EFFECT OF WATERPROOFING ADMIXTURE IPANEX ON CONCRETE DURABILITY

Final Report
For
MLR-98-2

March 1999

Project Development Division

Iowa Department of Transportation

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By
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INTRODUCTION AND OBJECTIVE

The concrete admixture Ipanex® manufactured by IPA Systems Inc. was submitted to the Iowa Department of Transportation New Products Committee on April 15, 1998. The New Products Committee requested that the Iowa DOT Materials Laboratory evaluate the durability, corrosion inhibiting and concrete permeability reduction affects of this admixture. This report is intended to present the results of testing in Iowa DOT Materials laboratories, review a Pennsylvania State University report as well as review of the IPA Systems Inc. marketing literature. The objective is to provide the new products committee with a recommendation concerning approval of this product based on the information gathered.

TESTING AND ANALYSIS

Four tests were performed on concrete samples as part of this evaluation. These tests and the results are described in the paragraphs below. The test samples were mixed as described in Table 1. The four mixes were cast into slabs with a ponding surface according to AASHTO 259-80. A #3 black steel rebar was placed at one inch from the ponding surface with a lead attached to measure half-cell potentials. Additionally, four-inch cylinders were cast from each mix to obtain samples for rapid chloride ion permeability testing.

Table 1

Mix Number:	1	2	3	4
Cement:	Lehigh I	Lehigh I	Lehigh I	Lehigh I
Coarse Aggregate:	Fort Dodge	Fort Dodge	Fort Dodge	Fort Dodge
Fine Aggregate:	Cordova	Cordova	Cordova	Cordova
NaCl:	- -	- -	3 lbs/yd^3	3 lbs/yd^3
Ipanex®:	- -	13.8 oz/cwt of cement*	- -	13.8 oz/cwt of cement*

*Manufacturer's recommended dosage

Chloride Content

At the end of the 90-day salt ponding, powdered samples were taken from each slab according to AASHTO T 260-95. Chloride determinations were performed with x-ray fluorescence (XRF). Four samples were retrieved from each slab (two locations per slab). The powdered samples were taken at 0.5 inch and 1 inch from the surface respectively. This total of 16 samples was then analyzed using XRF resulting in the data shown in Figure 1. There are two things apparent from the graph: (1) There is no significant difference between samples with and without Ipanex® or with and without added salt at the 0.5 inch depth; (2) At the 1 inch depth, there is less variation between samples with and without Ipanex® and the samples with added salt are easily visible.

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8. ABSTRACT

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The portland cement concrete admixture Ipanex® did not show any significant benefit in terms of improvement in areas of permeability, chloride resistance and strength in the testing performed at the Iowa DOT. The literature and reports reviewed did not provide enough credible evidence to refute this conclusion. Additionally, the benefits ascribed to this product can be more economically achieved using other currently available products such as slag and silica fume. Our recommendation is that this product not be approved for use on State projects in Iowa.

9. KEY WORDS

Permeability
Chloride resistance
PCC admixtures
Ipanex®
Corrosion

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19

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DISCLAIMER

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Rapid Chloride Ion Permeability
This test was performed according to AASHTO Test Method T 277-96. The resulting values were 2187 coulombs for the control and 1917 coulombs for the sample with Ipanex®. These are both on the borderline between Low and Moderate Chloride Ion Permeability as defined in Table 1 of T 277-96. These two results are not significantly different.

Half Cell Potential Test
This test is an adaptation of ASTM C876-91 Standard Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete. Four concrete slabs were prepared for this test as described previously. The slabs were subjected to salt ponding for 90 days with a 3 percent sodium chloride solution. Half-cell potentials were measured initially and weekly thereafter. The readings were taken at three locations on top of each slab. Results are shown in Figure 2. The results showed no significant difference between the readings for the Ipanex® samples and the controls. We would recommend cautious interpretation of these results both from our testing and that of Reference 1 because the ASTM method warns about inferences of corrosion without strong knowledge of all of the reactions that may be occurring at the steel. Readings for both Ipanex® and control samples were below (more positive than) -0.20 volt for the majority of the test period.

Compressive Strength
The East Central Iowa Transportation Center Materials Laboratory performed compressive strength tests on several cylinders of concrete from a project (STP-S-06(33)--5E-08) in Benton county in July 1998. See Figure 3 and the attached data sheets. The first three samples are from PCC without Ipanex® while the remaining six samples contain Ipanex®. Note that all of the samples had very similar characteristics and all were cured for 28 days. The average 28 day compressive strength values for these tests were about 1300 psi lower for the samples with Ipanex®.

DISCUSSION

The stated purpose for using Ipanex® in bridge concrete is to decrease the permeability of the concrete especially to chloride ions in order to protect the reinforcing steel (and hence the bridge) from the corrosive effects of the chloride ions. In order to make a recommendation in favor of using Ipanex®, we would need to be able to demonstrate two things: (1) that the product is having a significant effect on permeability and related corrosion and (2) that it is economically worthwhile to use this product to perform that function versus continuing current methods and materials. Let's look at each of these in turn:

(1) Performance
Concrete containing Ipanex® has not performed significantly better in any of the tests that were performed in Iowa DOT materials laboratories. In some cases it did not perform as well as control. The marketing literature provided by IPA Systems Inc. and the Report (Reference 1) produced by Pennsylvania State University list results and conclusions that are generally in sharp contrast to these findings. We have serious concerns, however, with some of the research and data that went into these references.

In the product literature (with the exception of the Turnpike bridges) there are very few controlled tests; most of the information is presented in terms of single case anecdotes (i.e. of the form 'Ipanex® was used in structure X and it's doing very well'). Also included are several copies of approvals by various entities (state, county, corporation) for use of Ipanex® in projects or field evaluations. At least one of these is included despite an explicit request by the approving authority that the approval not be used for promotional purposes - a point to consider if the Iowa DOT is to grant approval.

Reference 1 is a report by Pennsylvania State University. The report covers research done in two studies, one in 1991 and the other in 1998. We had several concerns about the results and conclusions reached by Reference 1:

Data from the rapid chloride ion permeability test was considered (by the authors of Reference 1) to be showing unusually high values, so the test was assumed to be invalid. Figure 4 contains the comparison graphs used in Reference 1 to reach this conclusion. The results of the same two tests conducted at the Iowa DOT do not indicate a problem nor do they indicate any significant difference between samples with and without Ipanex®. The data for these was discussed earlier and shown in Figures 1 and 2. If the high readings for rapid chloride ion permeability were due mainly to the use of Ipanex®, we would expect the values in our tests to be higher as well.

In the sample selection process for chloride penetration in the 1991 study, the control samples (those without Ipanex®) were chosen from "areas of high deterioration". Chloride levels are not listed for areas without deterioration in concrete without Ipanex®. This means that the high levels of chloride in those areas (without Ipanex®) could have resulted from other causes than high permeability, such as cracking.

Some areas on bridges with Ipanex® were found to have high chloride levels near the steel but no corrosion in the 1991 study. This emphasized (without explicitly stating) the corrosion fighting properties of the product based on chemistry effects. The question that arises is where did the chloride come from?. The 1998 study emphasized low chloride permeability, implying that the corrosion was not occurring (in the treated bridge decks) because the water and chlorides were not reaching the levels of the steel.

The written analysis of the performance of the bridge decks in general did not attempt to rule out any other plausible causes for deterioration or lack thereof. For example, air content in the 1973 bridges was listed as between four and seven percent. Entrained air content is an important factor for concrete durability; and concrete with four percent air could behave quite differently in comparison with concrete at seven percent air. Additionally, it would not be uncommon for the air content of one bridge to be different from the next. The air content in hardened concrete is a relatively easy test to perform but no such analysis was reported.

A lot of faith is put into the water permeability test by the authors of Reference 1. This test is apparently a modification of the Army Corps of Engineers test method CRD-C 48-55 (circa 1955). There is no discussion in Reference 1 for the rationale behind any of the modifications to this test method. We obtained a copy of the 1992 issue of CRD-C 48 (attached). In this issue, the samples tested are either 6 or 14.5 inches in diameter. The sample is confined and subjected to a pressure difference of 200 psi. Volume observations are "continued until the flow becomes essentially constant, normally for 14 to 20 days." Once the flow has become constant, the hourly flow rate is used in the equation shown on the last page of the method to determine the permeability.

Reference 1 describes the test and results as follows: The samples were "25 - 75 mm in diameter and approximately 67 mm in length" for a specimen (that is between 1 and 3 inches in diameter and approximately 2.5 inches long). The pressure used was 300 psi. One of the two control samples exhibited a permeability (k) of 0.22 microdarcy; the other "did not achieve a constant flow rate after seven days, and was subsequently shut down." The two samples with Ipanex® "were tested for seven days and produced no appreciable water." The amount of water was enough, however, to show up on the graph presented in the report.

Several questions arise from this information. What were the permeability values for the two Ipanex® samples? Why stop testing at seven days? What were the actual diameters of the samples? After all, flow rate Q (the subject of the graph) is inversely proportional to the <u>square</u> of the diameter. Were the diameters the same for the control as for the Ipanex® samples? What did the flow curve for the other Ipanex® sample look like? What did the curve for the other control sample look like? If the flow rate for a 6 inch or 14.5 in diameter sample is expected to stabilize in 14 to 21 days (per CRD-C 48), should we expect a 1 to 3 inch sample (25 - 75 mm) to stabilize in only 7 days (again Q is inversely proportional to sample diameter squared)? In fact, the control line on the graph in Reference 1 does not appear to have stabilized. The CRD-C 48 test method measures water flow using the input water which is not in contact with the atmosphere. In the reported test, flow was measured using a scale on the outflow. With only 2.5 ml or less of water flowing in 7 days, water evaporation could be affecting the result significantly. The graph appears to be cumulative volume with time. Evaporation would explain why the volume shown by the Ipanex® line actually appears to decrease toward the end of the test.

Essentially, there are too many questions, omissions and irregularities in this reported permeability test to accept the results.

(2) Economics

The results of testing at the Iowa DOT materials laboratories were not supportive of using Ipanex® based on performance. But even assuming performance, we can only recommend use of an admixture on Iowa projects if the economics favor it over what is being used now and what is available for use now. The following discussion is based on an approximate cost of Ipanex® of $23 per cubic yard of concrete placed.

Currently, all bridges specified by the Iowa DOT are required to use epoxy coated reinforcing. There is no indication that we will be moving away from that in the near future. The only cases where we have shown significant corrosion related distress in the last 20 years of use were the result of a combination of cracks in the concrete and defects in the epoxy coating. Realistically, neither of these would be affected by use of Ipanex®.

If low permeability of the concrete is desired (say for potential epoxy coating problems) there are other methods that will work at least as well as Ipanex® at far less cost. Two examples are slag and silica fume additions. Table 2 below shows a comparison of test data from the Materials Laboratory at the Iowa DOT. The data are results from testing in accordance with AASHTO T-277.

Table 2

Concrete/Cement Type	Rapid Chloride Ion Permeability Reading (coulombs)
C-4	2187
C-4 with Ipanex®	1917
C-4 Type 1S cement (slag), 10% fly ash	945
C-4 Type 1S cement, 10% fly ash, 5% silica fume	523

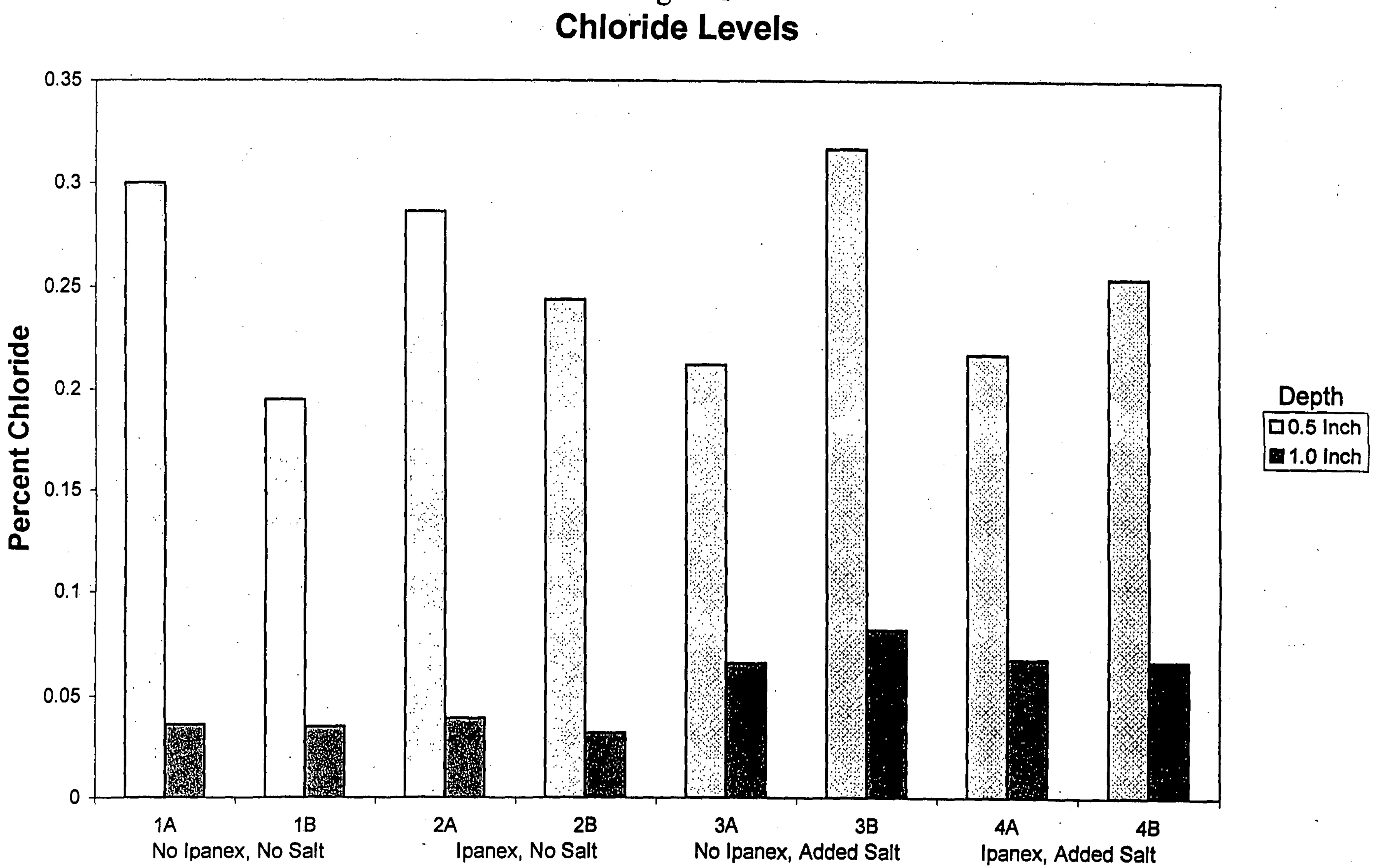
Note that the test results show we can reduce permeability by almost 60 percent by using cement with slag and by almost 80 percent by also using silica fume. Type 1S cement is almost the same price as regular cement and added silica fume is not much more. By the way, 28 day strengths for the concretes with slag and silica fume are generally higher too. Either of these is a much more economical approach than Ipanex® on simply a price basis (ignoring all of the performance issues).

CONCLUSIONS/RECOMMENDATION

The portland cement concrete admixture Ipanex® did not show any significant benefit in terms of improvement in areas of permeability, chloride resistance and strength in the testing performed at the Iowa DOT. The literature and reports reviewed did not provide enough credible evidence to refute this conclusion. Additionally, the benefits ascribed to this product can be more economically achieved using other currently available products such as slag and silica fume. Our recommendation is that this product not be approved for use on State projects in Iowa.

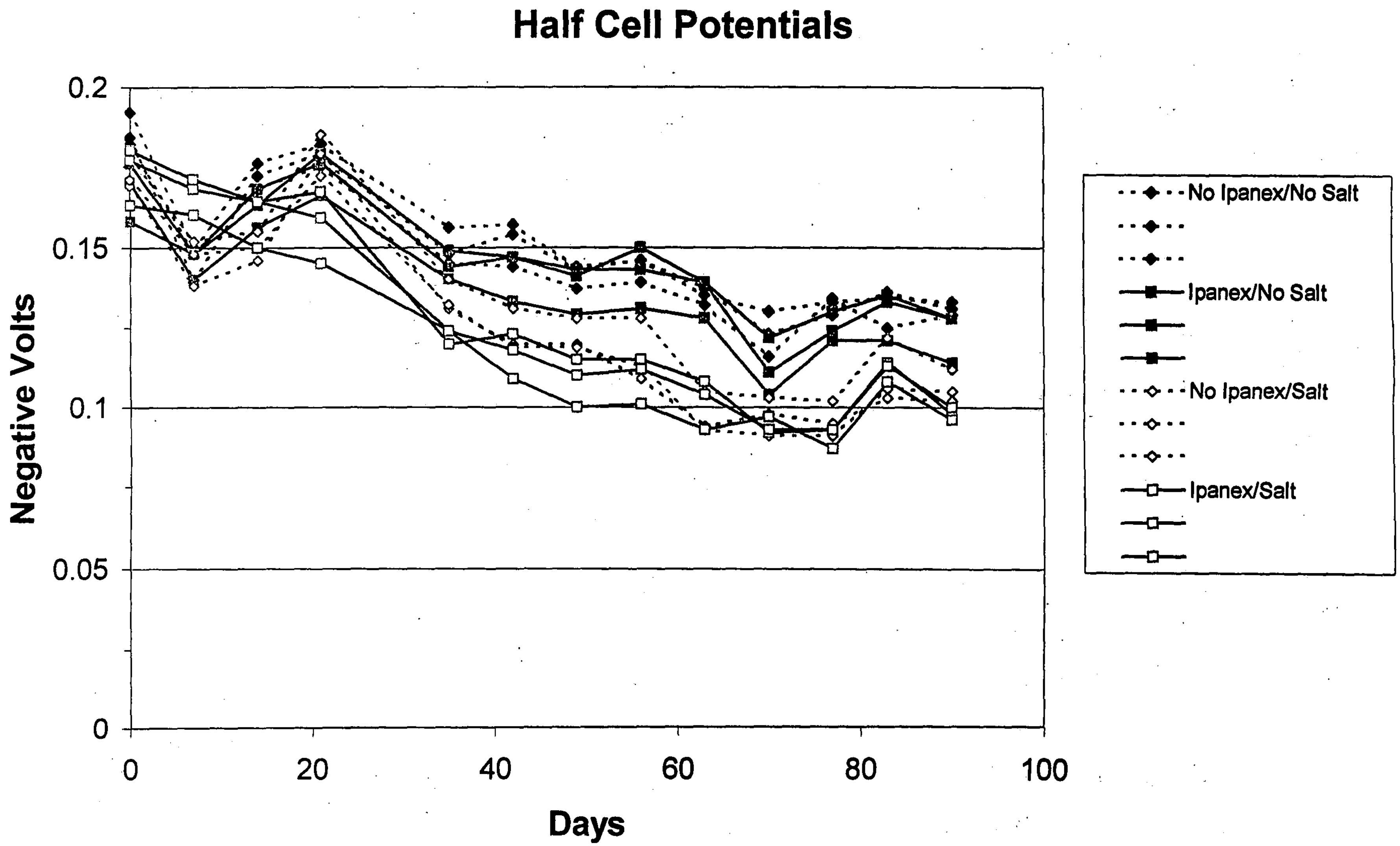
APPENDIX A
Figures

Figure 1


Chloride Levels
Percent Chloride
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1A
1B
No Ipanex, No Salt
2A
2B
Ipanex, No Salt
3A
3B
No Ipanex, Added Salt
4A
4B
Ipanex, Added Salt
Depth
0.5 Inch
1.0 Inch

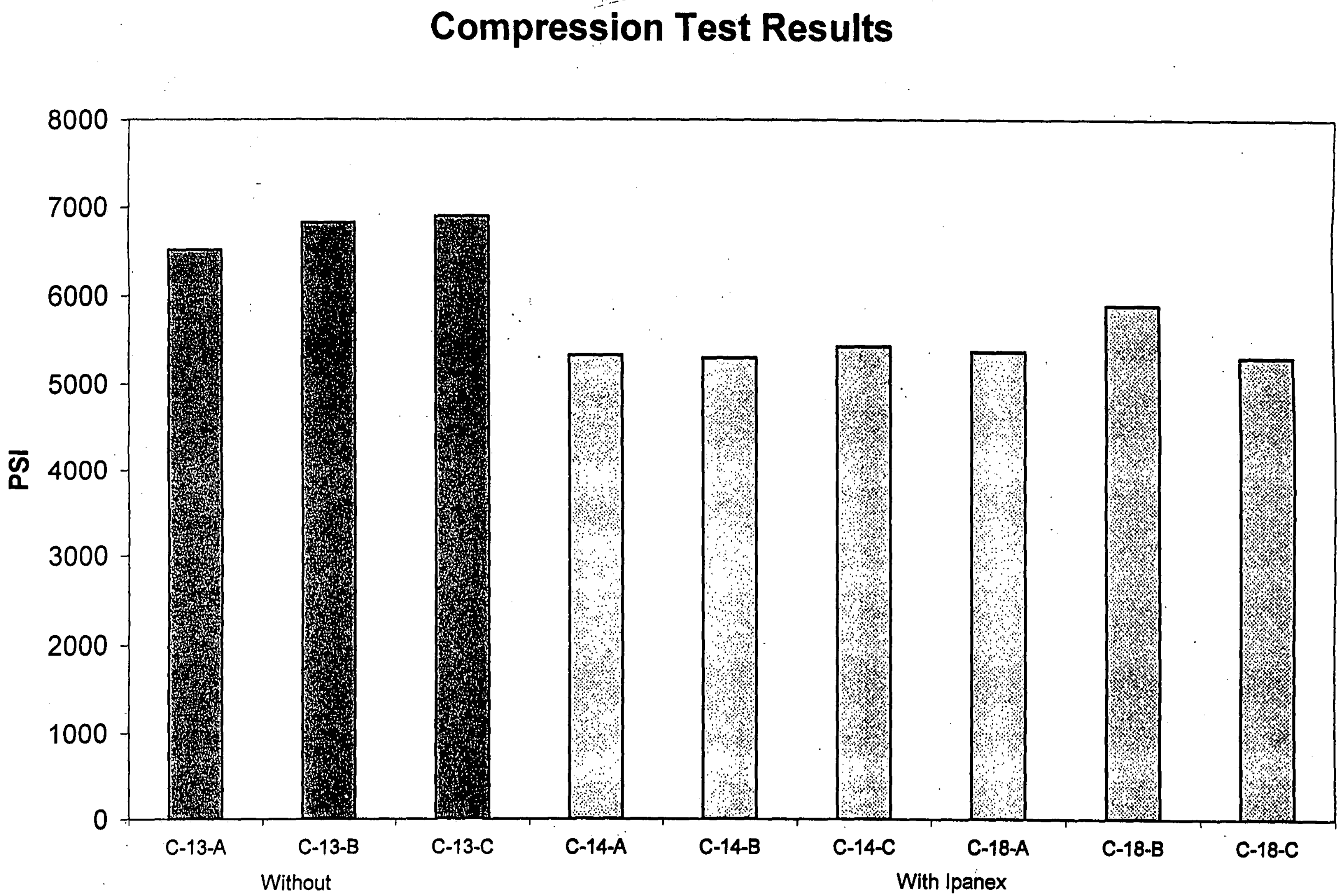
7

Figure 2



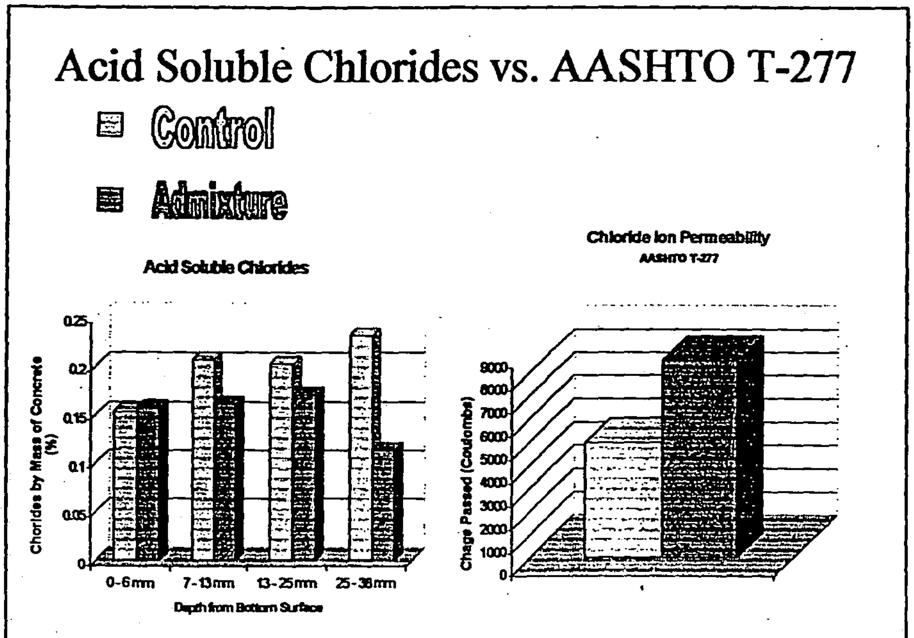
Half Cell Potentials
Negative Volts
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100
Days
No Ipanex/No Salt
Ipanex/No Salt
No Ipanex/Salt
Ipanex/Salt

Figure 3



Compression Test Results
PSI
8000
7000
6000
5000
4000
3000
2000
1000
0
C-13-A
C-13-B
C-13-C
C-14-A
C-14-B
C-14-C
C-18-A
C-18-B
C-18-C
Without
With Ipanex

Figure 4



Source, WJE Report, February 1991

APPENDIX B
Standard Test Method for Water Permeability of Concrete

CRD-C 48-92

Standard Test Method for Water Permeability of Concrete

1. Scope

1.1 This method of test covers a procedure for determining the permeability of concrete when subjected to water at a pressure of 200 psi (1.38 MPa). The calculations are based upon an application of Darcy's law for unidirectional flow at constant head.

2. Apparatus

2.1 The permeability test apparatus shall be as indicated schematically in Fig. 1 and as illustrated typically in Fig. 2, page 2. Two sizes of apparatus have been used: one, illustrated in Figs. 1 and 2, accommodates 14-1/2-in.- (368-mm-) diameter by 15-in.- (381-mm-) high cylindrical specimens; the other, of similar design, accommodates 6- by 6-in. (152- by 152-mm) cylindrical specimens. The apparatus is composed of the following items:

2.1.1 Specimen Containers:

2.1.1.1 Containers for 14-1/2- by 15-in. (368- by 381-mm) specimens shall consist of steel cylinders (Note) with a retainer ring at the bottom and a flange at the top. A removable cover of 1-1/2-in. (38-mm) steel and a removable bottom of at least 1/2-in. (13-mm) steel plate (Note) shall be provided for bolting to the container. The flange shall have a 1/4-in.- (6.4-mm-) wide by 1/4-in.- (6.4-mm-) deep

Note.- Containers for the larger specimens may be made from 16-in.- (406-mm-) OD pipe and for the smaller specimens from 7-in.- (178-mm-) ID pipe. The covers for the containers may consist either of flat plates or domed castings; the domed design facilitates the removal of entrapped air. The containers shown in Fig. 2 have 1-1/2-in. (38-mm) bottoms; such thick bottoms are not required for tests made according to this method.

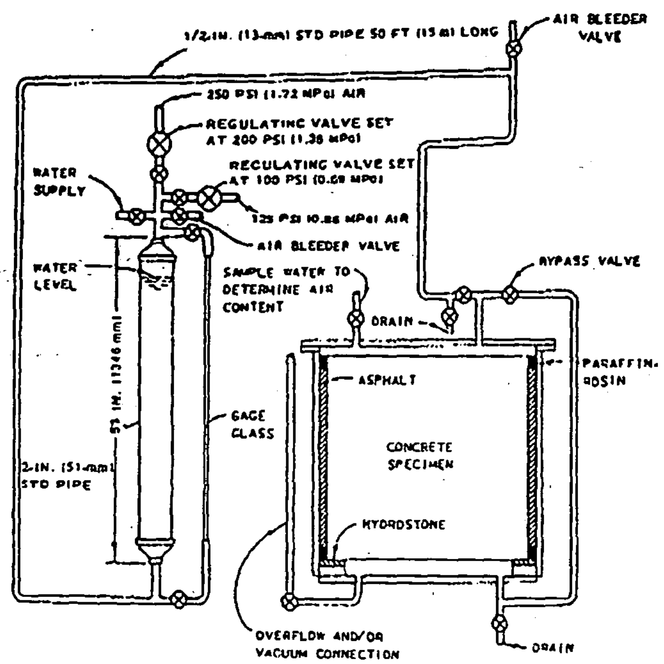


Fig. 1. Permeability test assembly (schematic)

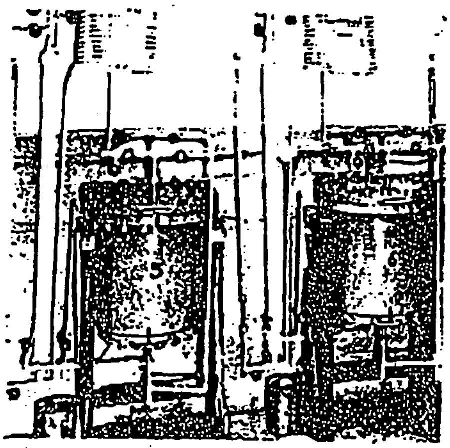


Fig. 2. Permeability apparatus

gasket groove and the cover shall have a raised tongue fitted so as to mesh with the groove. A rubber or neoprene strip of 1/4- by 1/4-in. (6.4- by 6.4-mm) cross section shall be used as the gasket.

2.1.1.2 Containers for the 6- by 6-in. (152- by 152-mm) specimens shall be made of steel (Note) with a cover, flange, and gasket as described above. These containers will be placed on sheet metal squares provided with drain holes when in use. The containers and sheet metal squares are sealed together by a thin layer of grease along the contact surface when in use.

2.1.2 Water Reservoir.- The water reservoir shall consist of a length of 2-in. (51-mm) pipe 48 in. (1219 mm) long to which is attached a side arm gage glass provided with a graduated scale. The reservoir shall be connected with suitable fittings, valves, and regulators to permit the admission of water for filling, and for the application of air pressures of 100 or 200 psi (0.69 or 1.38 MPa); and shall be connected to the specimen container. (Note)

Note.- The length of the connection between the reservoir and the container as shown in Fig. 1 is 50 ft (15 m). The assembly of apparatus using the smaller containers provides for a minimum of 15 ft (4.6 m) of line between the reservoir and the container. The length selected should be based on considerations of the rate of water flow, the rate of absorption of air by water at the operating pressure, and the inconvenience of replacing the water in the system so that the water in contact with the specimen at no time contains more than 0.2 percent air.

3. Utilities

3.1 Compressed Air.- Compressed air (Note) at 210-250 psi (1.45-1.72 MPa) for use at 100 and 200 psi (0.69 and 1.38 MPa) shall be provided.

Note.- Compressed nitrogen may be used instead of compressed air if it is more readily available.

3.2 Vacuum.- A vacuum pump or other source of reduced pressure capable of exhausting the system and maintaining a vacuum of 29 in. (9.79×10^4 Pa) of mercury shall be provided.

3.3 Water.- A supply of water at 73.4 ± 2 F (23 ± 1.1 C) shall be provided so that there will be available not less than 5 gal (0.019 m^3) for each large specimen and 2 gal (0.008 m^3) for each small specimen that may be under test at any one time.

4. Temperature

4.1 The tests shall be conducted in a room maintained at 73.4 ± 2 F (23 ± 1.1 C).

5. Calibration of Water Reservoir

5.1 Each water reservoir shall be calibrated using water under 200-psi (1.38-MPa) pressure. A small rubber hose is fitted by means of a threaded adapter to the bleeder valve in the line between the reservoir and the specimen container. The valve to the container is closed and the reservoir filled with water. Pressure at 200 psi (1.38 MPa) is applied. all bleeder valves are opened to remove entrapped air, and are immediately closed when water issues from them. The 200-psi (1.38-MPa) pressure is then released and the reservoir is again filled with water to a point above the zero mark on the graduated scale. The 200-psi (1.38-MPa) pressure is again applied and the bleeder valve is opened slowly and quickly closed when the water level in the reservoir and gage glass is at the zero mark on the scale. Water is then removed from the system and caught in 500-cm^3 increments in a graduated cylinder. After each 500-cm^3 increment the level in the gage glass is read on the scale. The calibration constant for the reservoir is calculated from these readings and is expressed in cm^3 per unit length on the scale.

6. Specimens

6.1 Specimens shall be made and cured as specified in the applicable sections of CRD-C's 10 and 49.

7. Procedure

7.1 Preparation of Specimens.- The top and bottom of the specimen shall be sandblasted to remove the surface layer of cement paste. The sides shall then be coated with two coats of a 70:30 by weight mixture of paraffin and rosin, applied hot using a paint-brush. Care shall be taken to prevent the paraffin-rosin mixture from getting on the ends of the specimens and any drops that do so shall be carefully removed by wire brushing.

7.2 Installation of Specimens.- The inner surface of the container shall be coated with one coat of the paraffin-rosin mixture and a 1/4-in. (6.4-mm) layer of high-strength plaster (Note) shall be placed on the retainer ring at the bottom. The specimen shall be lowered immediately into the container and firmly seated in the plaster ring before the plaster sets. A 1/4-in. (6.4-mm) metal rod may be used as a guide and lever between the specimen and the inner wall of the container to assist in centering the specimen. After the plaster has set, a 1-in. (51-mm) layer of paraffin-rosin shall be poured into the annular space between the specimen and the container, the remainder of the annular space shall be filled with 200- to 300-penetration asphalt heated to 230 F (110 C). The depression of the asphalt filling formed upon cooling and shrinkage shall be filled with paraffin-rosin. The paraffin-rosin layers thus enclose the asphalt and prevent it from escaping through the plaster or mixing with the water. The cover shall then be bolted on, the bottom attached, and all connections made.

Note.- "Hydrostone," manufactured by the U. S. Gypsum Co., is recommended.

7.3 Pressure Testing.- The system shall be exhausted to a reduced pressure of at least 28 in. (9.46×10^4 Pa) of mercury. The system shall then be filled with water at 73.4 ± 2 F (23 ± 1.1 C) until the vacuum gage shows an abrupt decrease to about 20 in. (6.75×10^4 Pa) of mercury, at which time the vacuum valve shall be closed. Trapped air shall be flushed out through the bleeder valve and the bleeder valve then closed. With bleeder and bypass valves closed, 100-psi (0.69-MPa) air pressure shall be applied to the water reservoir. The overflow standpipe valve shall be opened. After 5 min the air pressure shall be increased to 200 psi (1.38 MPa). The gage glass level shall be observed and recorded daily with the time of observation recorded to the nearest 0.1 hr (Note 1). Observations shall be continued until the flow becomes essentially constant, normally for 14 to 20 days. The water in each assembly shall be replaced at sufficiently frequent intervals so that at no time the water in contact with the specimen has an air content greater than 0.2 percent (Note 2). For normal rates of flow using apparatus of the sort described, changing the water once a week has been found to be sufficient to prevent excessive air content. The flushing operation shall be accomplished by relieving the air pressure and flushing approximately 5 gal ($0.019 m^3$) of water through each large assembly or 2 gal ($0.008 m^3$) through each small assembly.

Note 1.- Careful observations shall be made to detect and correct any leaks that may develop in the system, especially at plumbing connections or through the seal around the specimens. Whenever the flow between successive readings appears excessive, the possibility of leaks in the system should be suspected and appropriate inspection made to detect and correct them.

Note 2.- The air content of the water shall be determined by measuring the volume of air that escapes from a measured volume of the water maintained at 73.4 ± 2 F (23 ± 1.1 C) and atmospheric pressure for 24 ± 4 hr.

8. Calculation

8.1 The differences of daily readings of water reservoir level are converted to volume of water flow in ml by multiplying by the reservoir calibration constant. The rate of flow in cm^3 per hr is obtained by dividing volume by elapsed time in hours between readings. Permeability is then calculated from the following formula:

$$K = M \times 23.35 \times 10^{-12} \text{ or}$$

$$K = M \times 54.55 \times 10^{-12}$$

where:

K = permeability in $\frac{\text{cu ft/sec}}{\text{sq ft (ft head/ft)}}$.

M = average flow rate for the final 5 days of the test in cm^3/hr, and

23.35×10^{-12} or 54.55×10^{-12} = conversion factors for 14-1/2- by 15-in. (368- by 381-mm) and for 6- by 6-in. (152- by 152-mm) specimens respectively for changing cm^3/hr to $\frac{\text{cu ft/sec}}{\text{sq ft (ft head/ft)}}$ (Note).

Note.- Cu ft/sec × 2.831685E-02 = m^3/s.

9. Report

9.1 The report shall include pertinent data on the characteristics of the concrete used in the specimens, the age at which the specimens were tested, values for permeability of each specimen, average values for groups of similar specimens, and notations of any unusual features of the testing procedure.

Appendix
Derivation of Equations

Darcy's law for fluid flow in a permeable medium can be expressed as

$$K = \frac{M}{A\left(\frac{h}{L}\right)}$$

where

K = hydraulic conductivity (or coefficient or permeability)

M = flow rate

A = Area of permeable medium perpendicular to flow

h = hydraulic head

L = length of flow path

This relationship, along with those listed below, were used to calculate the factors in CRD-C 48. The following relationships apply:

$$1\ cm^3 = 3.531 \times 10^{-5}\ ft^3$$

$$1\ ft^2 = 144\ in^2$$

$$1\ hr = 3600\ sec$$

$$h = \frac{P}{\gamma}$$

where

P = water pressure

γ = density of water

Thus, Darcy's Law becomes

$$K = M\frac{cm^3}{hr} \times 3.531 \times 10^{-5}\frac{ft^3}{cm^3} \times \frac{1\ hr}{3600\ sec} \times \frac{1}{A\ in^2} \times 144\frac{in^2}{ft^2} \times \frac{1}{\dfrac{200\frac{lb}{in}}{62.4\frac{lb}{ft^3}} \times 144\frac{in^2}{ft^2} \times \frac{1}{L\ in} \times 12\frac{in}{ft}}.$$

Reducing this relationship further, we find that

$$K = M \times 2.550 \times 10^{-10} \times \frac{L}{A} \qquad (1)$$

where M has units of cm^3/hr, A is the area perpendicular to flow in square inches, and L is the length of the specimen in inches. For a specimen with a diameter of 14-1/2 in. and a length of 15 in., L/A = 0.09085. Using this value of L/A, I calculate

$$K = M \times 2.550 \times 10^{-10} \times 0.09085 =$$

$$M \times 23.17 \times 10^{-12}$$

For a diameter of 6 in. and a length of 6 in., L/A = 0.2122. Thus, I calculate

$$K = M \times 54.11 \times 10^{-12}$$

These values are reasonably close to the values given in CRD-C 48. The difference is in the significant figures used in conversion factors and constants.

For specimens of other dimensions, one has only to calculate the L/A ratio of the specimen and use Equation (1) given above.

APPENDIX C
Concrete Compression Tests

Form 820958
2/97

ASSURANCE

Iowa Department of Transportation

OFFICE OF MATERIALS

CONCRETE COMPRESSION

Ames
R. Boulet
G. Petermeier
G. Smith

Project STP-S-06(33)- -5E-06 Contract No. ____ County Benton Lab. No. CR8VS-C-13

Producer Manatts Plant Newhall Contractor Taylor Const.

Unit of Material ____

Cement: Type I Source Lafarge Fly Ash Source ____ CA Source A57026- Cedar Rapids Q. FA Source A06504- Mt. Auburn Pit

Sampled by G. Smith Date Received 7-13-98 Date Reported 8-7-98

Lab. Number	Sdrs. Number	Date Made	Cylinder No.	% Air Content	Slump	W/C	Description	Tested Date	Tested Age	Total Load	Lb./Sq. In.
		7-10-98	CR8AS C-13-A	4.0	3"		C-4	8-7-98	28	103500	8510
		7-10-98	C-13-B	4.0	3"			8-7-98	28	108500	8820
		7-10-98	C-13-C	4.0	3"			8-7-98	28	106500	8895
17											

Signed Ross H. Boulet
E.C.I.T.C. ENGINEER

Form 820058
2/17

ASSURANCE

Iowa Department of Transportation

OFFICE OF MATERIALS

CONCRETE COMPRESSION

Ames
R. Boulet
G. Petermeier
G. Smith

Project STP-S-06(33)- -5E-06 Contract No. County Benton Lab. No. CR8VS-C-14

Producer Manatts Plant Newhall Contractor Taylor Const.

Unit of Material

Cement: Type I Source Lafarge Fly Ash Source CA Source A57028- Cedar Rapids Q. FA Source A06504- Mt. Auburn Pit

Sampled by G. Smith Date Received 7-13-98 Date Reported 8-7-98

Lab. Number	Sdrs. Number	Date Made	Cylinder No.	% Air Content	Slump	W/C	Description	Tested Date	Tested Age	Total Load	Lb./Sq. In.
		7-10-98	CR8AS C-14-A	6.5	4"		C-4	8-7-98	28	85200	5325
		7-10-98	C-14-B	6.5	4"		with	8-7-98	28	84200	5290
		7-10-98	C-14-C	6.5	4"		Ipanex	8-7-98	28	86200	5420
18											

Signed Roger H Boulet
E.C.I.T.C. ENGINEER

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ASSURANCE

Iowa Department of Transportation

OFFICE OF MATERIALS

CONCRETE COMPRESSION

Ames
R. Boulet
G. Petermeier
G. Smith

Project STP-S-06(33)- -5E-06 Contract No. 86061 County Benton Lab. No. CR8AS-C-18

Producer Manatts Plant Newhall Contractor Taylor Const.

Unit of Material

Cement Type I Source Lafarge Fly Ash Source CA Source A57028- Cedar Rapids Q. FA Source A06504- Mt. Auburn Pit

Sampled by G. Smith Date Received 8-3-98 Date Reported 8-28-98

Lab. Number	Sdrs. Number	Date Made	Cylinder No.	% Air Content	Slump	W/C	Description	Tested Date	Tested Age	Total Load	Lb./Sq. In.
		7-31-98	CR8AS C-18-A	6.2	3-3/4"		C-4	8-28-98	28	85200	6355
		7-31-98	C-18-B	6.2	3-3/4"		with	8-28-98	28	80300	5680
		7-31-98	C-18-C	6.2	3-3/4"		Ipanex	8-28-98	28	84200	5290

Signed Roger H Boulet
E.C.I.T.C. ENGINEER

EFFECT OF WATERPROOFING ADMIXTURE IPANEX ON CONCRETE DURABILITY

Addendum to the
Final Report
For
MLR-98-2

May 1999

Project Development Division

Iowa Department of Transportation

EFFECT OF WATERPROOFING ADMIXTURE IPANEX ON CONCRETE DURABILITY

Addendum to the
Final Report
for
MLR-98-2

By
Ed Engle
Secondary Road Research Coordinator
515-239-1382
FAX 515-239-1092
Office of Materials
Project Development Division
Iowa Department of Transportation
Ames, Iowa 50010

May 1999

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INTRODUCTION

This addendum is intended to clarify and elaborate some of the statements and analyses in the report MLR 98-2, "Effect of Waterproofing Admixture Ipanex on Concrete Durability." Some of the information in this addendum was provided by representatives of IPA Systems Inc. and Dr. Barry Scheetz, Pennsylvania State University at a meeting at the Iowa DOT on 20 April 1999. Also referenced are "Evaluation of Bridge Deck Slabs Incorporating Ipanex Concrete" by Wiss, Janney, Elstner Associates, Inc., 1992 (hereafter referred to as WJE) and "Evaluation of Ipanex on the Durability of Pennsylvania Turnpike Bridges" by Barry Scheetz, Ph.D. et al., 1998 (hereafter referred to as PSU). Note that this addendum does not change the conclusions/recommendation of the referenced report MLR 98-2.

DISCUSSION

1. The Rapid Chloride Ion Permeability test, AASHTO T-277 was performed in addition to and not in place of the Duggan test for concrete durability. The results of the Duggan test were considered irrelevant to the conclusions of the report and were left out. Those results showed essentially no difference between test sample and control (data is available upon request).

   The PSU report recommends against using the T-277 test because of claims of erroneous high readings. The justification for this claim is based on a paragraph and note in the AASHTO test which read in part, "This test method can produce misleading results when calcium nitrite has been admixed into a concrete .... Other admixtures might affect results of this test similarly. Long-term ponding tests are recommended if an admixture effect is suspected." In testing for this MLR, the results of the T-277 were consistent with the ponding test in showing no significant difference between the Ipanex concrete and the control. In the WJE report, the high permeability values were correlated to high water absorption and low density of the Ipanex cores tested.

2. Data are provided in the MLR from compressive strength tests performed on concrete from the field. IPA Systems raised some concerns about the testing of concrete samples at different air contents. Essentially, the concrete samples with Ipanex had significantly higher air contents. The author acknowledges that the decrease in strength probably was due, at least in part, to the increase in air content. However, adding an air entraining agent to the concrete

without Ipanex would have made the two cases even more difficult to compare in a controlled sense. Also, all of the other variables were maintained constant. Note too that the concrete that was actually placed in the bridge was that with the higher air content and lower strengths. Note that the mixes described in Table 1 were standard DOT lab mixes.

3. The MLR discusses the use of a state generated letter in the IPA Systems promotional literature received by the Iowa DOT New Products Committee. IPA Systems has stated that the letters from other states and cities were only included in the package sent to the Iowa DOT New Products Committee in response to the committee's request for that type of information, and that those items are never included in the promotional packages that are sent to other potential customers.

4. In the economics portion of the MLR the cost of silica fume is discussed. This discussion needs to be clarified. In that paragraph the report states "Type 1S cement is almost the same price as regular cement and added silica fume is not much more.... Either of these is a much more economical approach than Ipanex on simply a price basis...."

   (1) Note that Type 1S cement is slag cement, not cement with silica fume. So the MLR is correct in saying that slag cement is the same price as regular cement.

   (2) Also, the current price for silica fume in Iowa results in an added cost to concrete of about $30.00 per cubic yard placed. This is considerably higher than regular concrete but comparable to the cost of using Ipanex.

5. Some concern has been expressed about the claim in the MLR that there is a lack of controlled tests in the product literature provided (here we are speaking of controlled field tests). In the literature and data provided to the New Products committee, there is only one field case cited that is a controlled study. This is the evaluation of bridge structures on the I-76 Turnpike in Pennsylvania. All of the others listed are single case studies (with no controls). No other controlled field study information has been provided since the publication of the MLR or the meeting on April 20, 1999.

The WJE report is carefully and objectively written. Its conclusions are different from those of the PSU report, although many references are made to its content. The WJE report indicated considerable differences between the Ipanex and control concretes. Those differences included air content, aggregate gradation, flat and elongated particle content, maximum aggregate size, and cover over steel. The WJE report states in the conclusions "These differences prevent an accurate comparison of the Ipanex concrete with the control." In the product literature and in the PSU report, the visual survey results are strongly emphasized. The visual survey results showed considerably more deterioration on bridges without Ipanex compared to the bridge with Ipanex. However, the bridge with Ipanex had air contents ranging from 3 to 12 percent and the control had air contents between 1.5 and 2.5 percent. Also, the Ipanex bridge had at least 2.5 inches of cover over the steel in the places sampled. The controls had cover ranging from 1.25 to 2.12 inches. The control cores with at least 2 inches of cover did not exhibit corrosion. So the comment in the MLR about other plausible causes of deterioration remains valid.

6. Another concern expressed about the testing that was performed by the Iowa DOT is that chloride ion permeability was tested and not water permeability. The tests performed by PSU were intended to evaluate this permeability. The MLR listed several questions about the Pennsylvania State University research results and several have been answered since the publication of the MLR. Some of the more important new information is listed below:

   (1) The samples were one inch in diameter and two inches long. This being the case, the actual area of the cross section that was being tested was very small as the maximum sizes of the aggregates were ¾ inch for the Ipanex samples and ½ inch for the control. This means that the measured flow rates were bound to be very small and the associated measurement errors significant. More importantly, the sample with the larger aggregate (Ipanex) is essentially guaranteed to have a lower permeability result because the aggregate is taking up so much more of the cross section.

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7. Finally, in the paragraph describing Table 2 on page 5 of the MLR, the ability of silica fume and slag to reduce permeability is described. Please note that this decrease in permeability is with respect to conventional concrete not concrete with Ipanex.

Addendum to MLR 98-2

Revisions to meet IPA complaints of June 99

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   ~~The one case study with control that was provided~~ ~~as described by PSU~~ ~~is flawed.~~ * The WJE report indicated considerable differences between the Ipanex and control concretes. Those differences included air content, aggregate gradation, flat and elongated particle content, maximum aggregate size, and cover over steel. The WJE report states in the conclusions "These differences prevent an accurate comparison of the Ipanex concrete with the control." In the product literature and in the PSU report, the visual survey results are strongly emphasized. The visual survey results showed considerably more deterioration on bridges without Ipanex compared to the bridge with Ipanex. However, the bridge with Ipanex had air contents ranging from 3 to 12 percent and the control had air contents between 1.5 and 2.5 percent. Also, the Ipanex bridge had at least 2.5 inches of cover over the steel in the places sampled. The controls had cover ranging from 1.25 to 2.12 inches. The control cores with at least 2 inches of cover did not exhibit corrosion. So the comment in the MLR about other plausible causes of deterioration remains valid.

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