Australian Industrial Additives Pty Ltd
ABN: 54 098 340 062

CERTIFICATE OF TEST

Test for:

Corrosion inhibiting properties for concrete steel reinforcement

Test Material:

C R P " L" (Aqueous Solution)

Test Standard:

Polarization curves method.
As no Australian standard exists for determining the inhibiting properties of concrete for protection against reinforcing steel corrosion the polarization curves method was chosen.

The polarization curves method is based on the following:

- After immersion of a steel rebar in water or electrolyte solution, some quantity of the iron ions moves to the solution (anodic process). The corresponding quantity of the electrons is left in the steel. As a result a double electrical layer is formed with a sudden change of the potential on the outer face of 'metal liquid', which prevents the iron dissolving. This balance in the double electrical layer is disturbed due to the reduction of oxygen or hydrogen ions (cathodic process).
- The speed at which steel dissolves is determined by the process having the largest inhibition, the anodic process.

The degree of anodic process inhibition is evaluated by the anodic polarization curves which determine the dependence of the potential from the strength of the current. By analysing the anodic polarization curves the stationary potential E_{st} (current strength = 0), the potential of passivation E_{pass} (first peak of polarization curve) and the disruption potential of passivated layer E_{disrup} (second peak of polarization curve) are determined. The criteria [references 1, 2 & 3] for evaluating the steel rebar electrochemical condition are presented in Table 1.

Table 1. Criteria of evaluation of electrochemical steel condition.

Criteria	Steel condition		
	Stable passive No corrosion possible	Unstable passive condition (possible minor corrosion)	Active (possible intensive corrosion)
Stationary potential E_{st}	> -350mV	< -350mV	< -350mV
Potential of passivation, E_{pass}	> -350mV	> -350mV	-
Disruption potential, E_{disrup}	> 450mV	> 300mV	< 300mV

Findings:

Treating concrete (containing up to 1.5% by weight of calcium chloride to cement) with C R P "L" changes the rebar to a stable passive condition eliminating further corrosion.

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Specimens: 3 of concrete slabs from each of 3 different concrete mixes (9 in total). Each slab 280mm x 200mm x 80mm thick with 3 of 6mm diameter x 250mm long steel reinforcing bars placed on the centre line of thickness at 100mm centres and protruding 25mm from the slab.

Concrete mix design (cubic metre):

- GP cement – 298kg
- Coarse sand – 493kg
- Fine sand – 322kg
- Stone (20mm) – 740kg
- Stone (10mm) – 297kg
- Admixture 340 RI – 300ml/100kg of cement
- Water – 192kg (W.C. ratio 0.644)

Concrete properties:

Slump – 90mm
Air content – 2.2%
Fresh concrete density – 2342kg per cubic metre
Compressive strength (28 days) – 32 Mpa

3 specimens (A) each made to this mix
3 specimens (B) each made to this mix, plus .75% calcium chloride by weight to the cement content.
3 specimens (C) each made to this mix plus 1.5% calcium chloride by weight to the cement content.

Curing of specimens: All specimens were air cured for 28 days during which time they were sprayed daily with water.

At the end of this period they were placed in an electrolyte bath, connected to the measuring equipment and measurements of voltage at varying current flow taken. From these the anodic polarization curves for the untreated specimens were drawn.

On the completion of these tests the specimens were allowed to dry then treated with C R P “L” (applied in accordance with the application instructions) and allowed to stand for a further 28 days before being returned to the electrolyte bath to the measuring equipment. Again voltage was measured at varying current flow and the anodic polarization curves for the C R P “L” treated specimens drawn.

Polarization curves for the untreated and treated specimens are shown in Figure 1.

From the anodic polarization curves the potential of passivation and the disruptive potential of the passivated layer were determined in accordance with the procedure outlined; these results are shown in Table 2.

These results show that the steel rebar condition <u>in the untreated concrete slabs</u> as being:

- Stable passive in standard mix concrete.
- Unstable in standard mix concrete containing 0.75% calcium chloride to the cement by weight.
- Active in standard mix concrete containing 1.5% calcium chloride to the cement by weight.

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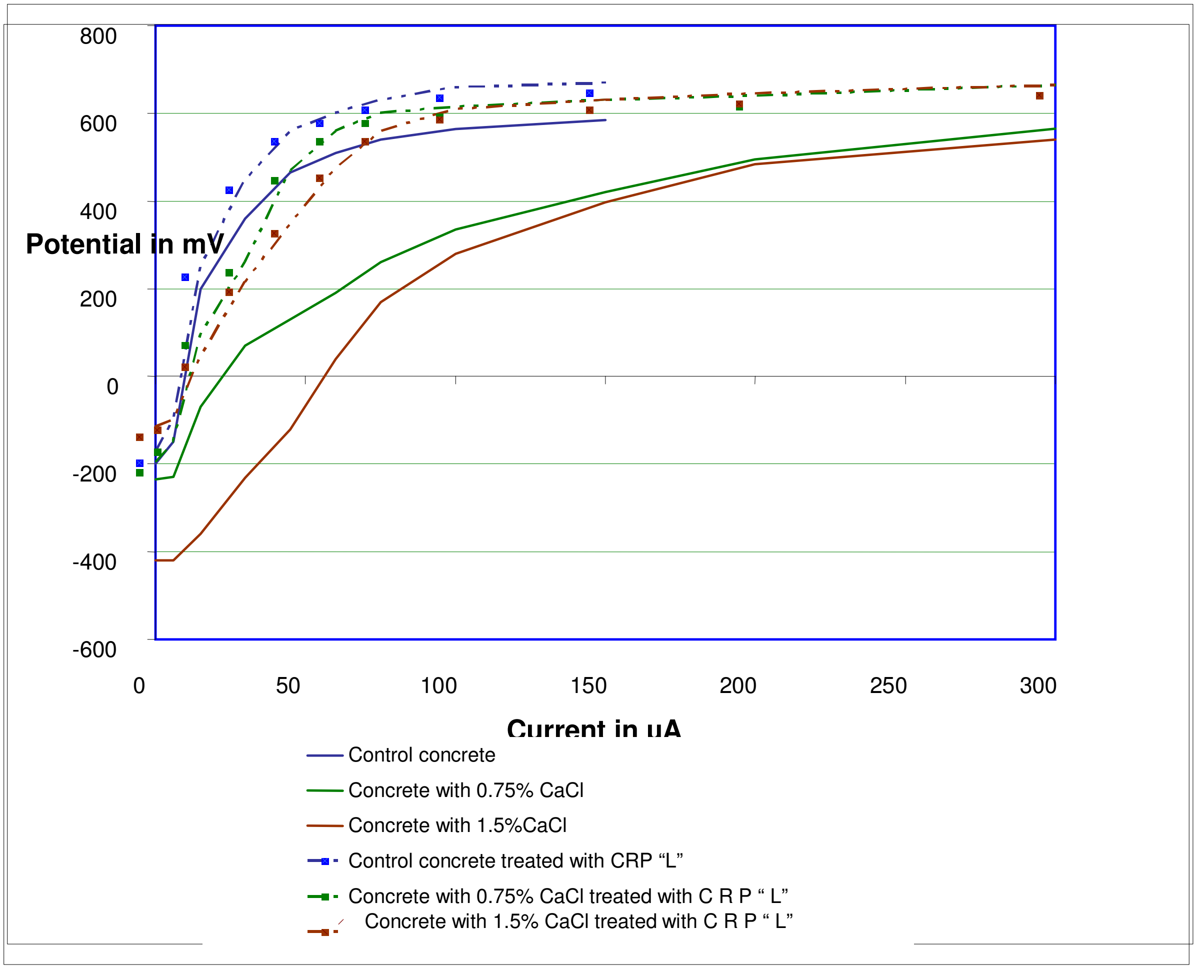

Figure 1: Anodic polarization curves of steel rebars in concrete slabs.

These results show that the steel rebar condition <u>in the concrete slabs treated with C R P "L"</u> as being:

- Improved stable passive in standard mix concrete.
- Stable passive in standard mix concrete containing 0.75% calcium chloride to the cement by weight.
- Stable passive in standard mix concrete containing 1.5% calcium chloride to the cement by weight.

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Table 2: Determined potential values and condition of steel rebars in concrete slabs.

Name of sample	Stationary potential E_{st}	Potential of passivation E_{pass}	Disruption potential of passivated layer E_{disrup}	Condition of steel rebars in concrete
Steel rebars in plain concrete	-200 mV	-150 mV	500 mV	stable passive
Steel rebars in concrete containing 0.75% calcium chloride	-235 mV	-180 mV	360 mV	Unstable
Steel rebars in concrete containing 1.5% calcium chloride	-420 mV	-360 mV	280 mV	Active
Steel rebars in plain concrete treated with C R P " L"	-175 mV	-100 mV	560 mV	stable passive improved
Steel rebars in concrete containing 0.75% calcium chloride and treated with C R P " L"	-195 mV	-150 mV	490 mV	stable passive
Steel rebars in concrete containing 1.5% calcium chloride and treated with C R P "L"	-115 mV	-100 mV	480 mV	stable passive

References

1. Alekseev S.N. and others. Steel Corrosion Inhibitors in Ferroconcrete Constructions. Publishing House "Strojizdat", Moscow, 1985, 273 p.

2. Startfull R.F. Half-cell potentials and the corrosion of steel in concrete. USA California. Highway Research Record, No 433, 1973, pp. 12-21.

3. Kliethermes J.C. Repair of Spalling Bridge Desk. USA California. Highway Research Record, No 400, 1972, pp. 83-92.

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