needs’.

TOD is committed to reducing consumption and material waste in their operations. Accordingly, it was important to both parties that curing the cancer at Munna Point Bridge would be achieved with minimal waste or emissions. The carbon footprint of three options were compared as follows:

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Up-front embedded CO2 in demolished and new components</th>
<th>Running Operations over 50 yrs CO2</th>
<th>Total CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1: Replace the Substructure</td>
<td>185 tonnes based on concrete and steel production emissions</td>
<td>3-6 tonnes (based on 6100 kw.hr electricity, gas or coal)</td>
<td>188-191 tonnes</td>
<td></td>
</tr>
<tr>
<td>Option 2: Remediate the existing structure</td>
<td>39 tonnes based on concrete and steel production emissions</td>
<td>3-6 tonnes (based on 6100 kw.hr electricity, gas or coal)</td>
<td>42-45 tonnes</td>
<td></td>
</tr>
<tr>
<td>Option 3: Replace the Bridge</td>
<td>619 tonnes based on concrete and steel production emissions</td>
<td>0</td>
<td>619 tonnes</td>
<td></td>
</tr>
<tr>
<td>Typical Australian Household emissions/yr</td>
<td>80-100 tonnes 18 tonnes/year x 50years =</td>
<td>900 tonnes</td>
<td>980-1000 tonnes</td>
<td></td>
</tr>
</tbody>
</table>

*CO2 emissions based on 270kg CO2/m³ - manufacture of Portland cement based concrete 178kgs CO2/m³ – manufacture of 80% portland : 20% flyash cement based concrete 825kg CO2/tonne reinforcement steel production


From the table, we can see that Option 2 (Remediation) should
emit the lowest amount of CO\textsuperscript{2} over its 50-year life.

The “Cure”

Research by Chris Dowding of TOD, and Adam Britton of NSC, indicated that ASR had been previously controlled with concrete encasements incorporating anti-bursting reinforcement.

- The fresh concrete needed to be carefully designed to avoid introducing more alkalis to the old ASR-prone concrete.
- This was achieved by replacing some portland cement with pozzolanic cements, including flyash and silica fume.
- Cathodic protection could protect the reinforcement from corrosion, even if some ASR cracking still occurred. This was important, given the worldwide indications about the difficulty of solving ASR problems.
- This approach was enhanced by Specialist design and construction Contractor, Marine and Civil Maintenance NSW (MCM), in 2016. MCM’s director, Alan Bird, and his team greatly reduced the time and complexity of repairs. They also developed a viable method to use simpler anodes in the cathodic protection system.

By delivering a way (option 2) to maintain this vital connection through Noosa, at a cost 50% lower than the substructure replacement option (1), and 70% less than full bridge replacement option (3), the project has benefited Council and it’s ratepaying Community significantly. Importantly, the bridge will continue to support the $600million/annum Noosa tourism industry.

Each of the main participants in the project, Noosa Shire Council, TOD Consulting and Marine Civil Maintenance were pleased and grateful to have contributed to the project’s success and were very proud to be recognised with an IPWEAQ Excellence Award in 2016. Project award judges commended the project participants for delivering such an effective solution to extend the useful life of an asset which was a win for sustainability with materials saved, the embedded energy of the bridge was not lost and it saved $3-5 million which can be directed elsewhere to benefit the community.

For more information about the project and participants, visit:

http://www.todconsulting.com/