Technical Bulletin No. 5

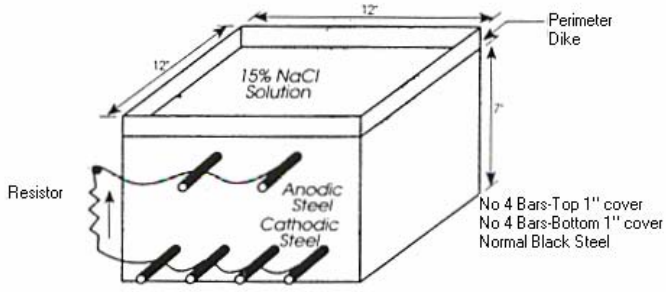
CORROSION PROTECTION OF **IPANEX** CONCRETE COMPARED TO MICROSILICA CONCRETE

TEST OBJECTIVE

This corrosion research project on IPANEX concrete and microsilica concrete was undertaken by IPA SYSTEMS, INC., to evaluate and compare the performance of both admixtures in similar concrete mixes as corrosion protection systems. The test procedure is a macrocell corrosion model that has been used by the Federal Highway Administration (FHWA) for many years to evaluate the corrosion of normal black reinforcing steel in concrete.

TEST DESCRIPTION

Concrete specimens with identical mix designs, using the same aggregates, cement and water are fabricated under controlled conditions. The specimens are 12" x 12" x 7" thick reinforced concrete slabs. See Figure 1. The NaCl solution is ponded on the slabs continuously for four days. After four days, the solution is vacuumed off and the slabs are rinsed and maintained at a constant temperature of 100ºF for three days. This repeating cycle of ponding with salt water and air drying at 100º F is continued for forty eight weeks.



TYPICAL CONCRETE SPECIMEN
Figure 1

IPANEX CONCRETE	MICROSILICA CONCRETE
Cem 48#	Cem 44#
FA 112.8#	FA 112.8#
CA 62# 3/4"	CA 62# 3/4"
CA 62# 1/2"	CA 62# 1/2"
H_2O 16.24#	H_2O 15.2#
HRWR 10 fl. oz.	HRWR 24 f1. oz.
AEA 3.8 ml.	AEA 12 ml.
IPANEX 6.6 fl. oz.	M.S. 4#
Air 6%	Air 6%
Slump 5"	Slump 5 1/2"
W/C 0.34	W/C 0.34
Air Entraining Agent Grace Daravair M	
HRWR Sikament 300	
Microsilica Grace Force 10,000	

TEST PROCEDURE

Concrete slabs were cast incorporating mix designs as indicated below.

Immediately after casting, slabs are placed in plastic bags for three days then air cured for twenty five days at 60ºF to 80ºF. The sides of the slabs and protruding ends of bars receive two coats of epoxy and dams are constructed around the top perimeter of the slabs to retain ponded salt water. The top slab surfaces are sand blasted lightly. The top bars are connected to one end of a ten ohm resistor with copper wire and the bottom bars are connected to the other end of the resistor. Macrocell corrosion current between the top bars (anodic) and the bottom bars (cathodic) can then be measured. Electrical half cell potentials (ASTM C 876) of the top reinforcing steel are also measured for the purpose of determining the corrosion activity of the reinforcing steel. All electrical measurements are taken once a week for forty eight weeks.

TEST RESULTS

Corrosion currents (Figure 2), copper-copper sulfate half cell potentials (Figure 3), and chloride ion contents (Figure 4) are shown on the following graphs.

Corresponding threshold limits for corrosion are included.

The vertical bar graphs in Figure 2 show corrosion current in microamperes at four week intervals throughout the forty eight week test. Very low currents indicating no corrosion of bars in either the IPANEX or microsilica concrete were observed.

The vertical bar graphs in Figure 3 show half cell potentials at four week intervals from weeks twenty-four to forty-eight. Earlier data is not included because copper-copper sulfate half cell was not available. Electrical half cell potentials are taken to determine the corrosion activity of the reinforcing steel. The significance of the numerical values of the potentials measured (according to ASTM C876) is as follows:

- If potentials over an area are more positive than -0.20 V CSE, there is a greater than 90% probability that no reinforcing steel corrosion is occurring in that area at the time of measurement.
- If potentials over an area are in the range of -0.20 to -0.35 V CSE, corrosion activity of the reinforcing steel in that area is uncertain.
- If potentials over an area are more negative than -0.35 V CSE, there is a greater than 90% probability that reinforcing steel corrosion is occurring in that area at the time of measurement.

Half cell determinations for both IPANEX and microsilica concrete specimens are all below the threshold of corrosion values.

The vertical bar graphs shown in Figure 4 show chloride ion contents as percent by weight of concrete after forty eight weeks of the ponding and drying cycles. Concrete samples were taken by drilling horizontally (parallel to reinforcing steel) at the depths indicated. Data shown are averages of at least three determinations. All chloride ion contents were well below the generally accepted threshold of corrosion.

At the end of the test, reinforcing bars were removed from the concrete slabs and inspected. No visible corrosion products were evident on any bars.

SUMMARY

IPANEX and microsilica concretes were compared for forty eight weeks. Neither concrete mix showed test data that exceeded established corrosion thresholds. This was supported by demolition and inspection at the end of the test. No corrosion could be determined by visual inspection.

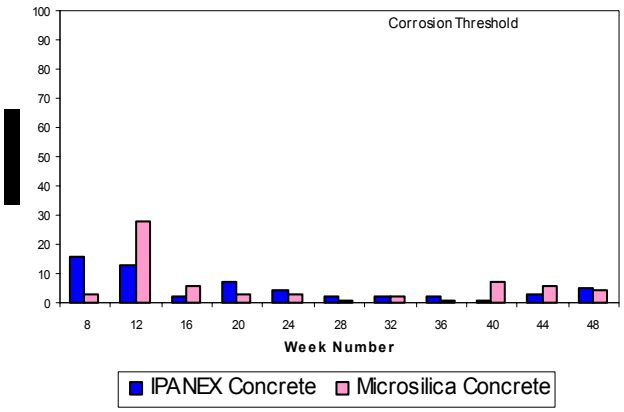
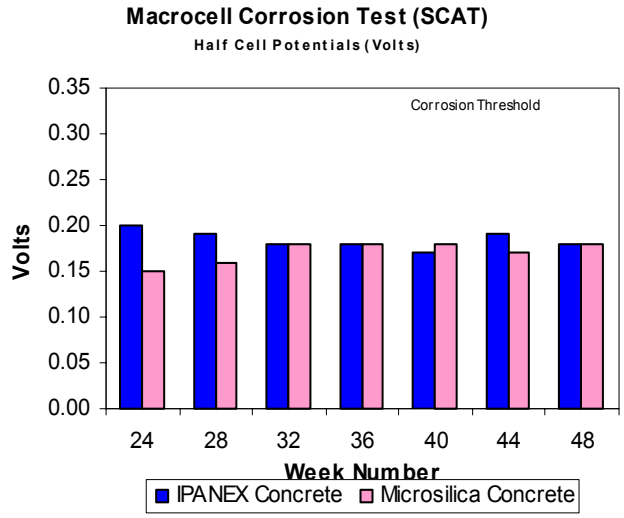
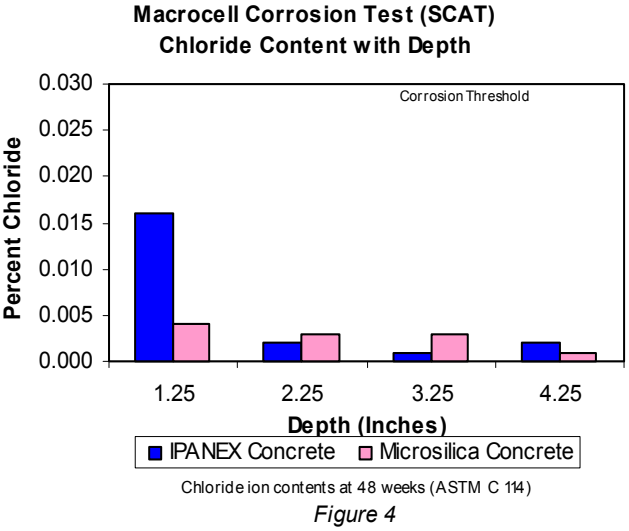


Figure 2



Note: Data not available until 24 weeks

Figure 3



Chloride ion contents at 48 weeks (ASTM C 114)

Figure 4