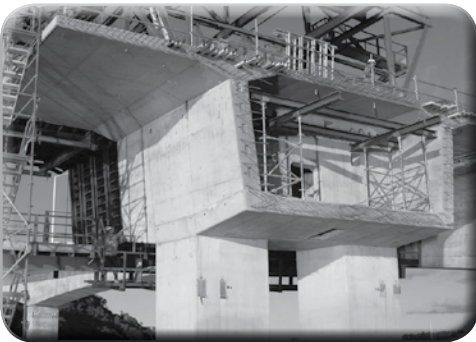




Marine Concrete



A Natural Pozzolan for High Performance Concrete



Microsilica 600

MICROSILICA 600 – for Marine Concrete

Reinforcement corrosion is the most common form of durability failure in concrete marine structures. The corrosion process is considered to progress in 2 phases - initiation and propagation.

The initiation phase involves the reduction in the concrete's alkalinity at the reinforcement. This can occur through carbonation, a very lengthy process, or by ionization. It is the ionization process, involving the movement of chloride ions through the concrete, that is considered as the major contributor to the breaking down of the protective alkaline coating on the reinforcement. The prime mechanism in moving the chloride ions is diffusion. At the early stages of chloride ion penetration, sorptivity can be influential.

The breaking down of the alkalinity afforded by the concrete, leads to corrosion - the start of the propagation phase. The rate at which the reinforcement corrodes is dependent on the availability of oxygen and water, the residual level of the alkalinity, the presence of the reactive chloride ions and the resistivity of the surrounding concrete.

The parameters directly influenced by the chemical reactivity and physical properties of Microsilica 600 which contribute to the durability performance of concrete are:

- Chloride ion Diffusion
- Sorptivity
- Electrical Resistivity



Figure 1. Microsilica 600 was used on the Motueka Wharf to give a 50 year life design

Rapid Chloride Permeability

The rapid chloride permeability test has found wide acceptance as a guide to concrete's corrosion resistance. Although there are concerns that in some cases it may prejudice against acceptable concrete, there is still no alternative simple test that gives a direct indication of corrosion resistance. 1000 coulombs is recognised in AASHTO T277 as the upper limit for concrete to provide adequate corrosion protection in a chloride environment.

Tests carried out on New Zealand concretes produced a range of values as shown in figure 2.

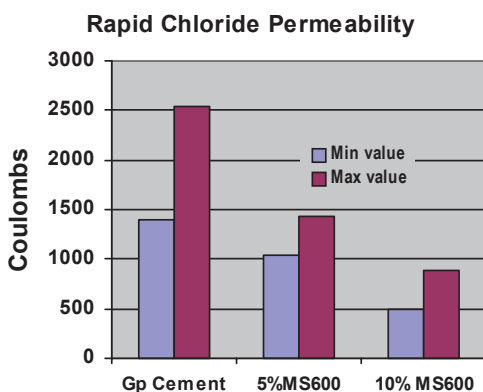


Figure 2. Use of Microsilica 600 reduces rapid chloride permeability by 300%.

Benefits of Microsilica 600 Marine Concrete

Extended life

- 3 to 5 times greater than GP concrete.

Reduced Rebar Cover

- Up to 50% of GP cement concrete.
- Thinner & lighter elements.

Improved Constructability

- High early strength.
- Less reinforcement.
- Early formwork stripping .
- Thinner & lighter elements.
- Lower temperature rise.

Chloride Ion Diffusion - Chloride Ion Penetration

Concrete's actual chloride ion diffusion coefficient (D_{act}) is measured on saturated concrete in a diffusion cell. The effective chloride diffusion coefficient (D_{eff}) in a real structure is affected by water being drawn in by sorptivity, the moisture content of the concrete (chlorides diffuse through the water) and changing environmental conditions. Both diffusion coefficients are determined using Fick's second law of diffusion.

Chloride Ion Profiles in Real Situations

The first stage in establishing diffusion coefficients is to examine the levels of chloride ion penetration in concretes exposed to marine environments. The worst possible conditions for rapid chloride ion ingress are those involving cyclic wetting and drying where salt laden mediums are in contact with concrete piles, sea walls etc.

Concrete degradation in marine structures is often apparent in the area referred to as the splash zone - an area normally extending approximately 1 to 2 metres above high tide. In 1998, BRANZ (The Building Research Association of New Zealand) started measuring chloride ion ingress in concrete blocks made with GP cements in combination with supplementary cementitious materials. The blocks were located within the confines of the Wellington Harbour. Readings (Figure 3) taken after 18 months of exposure show that chloride ions in the Microsilica 600 concrete have extremely low levels of penetration.

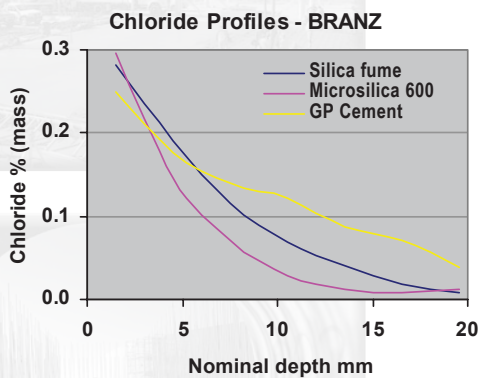


Figure 3. The Microsilica 600 concrete showed much less chloride penetration than the silica fume or GP cement after 18 months exposure in the splash zone.

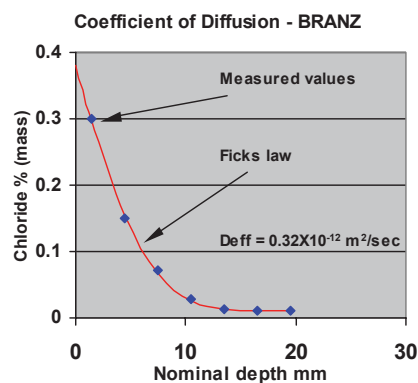


Figure 4. The correlation between measured and theoretical values (Fick's Law) illustrates the effectiveness of Microsilica 600.

Using the BRANZ data the effective diffusion coefficient (D_{eff}) was calculated, as shown in figure 4.

Laboratory Chloride Ion Profiles

Laboratory tests were undertaken by the Australian CSIRO (Building, Construction and Engineering) to determine actual diffusion coefficient (D_{act}). Concrete specimens, cementitious content 420 kg/M³, water/binder ratio of .38 were soaked in 3% NaCl solution for 90 days.

	$D_{act} M^2/sec$
GP cement	5.27×10^{-12}
Microsilica 600 (10%)	3.22×10^{-12}
Silica fume (10%)	3.29×10^{-12}

Table 1. Including Microsilica 600 in the concrete mix reduces the diffusion coefficient. relative to plain concrete.

Sorptivity

Sorptivity is a measurement that indicates the degree of the water absorbency. Sorptivity test measures the depth of water in concrete after specimens have been soaked in water for 24 hours. For Microsilica 600, concrete absorption is extremely small and in some cases impossible to measure. New Zealand concretes with cementitious contents of 400 kgs/m³, W/CB of 0.4 and cement replacements with Microsilica 600 at 5% & 10% gave results of 0 to 1.5mm. Testing was undertaken by the Australian CSIRO. Other tests carried out by BRANZ and Opus International Ltd produced results of less than 0.1mm/min 0.5-identical to silica fume concrete performance.

Specification for Marine Concrete

Corrosion Resistant Property Requirements

For a 50 year life, as defined by the NZ Building Code, rebar cover at 50mm or greater, the following requirements should be met:-

Rapid Chloride Permeability at 28 days less than 1000 Coulombs

Resistivity at 28 days greater than 20,000 ohm cm

Sorptivity at 28 days less than 0.1mm/min^{0.5}

Product Compliance Statement

Concrete having the following properties shall be deemed to comply with the above:

Min cementitious content	400kg/m ³
W/CB ratio	0.4
Microsilica 600 content	8.0%

Note: Microsilica NZ's life expectancy computer model will provide a more precise evaluation of life expectancy, taking into account, MS600 dosage, rebar cover, concrete strength and the prevailing environmental conditions.

Resistivity

Concrete resistivity is the resistance of concrete to the passage of corrosion induced electrical currents.

In the propagation phase of the corrosion process, a macro-cell is created with the concrete acting as part of the electrical circuit between anode and cathode. By increasing the resistivity of the concrete, corrosion will be slowed but not totally stopped.

As shown in figure 5, the resistivity of concrete containing Microsilica 600 is some 5 times greater than conventional concrete.

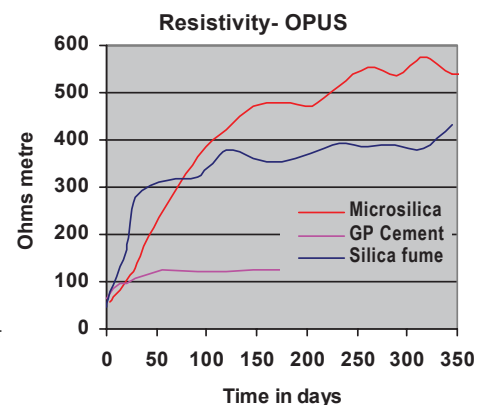


Figure 5. Resistivity of continuously soaked concrete specimen (Opus 1999)

MICROSILICA 600 APPLICATIONS & INFORMATION

Other Microsilica 600 applications for specialist concretes and high performance concrete are detailed in the following brochures:

- Industrial & Commercial Floors
- Chemical Resistant Concrete
- High Strength Concrete
- Water Proof Concrete
- Shotcrete

Reference should also be made to the operational and safety requirements in the following documents:

- Health & Safety Data Sheet
- Concrete Mixing Instructions
- Concrete Placement & Finishing Procedures
- Plastic Properties of Microsilica 600 Concrete

Product Note

The information contained in this brochure is offered in good faith and every effort has been made to ensure its accuracy. However, due to differences in conditions, environments and materials no liability is accepted by Microsilica NZ, Golden Bay Cement or their agents for loss or damage, direct or otherwise, resulting from the application of the information contained herein. Microsilica NZ reserves the right to change product specification without prior notice



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