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Xypex for Chloride Protection – A Case Study

Proof of Xypex permanence and its ability to enhance the durability of concrete structures was clearly evident in a recent review of the Xypex-treated precast concrete used to construct the Cronulla Marina floats in Gunnamatta Bay near Sydney, Australia. The results of this in-depth review indicated that the Xypex Crystalline Technology not only waterproofs and enhances the concrete, but also continues to work throughout the life of the structure, extending the design life beyond the original specification.

Cronulla Marina Jetty - Gunnamatta Bay, Sydney, Australia



1994 – Construction of Jetty

The marina is situated with a southerly aspect to its layout, exposing the concrete floats to continuous aerosol chlorides. The floats are also within the splash zone, and under conditions described by the report as ‘a severe marine environment’.

The marina floats were cast in October 1994. They were designed to be 100 mm (4 in) thick allowing only 40 mm (1⁵/₈ in) of cover over the pre-tensioned wire strands. The floats have foam flotation to the soffit and the top surfaces of the floats are a nominal 350 mm (14 in) above sea level. This design meant that the reinforcement cover would not meet the normal requirements for a severe chloride exposure environment of this type. Therefore, additional chloride protection was deemed necessary and Xypex Admix was chosen to provide this.

Mahaffey Associates of Australia tested concrete that incorporated the Xypex Admix against both a concrete control sample and concrete with the same mix design that contained a pore-blocking admixture. Testing results were noted as follows:

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“From this test it is apparent that concrete containing Xypex admix will have a better chloride diffusion resistance than concrete made with type SL cement, particularly if the concrete is given 7 days curing. Further, Xypex treated concrete performs significantly better than both plain cement and concrete containing a pore blocking additive when treated using a standard full immersion chloride ion diffusion test. This suggested that there are applications where the durability of concrete for marine applications can be enhanced by the use of Xypex admix in the concrete.

By observation of treated Xypex treated concrete used in the field, it is also apparent that the material has the ability to self heal should cracking occur. This is a characteristic that is of further benefit in concrete that is exposed to aggressive environments.”



A high early strength mix design was specified for each that incorporated 530 kg per m³ (875 lb/cu yd) of cement with a 0.32 water/cement ratio.

1998 – 4 Year Performance Field Review

In 1998, a condition-survey of the Jetty by BCRC (Durability Consultants) was commissioned. It included a visual inspection, chloride penetration and half-cell testing. The results were excellent and confirmed that, in high-chloride environments, Xypex-treated concrete outperforms untreated concrete. The indicators were low chloride diffusion rates and half-cell equipotential mapping that showed an insignificant half-cell potential gradient over the slab area.

2013 – The Jetty’s 19-Year Performance Review

Testing of the same properties was commissioned again in May 2013 after 19 years of continuous service. The same tests and inspections as conducted in 1998 were performed by BCRC. While chloride contents increased in the top 20 mm ($\frac{3}{4}$ in) of the concrete, the chloride content deeper into the slab was well below that which would promote corrosion. Half-cell results again showed an absence of any significant potential gradient over the slab, thus indicating a lack of corrosion activity.

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The key objectives of the testing were the assessment of “concrete durability”, “chloride permeability” and “performance life”.

A comparison of results for the two sets of identical testing taken 15 years apart highlights the following:

1. Chloride diffusion rates are directly affected by, and are a consequence of, the ability of the Xypex Crystalline Technology to reduce concrete’s permeability (the passage of water is the primary vehicle for the diffusion of chlorides). A very low chloride diffusion coefficient was achieved by the Xypex treated concrete in the Cronulla floats. Further, over the 15 years between studies, the diffusion coefficient of the concrete decreased by 92%. This reduction was most likely due to the continued development of the Xypex crystal structure within the concrete, causing a continued reduction in the permeability over time.
2. In 1998 the condition of the concrete was described as “in good service condition after a four year exposure in a severe marine environment”. In 2013 (19 years later) it was described as “in an excellent condition after nineteen year’s exposure in a severe marine environment.” This appears to reflect the view of the testing authority that the condition of the concrete is exceeding expectations.

Conclusions

1. Using the derived diffusion coefficients, the current expected time to corrosion was calculated at 129 years from the time of the survey. This translates to a predicted service life of **150 years** from the time the floats were commissioned.
2. There is an absence of any evidence of corrosion in the structure even with only a 40 mm (1⁵/₈ in) of concrete cover and after 19 years in a severe marine environment.

Many independent lab tests have indicated that Xypex Crystalline Technology has the ability to improve reinforced concrete’s resistance to chloride induced corrosion. This recently completed 19-year survey of the Cronulla Marina floats is an excellent example of ‘field-performance’ supporting laboratory results.