Technical Bulletin No. 3

IPANEX Concrete Exhibits Exceptional Durability and Corrosion Protection on I-76

HISTORICAL DATA

The Pennsylvania Turnpike Commission replaced the deck slabs of seven bridge structures on the turnpike (I-76) between Bedford and Somerset. The bridges averaged ten feet (span) by eighty feet (width). Each bridge contains twenty slabs placed parallel to traffic. Ipanex admixture was used in the slabs precast at a turnpike maintenance yard in 1973 and then set on the bridge structure at milepost 133.4. One year later, in 1974, the decks of six other bridge structures were precast with regular concrete in a local precast plant. These slabs are set at structures between mileposts 134.4 and 138.0. These slabs will be referred to as control. Plans, specifications and concrete mix designs were all in accordance with Pennsylvania Turnpike Commission standards. All of the bridges are located within a five mile stretch with similar exposure and traffic conditions.

A visual inspection in 1981 revealed that the Ipanex decks had no deterioration whereas, the regular concrete decks exhibited severe deterioration in the form of cracks, efflorescence and spalling.

In 1986 the Pennsylvania Turnpike Commission used Ipanex Concrete in the replacement of another bridge deck over the highway at milepost 153.1.

INDEPENDENT STUDY

The firms of Wiss, Janney, Elstner Associates, Inc. of Northbrook, Il. and A & R Engineering, Inc., Philadelphia, PA were requested by IPA Systems, Inc., to evaluate the performance of the precast concrete bridge slabs containing Ipanex admixture and to compare them with the adjacent structures without Ipanex. The field testing was completed in August and September of 1990. A report titled "Evaluation of Bridge Deck Slabs Incorporating Ipanex Concrete" is dated February 1991. All quotations within this technical bulletin are taken from the WJE Report dated February 1991.

TESTS

The following tests were conducted as part of the WJE study:

1. Visual inspection and mapping.
2. ASTM C876, Standard Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete.
3. ASTM C1104, Standard Methods for Chemical Analysis of Hydraulic Cement (Modified).
4. Petrographic Examination.
5. ASTM C642, Standard Test Method for Specific Gravity, Absorption and Voids in Hardened Concrete.
6. AASHTO T277, Rapid Determination for the Chloride Permeability of Concrete.

FIELD INVESTIGATION

A field investigation was conducted between August 21 and September 25, 1990. The Ipanex structure and three of the control structures were selected for in-depth testing.

1. Visual Survey

The surface condition of the Ipanex structure and six control structures was inspected and mapped. "All of the control decks contained large areas of delamination and spalling. The deck slabs containing the Ipanex admixture were visually in much better condition than the deck slabs in the other structures. The control structures had serious corrosion of the lower mat of reinforcing steel near the median and near the ends of the structures. The Ipanex structure had no cracking except at one delamination in an outside slab. This delaminated area could only be removed with difficulty, using an electric impact chisel." A summary, taken from the WJE Report showing the visual observations, is shown in the table below:

SUMMARY OF VISUAL OBSERVATIONS
(Approximate values)

	Bridge Station	Delaminations (sq. ft.)	Spalling (sq. ft.)	Cracking (lin. ft.)
IPANEX				
	133.4	2	0	3
Controls				
	134.4	80	7	80
	135.3	110	30	110
	136.35	155	28	110
	137.07	160	12	80
	137.6	170	32	80
	138.0	145	15	70
Averages for controls		135	20	90

3/91

2. Potential Survey

Half-cell potential surveys were conducted on the three control structures and on the Ipanex structure in accordance with ASTM C876. WJE indicates in the report that "A potential near, but numerically greater than -0.25 volts CSE is indicative of the onset of reinforcement corrosion." As the potential becomes numerically greater, corrosion becomes greater. The half-cell potential readings that were recorded in the survey "indicate that a high probability of corrosion should exist in all the structures near the median and abutments."

"The slabs that exhibited visual distress had high half-cell potentials, except for the Ipanex concrete slabs that had areas of high potentials but did not exhibit distress." It was also noted that "the reinforcing steel in the Ipanex concrete core samples was generally free of corrosion, even though the half-cell potentials were high." The reinforcing steel in the control slabs showed severe corrosion in the areas of spalling and delamination.

3. Chloride Ion Content

Powder samples of the concrete slabs were obtained by drilling into the bottom of the slabs and collecting the powder at depths of 0-¼ inch, ¼-½ inch, ½-1 inch, and 1-1½ inch. The samples were analyzed for chloride ion concentrations by a procedure essentially equal to that of ASTM C1104. "The areas with greater joint leakage showed high chloride contents on all structures, much higher than the accepted threshold." The highest contents were typically where joint leakage was greatest. Although chloride ion content of the Ipanex concrete near the bottom steel in a core sample was found to be high, only minor corrosion products were seen on the reinforcing.

CONCLUSIONS FROM THE WJE REPORT

Petrographic examination, absorption and density tests, rapid chloride ion diffusion tests, core strengths, and modulus of elasticity were completed on the core samples obtained during the field investigation. The results of this testing are summarized in the following conclusions reached by WJE:

1. "The deck slabs containing the Ipanex admixture have performed visually better than the control structures." The control structures show considerably greater deterioration than the structure at milepost 133.4 containing Ipanex.
2. "The properties of the concrete containing the Ipanex admixture would tend to allow increased chloride ion ingress, causing an increased potential for corrosion of the reinforcing steel. However, less corrosion was observed in the Ipanex concrete planks, even though they had similar exposure conditions and were one year older."
3. "The chloride content of the concrete was generally uniform with depth, and above the accepted corrosion threshold in all structures where severe water leakage was present. However, the control structures had slightly higher chloride ion contents, with several areas very high. Half-cell potential measurements indicate a high probability of corrosion in all structures where water leakage was present. However, there was no significant corrosion of the reinforcing steel observed in the Ipanex concrete even though high chloride contents and half-cell potentials were measured. The slabs containing the Ipanex concrete, exhibit minimal corrosion of the reinforcing after 17 years of exposure to significant amounts of water and deicer salts."

COMMENT REGARDING PHYSICAL PROPERTIES

The average compressive strength of the Ipanex concrete was high, 6,540 psi, whereas, the control concrete was considerably higher, averaging 9,540 psi. Other physical properties of the control structure concrete were also better than the Ipanex concrete. As noted earlier, the Ipanex concrete was cast in a turnpike maintenance yard one year prior to the control concrete being cast in a precast plant.

The WJE investigation identifies the reasons for the difference in physical properties between the Ipanex concrete and control concrete. "The large difference in air content and the difference in the aggregate gradation explains the lower compressive strength, lower modulus of elasticity, lower unit weight, higher absorption, and higher chloride permeability measured in the Ipanex concrete cores." However, comparing the performance of the Ipanex concrete over a seventeen year period, one finds the Ipanex concrete has performed significantly better than the control concrete in spite of the poorer mixture in the Ipanex concrete.

SUMMARY

In 1973 Ipanex admixture was presented to the Pennsylvania Turnpike Commission as a product that would waterproof concrete, thereby increasing the durability of concrete structures. The facts presented in the WJE report reveal that the Ipanex concrete in the seventeen-year-old deck slabs at milepost 133.4 has provided superior performance and excellent resistance to reinforcing steel corrosion.

The following chart reflects the performance of the Ipanex concrete compared to the control concrete.

	Ipanex	Average of Control Structures
Delaminations, sq. ft.	2	135
Spalling, sq. ft.	0	20
Cracking, lin. ft.	3	90
Durability	Excellent	Poor
Corrosion Resistance of Reinforcing Steel	Excellent	Poor

3/91