DCI®
DCI/Force 10,000® concrete – bond to reinforcing steel

It is very important to know whether a material added to concrete increases or decreases the concrete's bond to reinforcing steel. Flood Testing Laboratories, Inc. Chicago, Illinois was asked in 1990 to study the bond strengths of four concrete mixes containing Force 10,000® microsilica admixture and/or DCI® Corrosion Inhibitor to black rebar and epoxy-coated rebar. This Engineering Bulletin will report the effect on bond strength and other mechanical properties of concrete by the addition of Force 10,000 and DCI.

Table 1
Concrete Mix Designs

	MIX A Reference	MIX B DCI	MIX C Force 10,000	MIX D DCI/Force 10,000
Cement - Type I – kg/m³	390	390	390	390
Sand – kg/m³	840	840	840	840
Coarse Aggregate - #57 – kg/m³	1070	1070	1070	1070
Total Water* – kg/m³	148	148	148	148
Water/cement-ratio	0.38	0.38	0.38	0.38
Force 10,000				
L/m³	-	-	44.5	29.6
kg microsilica/m³	-	-	29.4	19.6
% microsilica/100 kg	-	-	7.5	5.0
DCI – L/m³	-	19.8	(4)	14.8
Daracem 19 – mL/100 kg	835	795	725	725
Slump – mm	150	150	150	150
Air (%)	2.5	1.8	2.3	2.0
Unit weight – kg/m³	2435	2454	2437	2437
Compressive Strength – MPa (psi)				
3 days	43.7	46.0	56.8	46.3
7 days	56.1	58.5	65.0	61.7
28 days	64.5	74.5	88.6	76.0
Flexural Strength – MPa (psi)				
3 days	5.24	5.24	6.31	5.10
7 days	6.41	6.83	8.03	6.17
28 days	7.41	7.64	10.53	9.19

* Total water includes added mix water, aggregate moisture, and Force 10,000 and DCI water.

Table 2
Comparison of Average Bond Strength for Standard and Epoxy-Coated Rebars

	Standard Uncoated Rebar			Epoxy-Coated Rebar			
Concrete Mixture	Bond Strength MPa	Bond Strength (psi)	Improvement Compared to MIX A (%)	Bond Strength MPa	Bond Strength (psi)	Improvement Compared to MIX A (%)	Compared to Standard Rebar MIX A (%)
A	12.1	1760	—	8.4	1213	—	68.9
B	12.9	1878	106.7	9.8	1425	117.5	81.0
C	12.7	1845	104.8	8.8	1275	105.1	72.4
D	12.4	1808	102.7	10.6	1533	126.4	87.1

Test Data

The concrete mix design studied is a fairly common mix used for corrosion protection type concretes. The reference mix (Mix A) contains 390kg / m^3 Type I cement and a water-cement ratio of 0.38. All mixture designs tested are shown in Table 1. Mix B contains 19.8L / m^3 of DCI per cubic metre. Mix C contains Force 10,000 at 7.5% microsilica by weight of cement. Mix D includes Force 10,000 at 5% and DCI at 14.8L. The amount of water in all materials was added to maintain a constant total water content. Slump was adjusted to 150mm with the use of a superplasticiser, Daracem® 19. The mixtures were not air entrained. Each litre of Force 10,000 contains 0.66kg of microsilica. Slump, air and unit weight were measured. Compressive and flexural strengths at 3, 7 and 28 days were determined using ASTM C 39 and ASTM C 78 respectively.

Bond strength to the reinforcing steel was determined using ASTM C 234-86 "Comparing Concretes on the Basis of the Bond Developed with Reinforcing Steel". Number 6 reinforcing steel was used in concrete specimens 150mm x 150mm x 300mm. Tension is applied to the bar in an attempt to pull it out of the concrete specimens. The bond strength in MPa (psi) is recorded throughout the test and that strength reported at a bar slippage of 0.25mm. Results of the bond test are reported in Table 2.

Conclusions

The addition of DCI and/or Force 10,000 increased the concrete's bond to standard uncoated reinforcing steel by an average of 4.7% and to epoxy-coated rebar by an average of 16.3%.

The addition of DCI and/or Force 10,000 increased the compressive and flexural strength of concrete.

There was an average 22.7% reduction in bond strength when epoxy-coated reinforcing steel was used when compared to standard rebar.

Australia 1800 855 525 New Zealand +64 9 448 1146 China Mainland +86 21 3158 2888 Hong Kong +852 2675 7898
India +91 124 402 8972 Indonesia +62 21 893 4260 Japan +81 3 5226 0231 Korea +82 32 820 0800 Malaysia +60 3 9074 6133
Philippines +63 49 549 7373 Singapore +65 6265 3033 Thailand +66 2 709 4470 Vietnam +84 8 3710 6168

GCP Applied Technologies Inc., 62 Whittemore Avenue, Cambridge, MA 02140, USA

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