Swansea Bridge Rehabilitation

Summary

Swansea bridge, constructed circa 1989, is a high profile opening bridge on the Pacific Highway at Swansea, NSW (refer Figure 1). Due to harsh marine exposure, the bridge substructure elements have suffered from reinforcement corrosion induced deterioration. A long life and environmentally sustainable rehabilitation option was required to be adopted to minimise community disturbance and achieve best value for money. There were numerous engineering challenges which were overcome by utilising sound and innovative engineering practice.

A comprehensive condition investigation was undertaken which assisted in careful selection of a most cost effective yet durable rehabilitation. Concrete cathodic protection (CP), a state of the art rehabilitation technique utilising DC electric current to combat reinforcement corrosion, was selected as the principle rehabilitation technique. A comprehensive condition investigation was undertaken which assisted in careful selection of a most cost effective yet durable rehabilitation. Concrete cathodic protection (CP), a state of the art rehabilitation technique utilising DC electric current to combat reinforcement corrosion, was selected as the principle rehabilitation technique. This project received the highly commended award from Engineers Australia in 2011. The related paper presented to Austroad 2011 conference also received a Merit award.

Introduction

The original channel crossing at Swansea was a drawbridge built in the early 1880s. This was replaced in 1909 with a bridge, which incorporated a roadway, later to become the Pacific Highway.

The current crossing has two opening bridges spanning the entrance to Lake Macquarie. The older northbound bridge was opened in 1955 and the second southbound bridge (Swansea Bridge) was opened in 1989 (built circa 1986). Each of the bridges contains two lanes for traffic and provides pedestrian and cycleway access.

Swansea Bridge is approximately 175 m long, comprised of precast piles, cast in situ pile caps and pier columns, cast in situ edge beams, precast prestressed concrete deck planks (spanning between pier columns), and deck top slab.

Numerous engineering challenges were overcome by utilising sound engineering practice as there are very few instances where such a system was installed to a lifting bridge in Australia or overseas.

Benefits to the community and focus on customer needs

Swansea Bridge is a high profile bridge and demolition and new construction was not an acceptable or sustainable solution to the community. The asset owner, Roads and Maritime Services (RMS) NSW, required a cost effective rehabilitation design in line with community expectation.

Considering the deterioration mechanisms identified and the extent of physical damage, the following two repair options were considered:

- **Option 1:** Conventional concrete patch repair and silane coating
- **Option 2:** Combination of concrete patch repair, CP and silane coating.

After undertaking an engineering cost estimate, Option 2 was selected to provide best value for money for RMS. CP was not selected for all members from both technical and cost considerations. The following combination was adopted:

- Concrete patch repair to all existing damage
- Application of CP system to the following elements:
  - Piles
  - Pile caps
  - Pier columns
  - Deck soffit – wet areas (refer Figure 4)
- Application of coating systems to the edge beams and deck plank soffit dry areas

Figure 2 DC current applied through the anodes and cables, to stop corrosion to the reinforcement.

Figure 3 Direct current supply unit.

Figure 4 Distinctive Wet Areas.

Innovation in design, construction, maintenance and management

One of the very unusual observations on this bridge was wetness of the deck soffit towards certain piers due to unique wind actions and turbulence that prevailed under the bridge.

The wetness assisted suction of airborne chlorides and posed significant threat to the integrity of the prestressed concrete deck planks. A sacrificial anode CP system was designed only for the wet section and a cost effective silane coating was proposed for the dry section of the wet planks. Due to the potential damaging effect on the prestressing tendons by the direct current (DC) used in impressed current CP, a sacrificial anode CP was designed for the deck planks.

Impressed current CP application in tidal area is a challenge and there were a number of failures reported subsequent to the installation. Specialised types of CP application were designed to minimise the likely problems. Coating materials were also carefully selected to provide long life and were suitable for the gases produced by the CP current. Note that the CP reactions produce gases that need to be escaped to the atmosphere.
**PROJECT PROFILE**

The coating material, therefore, should be breathable to the CP gases. The coating material is also expected to provide long life to the CP system by restricting moisture ingress and hence limiting anode backfill deterioration.

Concrete CP, that utilises DC electric current to combat reinforcement corrosion, is still a developing technique worldwide. It provides long term corrosion protection to reinforced concrete structures (life in excess of 40 years with CP, compared to typically 5-10 years’ life with traditional concrete patch repair). Maintenance and management of the bridge will be a simple exercise with the rehabilitation option designed.

**Environmental sustainability**

Due to long life achieved with minimal use of new materials and no requirement for demolition, CP is considered a truly sustainable option. A detailed innovative and unique study was also made to determine the effect of CP current on marine life, flora and fauna. It was a GHD internal research work with assistance from a study undertaken by others including a report for the RMS by the Ecology Lab on “Cathodic Protection Systems on Built Structures: Effects of Marine Fauna” dated December 2007. Our assessment concluded that:

- There should always be plenty of marine growth on piles with no discernable difference between CP and non CP piles.

- Local fish should continue to feed as normal off the marine growth on structures with CP. Schools of fish are expected to hang around anodes like they do with anything dangling in the water. Dolphins, seals, turtles, stingrays, sharks and even small whales are all expected to swim under the bridge without any problems.

- The CP anodes for the section above the mid-tide level will have no influence on the marine fauna. For the elements below the mid-tide level, the effect of CP current to the marine life or marine growth should be minimal or nil.

- Any potential effect was further reduced by judicious CP design. For example, only sacrificial anode CP was designed for the steel piles which will have no or minimal effect on the marine life. Similarly, impressed current CP anodes were embedded in concrete to minimise the risk to marine life, flora and fauna.

**Use of sound engineering practices and principles**

GHD has used its in-house developed computer models to predict the service life of the bridge. Since the deterioration was not uniform for all the elements, specialised repair was targeted only for certain elements which enabled formulation of a cost effective yet technically sound long term rehabilitation for the bridge.

The rehabilitation design has considered minimisation of waste by reducing the amount of concrete removal required. The detailed ecological study undertaken to assess the effect of this rehabilitation design on the marine life, flora and fauna is considered to be unique and innovative.

**An engineering challenge**

A defect free and durable CP system for the tidal and splash zones has been seen as a challenge. GHD worked closely with RMS and the Contractor (Marine and Civil Maintenance) to devise a rehabilitation design that would be durable in the differing exposure conditions of tidal, splash and atmospheric areas.

Careful selection of targeted repairs assisted RMS in managing the required budget for the rehabilitation work.

**Significance of the work**

CP is a specialised repair technique for existing structures. It can also be used in new construction. The mass engineering practice has limited knowledge on this less used yet very effective corrosion control measure for reinforced concrete structures. Careful and innovative investigation and design yielded a very successful and unique CP system for this bridge.

The ecological study of CP on marine life, careful and targeted selection of specialised repairs to certain elements, and sound engineering practice principles used in selection of durable CP design, provide one of the most durable yet cost effective repairs to any deteriorated bridge structure.

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