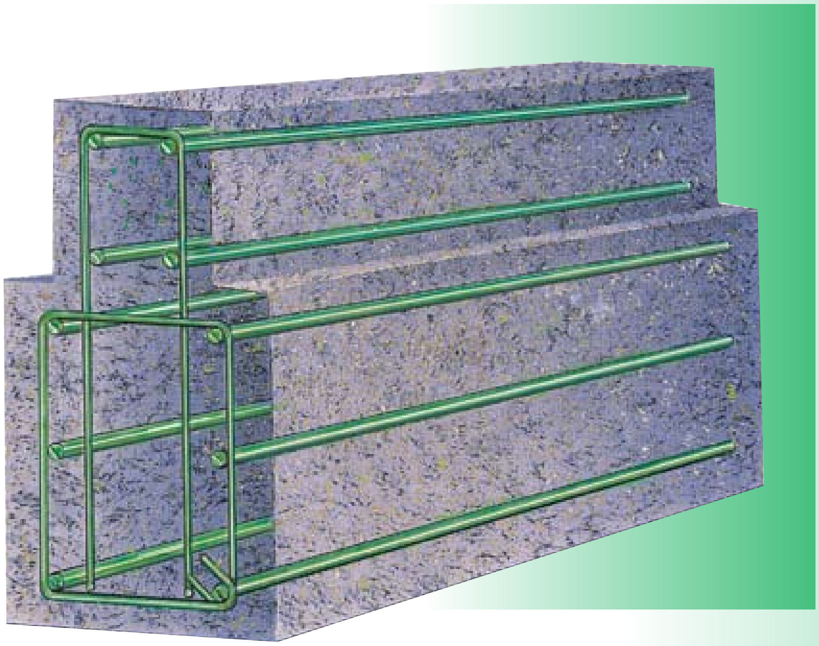
Migrating Corrosion Inhibitors™!

MCI® Admixtures

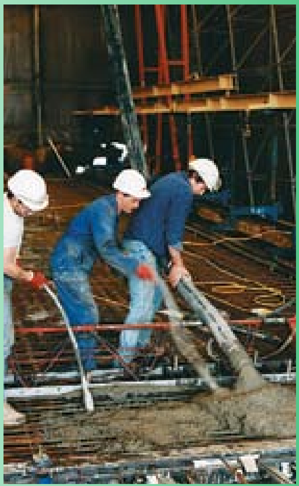
Migrating, corrosion-inhibiting admixtures for reinforced structures.

Increases durability and dramatically reduces corrosion.



CORTEC CORPORATION

Environmentally Safe VpCI®/MCI® Technologies



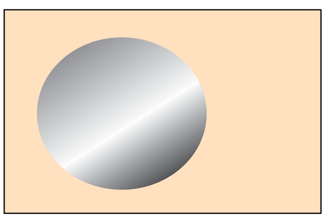
MCI® 2000 Series

Migrating, Corrosion-Inhibiting Admixtures

A new reinforced concrete structure is designed to have a long service life – typically in excess of 50 years. Unfortunately, many structures fall short of this goal, requiring expensive repair and protection work in the future.

A major reason for the premature deterioration of our reinforced concrete infrastructure is ***corrosion of the reinforced steel.***

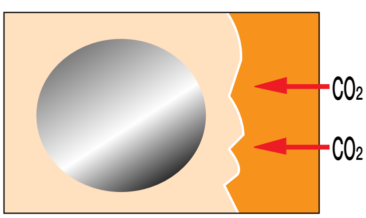
The Two Major Causes Of Corrosion In Concrete



Rebar in alkaline concrete.

Concrete is a highly alkaline material when first produced (pH range 12-13). The embedded steel is protected by a passive oxide layer which is maintained by high alkalinity at the surface of the steel.

Under certain exposures and conditions the natural passivating protection of the steel breaks down. In the presence of moisture and oxygen, corrosion then occurs.



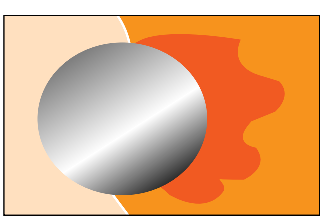
Loss of alkalinity with CO_2 ingress.

Carbonation of Concrete
The most common cause of loss of passivating alkalinity is carbonation – a process whereby atmospheric carbon dioxide reacts with the soluble alkaline calcium hydroxide and other cement hydrates in concrete. These are then converted into insoluble calcium carbonate.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3\downarrow + H_2O$$

(Soluble) High Alkalinity   Lower Alkalinity (Insoluble)

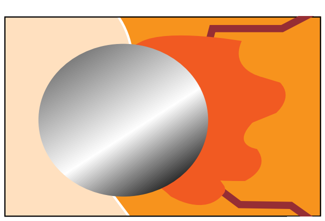
The alkalinity of the cement matrix is reduced and its passivating ability is lost progressively from the surface inward.



Corrosion can begin when carbonation reaches the steel.

Once the concrete in contact with reinforced steel has carbonated, the steel is no longer protected. In the presence of moisture and oxygen, corrosion damage is inevitable.

Chlorides in Concrete
The concentration of chlorides required to promote corrosion of embedded reinforcement is affected by the pH of the concrete. In alkaline fresh concrete a threshold level of about 7,500-8,000 ppm is required to start corrosion, but if the alkalinity is reduced the chloride threshold is significantly lower (below 100 ppm). Typical sources of chloride include deicing salts, salt water environments and some commercial admixtures.



Cracking and spalling will ultimately occur.

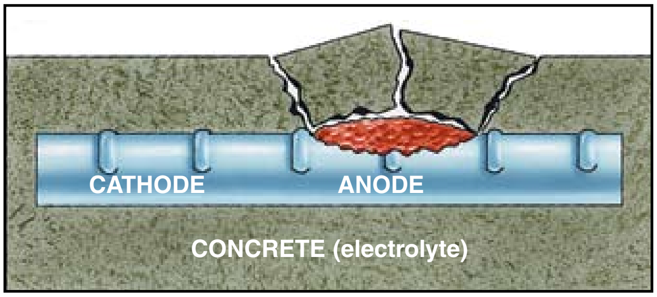
An Innovation That Fights Corrosion And Extends The Service Life Of Reinforced Concrete Structures

The Electrochemical Process of Corrosion

The corrosion products of steel (iron oxides or hydroxides), occupy a much greater volume than the steel (4-12 times the volume). This increase in volume exerts a great expansive pressure within the concrete, leading to cracking, rust staining and spalling over the corroded reinforcement.

Being an electrochemical process, corrosion of steel in concrete requires an electrolyte. Concrete is full of small pores which contain moisture, and so, is an effective electrolyte. A small, electrical current flows between the anode and the cathode with corrosion activity (rust formation) taking place at the anode.

Unprotected Reinforcing Steel

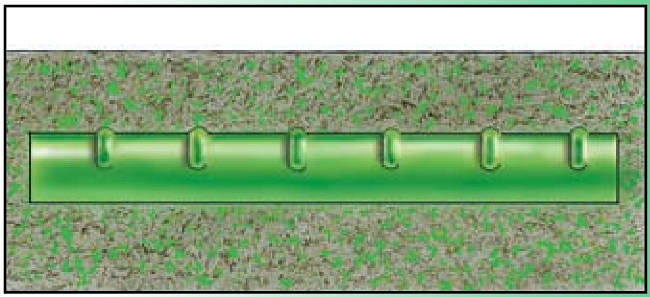


The Corrosion Process Without Cortec MCI® Admixtures.

At the Cathode: ($O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$)

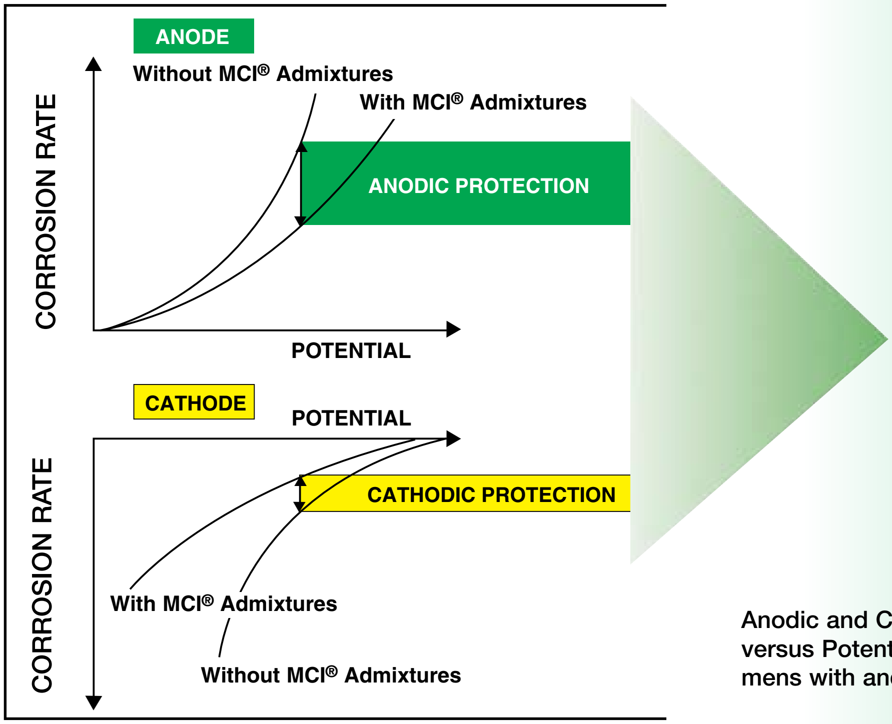
At the Anode: ($Fe \rightarrow Fe^{++} 2e^-$)

Reinforcing Steel Protected By Cortec MCI® Admixtures



When MCI® reaches reinforcing steel, it forms a protective layer (about 20Å thick) that protects the steel in both anodic and cathodic areas.

The Double-Action Performance Of Cortec MCI® 2000 Series Protects At Both The *Anode And Cathode*



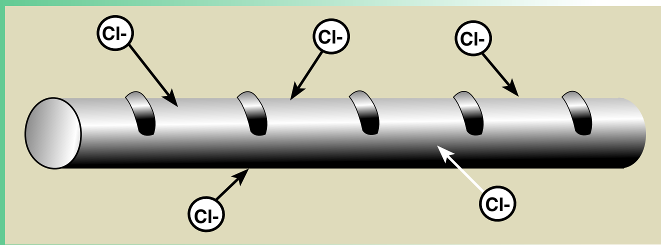
Laboratory tests measure the potential shift at both the anode and cathode.

The combination of these two protective mechanisms leads to dramatic overall reduction in corrosion activity.

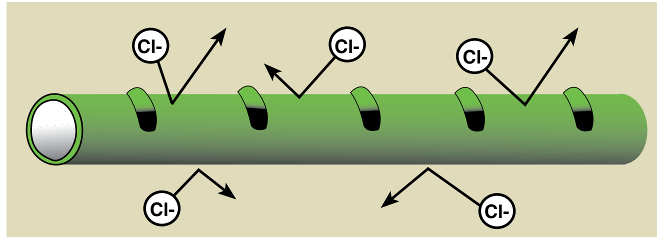
Anodic and Cathodic plots of corrosion rate (μA/cm²) versus Potential (mV) of reinforced concrete specimens with and without Cortec MCI® admixtures.

How does MCI® Technology Work?

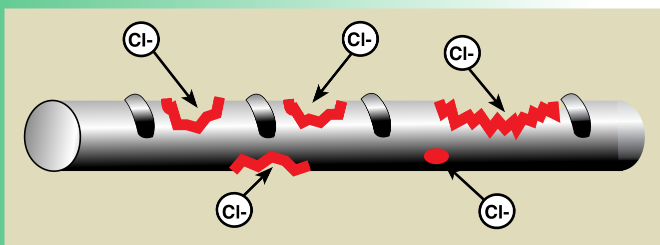
Unprotected Steel



MCI® Protected Steel



Chloride-Induced Corrosion

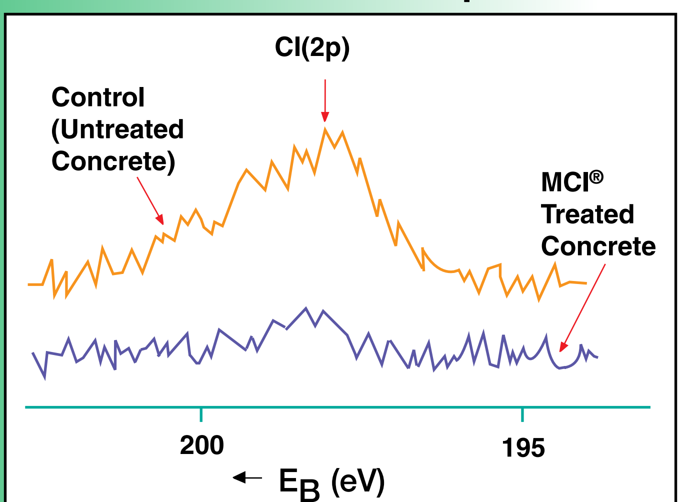


The corrosive effects of carbonation and chlorides cause a breakdown of the natural passivating protection of steel. When MCI® comes in contact with steel it forms a protective layer. This layer has been measured (using X-ray Photoelectron Spectroscopy — XPS) to be between 20 and 100Å thick at the molecular level.

MCI® 2000 Actually Displaces Chloride Ions at the Steel Surface

XPS Surface analysis testing has also proven MCI's ability to displace chloride ions from the surface of steel in chloride environments.

Chloride Part Of XPS Spectrum



Note the almost complete elimination of chloride at the surface with MCI® treatment.

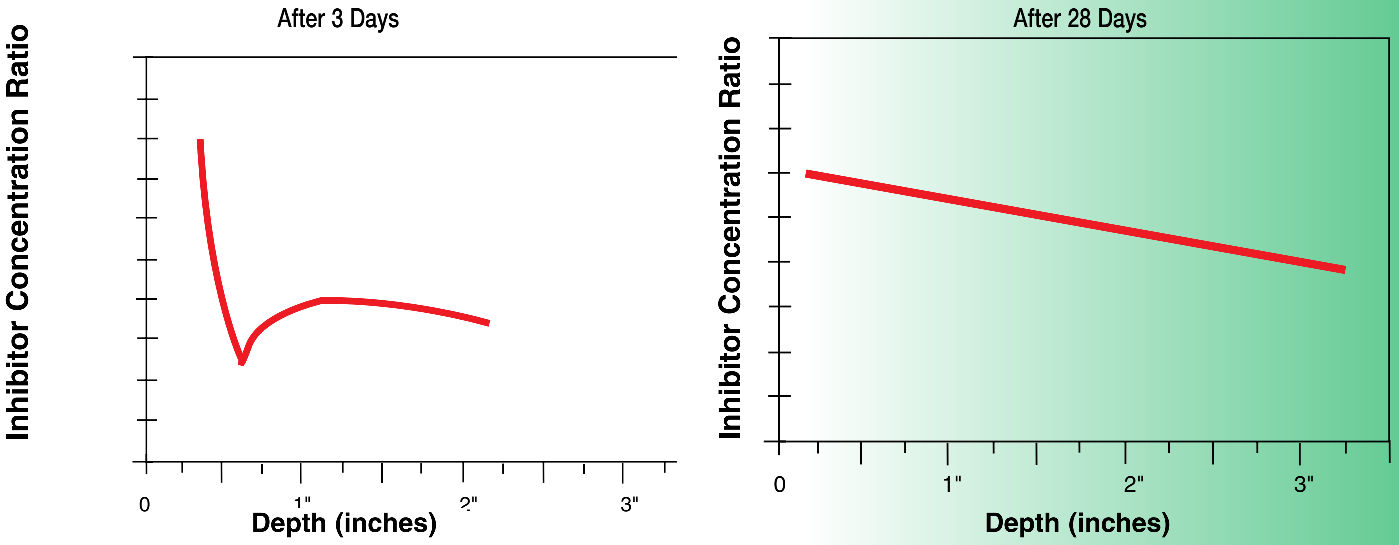
Immersion In Seawater

Without MCI® 2000 With MCI® 2000

For Durable Concrete Overlays...
Migration Of
Cortec MCI® 2000 Series Is Key

MCI® admixtures are unique in their ability to travel or migrate throughout the concrete. This migration occurs via both liquid and vapor diffusion and has been proven in concrete using Secondary Neutron Mass Spectroscopy (SNMS) methods.

Migration Concentration Curve



The rate of migration is dependent on the density and permeability of the concrete and other factors. The migration of MCI® amounts to a distance of about 7.5 cm within 7 days of initial application. This migration rate is relatively independent of the moisture content of the concrete. As a result, MCI® can also help protect the original embedded rebar in decks receiving partial depth overlays.

Long-Term Corrosion Studies

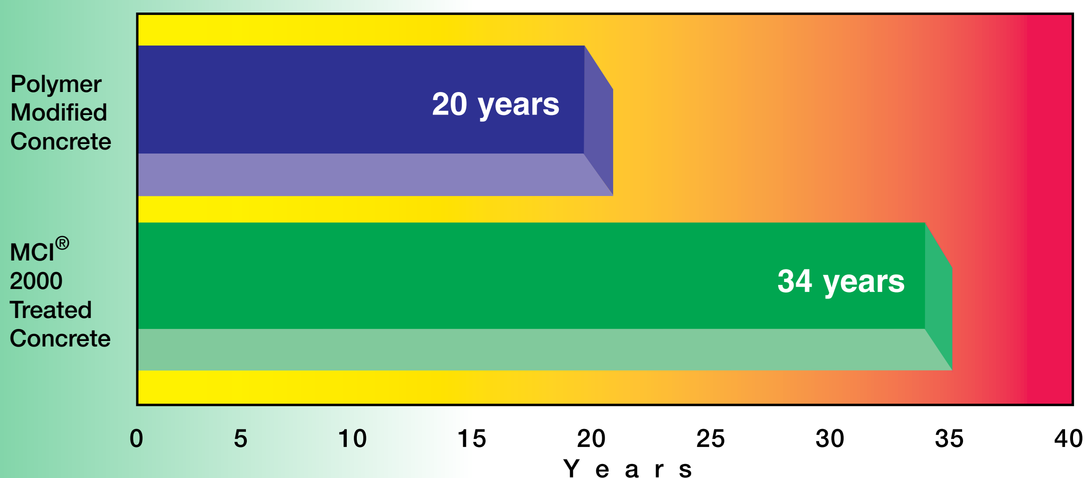
Proven Effective In Long-Term Independent Tests

The chemical structure of MCI® admixtures is such that they do not decompose over an extended period of time, making them effective for periods in excess of 34 years. This effectiveness has been proven in two long-term independent test programs: The Strategic Highway Research Program (SHRP) and Cracked Beam studies based on ASTM G 109.

The SHRP Program

The SHRP Program involved both lab testing and actual field installation on bridges throughout the USA. In comparison to Polymer Modified Concrete Overlays, MCI® treated concrete overlays demonstrated a dramatic extension of predicted service life.

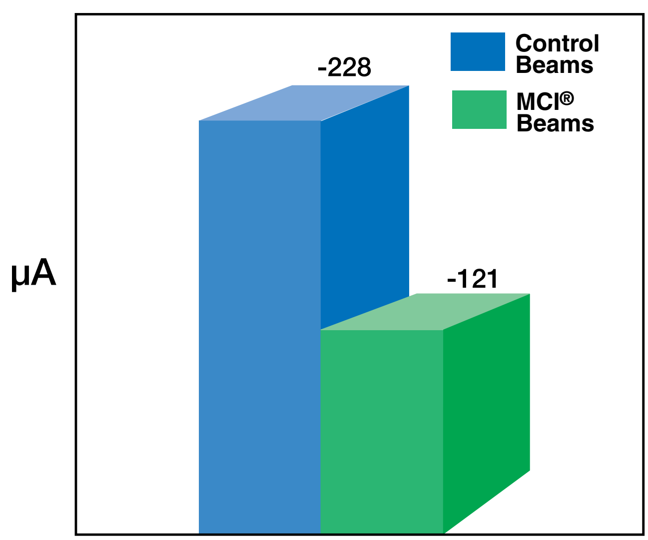
Predicted Service Life of Bridge Decks



Cracked Beam Corrosion Testing

Cracked beam tests are based on ASTM G 109. This is the standard test method for determining the effects of chemical admixtures on the corrosion of embedded steel reinforcement in concrete exposed to chloride environments.

Concrete beams are cast and cracked, some containing MCI® admixtures and others not (control beams). A salt water solution is then ponded and rinsed periodically over a 1-1/2 year period. Corrosion current is measured in microamps and compared.



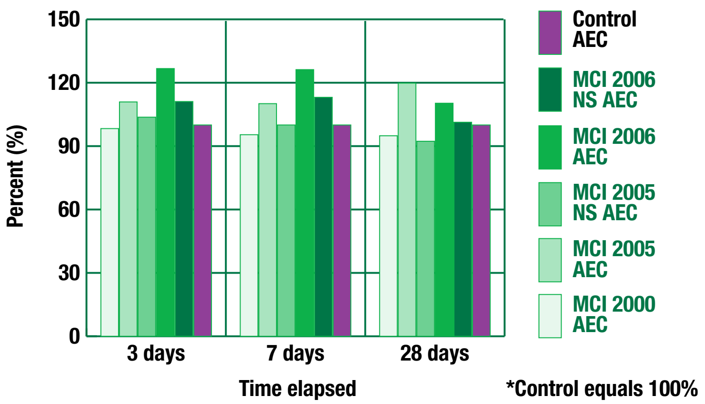
After 1-1/2 years of severe exposure corrosion, activity has significantly decreased over control specimens.

For Producing High Durability Concrete That Resists The Harmful Effects Of Corrosion

MCI® corrosion inhibiting admixtures do not compromise any of the physical properties of concrete at the recommended dosage rates.

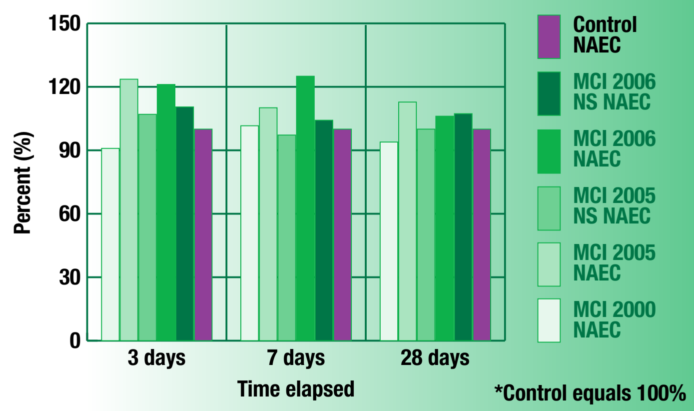
Change in Air Content (%) MCI Vs. Control	MCI 2000	MCI 2005	MCI 2005 NS	MCI 2006	MCI 2006 NS
Air Entrained	0.5	0.2	0	0.2	0
Non-Air Entrained	0.1	0.1	-0.2	0	0.2

Average Flexural Strength, MCI Compared to Control*
Air Entrained Concrete (AEC)



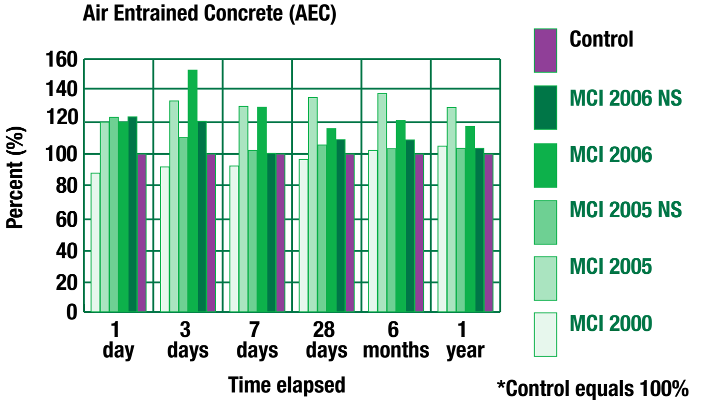
*Control equals 100%

Average Flexural Strength, MCI Compared to Control*
Non-Air Entrained Concrete (NAEC)



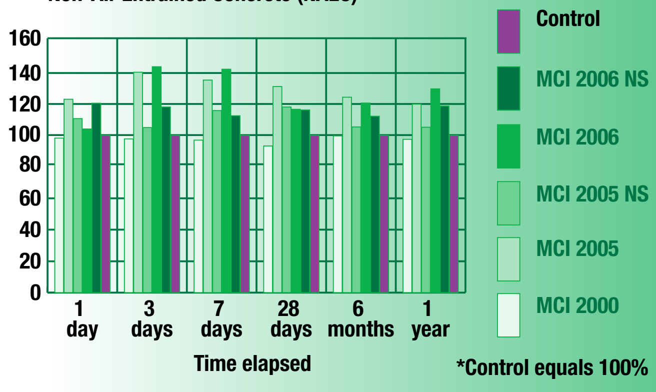
*Control equals 100%

Average Compressive Strength, MCI Compared to Control*
Air Entrained Concrete (AEC)



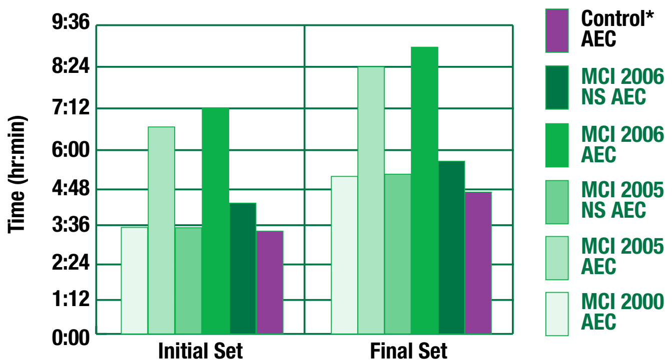
*Control equals 100%

Average Compressive Strength, MCI Compared to Control*
Non-Air Entrained Concrete (NAEC)



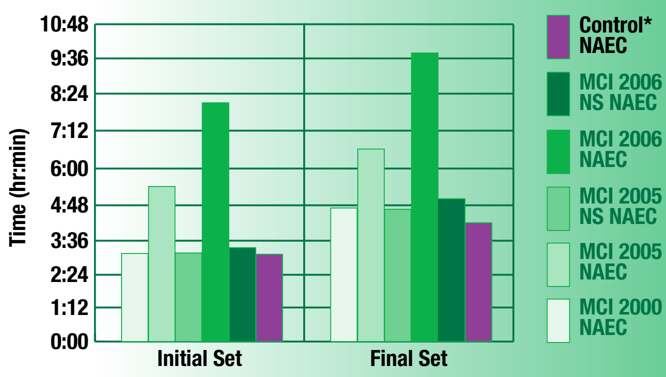
*Control equals 100%

Average Setting Time, MCI vs. Control*, Air Entrained Concrete
MCI Set Time Vs. Control (Air Entrained Concrete)



*Control is an average of set times from all control test samples.

Average Setting Time, MCI vs. Control*, Non-Air Entrained Concrete
MCI Set Time Vs. Control (Non-Air Entrained Concrete)



*Control is an average of set times from all control test samples.

Cortec MCI® Series Dramatically Reduces Corrosion In Concrete Structures. MCI Protects Your Investment!

	Product	Description	Dosage rate	Packaging	Applications
Aminoalcohol Based	MCI 2000	Liquid, aminoalcohol based concrete admixture.	1 pt/yd^3 (0.62 l/m^3)	5 gal (19 l) pails, 55 gal (208 l) drums	Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.
Aminoalcohol Based	MCI 2001	Powder, fumed silica/MCI 2000 combination.	3 lb/yd^3 (1.78 kg/m^3)	5 lb (2.3 kg) boxes, 50 lb (22.7 kg) and 100 lb (45.4 kg) drums.	Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.
Aminoalcohol Based	MCI 2002	Microsilica/MCI 2000 slurry combination.	3-5 pts/yd^3 (1.5-2.5 l/m^3)	5 gal (19 l) pails, 55 gal (208 l) drums	Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.
Amine Carboxylate Based	MCI 2005	Liquid, amine carboxylate based concrete admixture. Can retard concrete setting time 3-4 hours at 70° F (21° C). Patented.	1.0 pts/yd^3 (0.6 1/m^3)	5 gal (19 l) pails, 55 gal (208 l) drums	Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.
Amine Carboxylate Based	MCI 2005 NS	Liquid, normal set version of MCI 2005. Patented.	1.5 pts/yd^3 (1.0 1/m^3)	5 gal (19 l) pails, 55 gal (208 l) drums	Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.
Amine Carboxylate Based	MCI 2006	Powder, amine carboxylate based concrete admixture. Can retard setting time 3-4 hours at 70° F (21° C). Patented.	1 lb/yd^3 (0.6 kg/m^3)	5 lb (2.3 kg) boxes, 50 lb (22.7 kg) and 100 lb (45.4 kg) drums.	Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.
Amine Carboxylate Based	MCI 2006 NS	Powder, normal set version of MCI 2006. Patented.	1 lb/yd^3 (0.6 kg/m^3)	5 lb (2.3 kg) boxes, 50 lb (22.7 kg) and 100 lb (45.4 kg) drums.	Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.
Amine Carboxylate Based	MCI Grenades	MCI 2006 NS powder pre-dosed into water soluble bags for admixing into concrete. Patented.	1 grenade/yd^3	20 grenades/carton	Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.
Amine Carboxylate Based	MCI Metric Grenades	MCI 2006 NS powder pre-dosed into water soluble bags for admixing into concrete. Patented.	1 grenade/m^3	20 grenades/carton	Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.
Amine Carboxylate Based	MCI Mini Grenades	MCI 2006 NS powder pre-dosed into water soluble bags for admixing into mortars. Patented.	1 grenade/0.5 ft^3	100 grenades/carton	Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.
Superplasticizers with Amine Carboxylate Based MCI	MCI 2007	Liquid, melamine based superplasticizer with MCI. Patented.	3-4 pts/yd^3 (1.5-2 l/m^3)	5 gal (19 l) pails, 55 gal (208 l) drums	Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.
Superplasticizers with Amine Carboxylate Based MCI	MCI 2007 P	Powder, polycarboxylate based superplasticizer with MCI.	3.5-6.0 oz/100 lb (5-9 kg/m^3) by weight of cement	5 lb (2.3 kg) boxes, 50 lb (22.7 kg) and 100 lb (45.4 kg) drums.	For use in self leveling, self compacting concrete mix designs, particularly 'low' or 'no' slump applications. Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.
Superplasticizers with Amine Carboxylate Based MCI	MCI 2008 ViaCorr	Powder, polycarboxylate based superplasticizer for self compacting, self leveling concrete with MCI.	0.4-0.6% by total weight of concrete mix.	5 lb (2.3 kg) boxes, 50 lb (22.7 kg) and 100 lb (45.4 kg) drums.	For use in self leveling, self compacting concrete mix designs, particularly 'low' or 'no' slump applications. Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.
Superplasticizers with Amine Carboxylate Based MCI	MCI 2008 L	Liquid, polycarboxylate based superplasticizer for self compacting, self leveling concrete with MCI.	0.4-0.6% by total weight of concrete mix.	5 gal (19 l) pails, 55 gal (208 l) drums	For use in self leveling, self compacting concrete mix designs, particularly 'low' or 'no' slump applications. Reinforced concrete structures such as bridges, parking garages, highways, decks and lanais.

Visit our website for more information on Migratory Corrosion Inhibitors™. **CortecMCI.com**

Total Corrosion Control™

Cortec Corporation® is dedicated to controlling corrosion at ALL STAGES of a product life cycle. Cortec has developed a diverse range of corrosion protection products including cleaners, metalworking fluids, water- and oil-based coatings and corrosion inhibitors, rust removers, paint strippers, powders, packaging foams, paper, films and surface treatments and admixtures for concrete. Contact Cortec for additional brochures and information.

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CORTEC CORPORATION
Environmentally Safe VpCI/MCI® Technologies
4119 White Bear Parkway, St. Paul, MN 55110 USA
Phone (651) 429-1100, Fax (651) 429-1122
Toll Free (800) 4-CORTEC, E-mail info@cortecvci.com
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