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Client:	Penetron Co.		
Project:	Information of Client		
Subject:	Laboratory Testing of Penetron Admixture As Per NCHRP-244 Methods		
Job No.:	06-98	Report No.: 06-1918	Date: 3/29/2006

We present herewith laboratory test results of the Penetron admixture sent to us by the client. The admixture was tested in accordance with the requirements of the National Cooperative Highway Research Program Report 244. In addition, the Penetron treated concrete mix was tested in accordance with ASTM C-672.

The study consisted of a control mix and a Penetron admixture treated concrete mix. The amount of Penetron admixture used was 0.8% by weight of cement.

I. TEST MATERIALS AND PROCEDURES

A. Concrete Mix Design (f_c' = 4000 psi)

Materials (*)	lbs./cu. yard
Portland Cement Type I/II, ASTM C-150	611
Clayton Sand, ASTM C-33	1255
Weldon Stone, Size #57, ASTM C-33	1800
Penetron Admixture	4.89
Water	268
Air Entraining Agent, oz.	4.3
Slump, inches	3.0
Air Content, %	6.0
Water/Cement Ratio, lbs./lb.	0.44
Plastic Unit Weight, lbs./cu. ft.	146.8
Compressive Strength, psi (28 days of age)	5260

(*) Sand and stone were SSD basis.

B. Experimental Design for NCHRP-244 Method

1. Control Samples – Untreated:
   - Cured 7 days in Curing Room at 100% Relative Humidity at 73°F.
   - Air dried for 21 days at 50% Relative Humidity and 73°F.
   - No other treatment.

2. Controlled Samples Soaked in NaCl Solution – Untreated:
   - Cured 7 days in Curing Room at 100% Relative Humidity at 73°F.
   - Air dried for 21 days at 50% Relative Humidity at 73°F.
   - Soaked in 15% NaCl solution for 21 days.

3. Samples Treated with Penetron Admixture:
   - Cured 7 days in Curing Room at 100% Relative Humidity at 73°F.
   - Air dried for 21 days at 50% Relative Humidity at 73°F.
   - Kept in controlled Climate Room for 14 days at 50% Relative Humidity at 73°F.
   - Soaked in 15% NaCl solution for 21 days.
   - Half of the cubes were subjected to ultra violet light for 14 days prior to soaking in NaCl solution.

C. Test Procedures for NCHRP-244 Method

- At the end of the curing and treatment periods, all samples were weighed to determine moisture loss or gain.

- At the end of the NaCl solution treatment period, all cubes were saw cut at 1-inch and 2-inch depths from the surface. Total chloride content at each section (0-1 inch and 1-2 inch) was determined in accordance with AASHTO-T260 procedures. At each depth, duplicate chloride tests were performed.

D. Scaling Resistance Tests (ASTM C-672)

In this test, the specimens were subjected to 100 cycles of freeze-thaw. The test results are presented herein.

II. TEST RESULTS (NCHRP-244 METHODS)

A. Water Loss During the Initial 28-Day Curing Period

Days After Casting of Cubes	Moisture Loss % by Weight (*) (**)
7	0.05 ± 01
28	2.10 ± 06

(*) Based on the cube weights at 1-day of age.
(**) Average of 30 cubes.

B. Water Loss of Treated Samples During 14 Days in Controlled Room at 50% R.H

Type of Treatment	Water Loss, g/Cm2 (*)
Control (Untreated)	0.090
Penetron Treated	0.017
Exposed to U.V. Light (Treated)	0.018

(*) All results are the average of triplicates.

C. Water Absorption After Soaking in 15% NaCl Solution for 21 Days

Type of Treatment	Weight, Gain, % (*)
Control (Untreated)	2.89
Control – Untreated (Exposed to U.V. Light)	2.92
Penetron Treated	0.57
Penetron (Treated) (Exposed to U.V. Light)	0.60

(*) All test results are average of triplicate tests.

D. Chloride (Cl^-) Ion Content of Concrete Cubes After 21-Days Soaking in 15% NaCl Solution (*) (**)

Type of Treatment	Chloride Ion Content % by Weight of Concrete	
	0-1 Inch Depth	1-2 Inch Depth
Control (Untreated)	0.244	0.021
Control (Untreated) (Exposed to U.V. Light)	0.246	0.021
Penetron Treated	0.023	0.004
Penetron Treated (Exposed to U.V. Light)	0.024	0.005

(*) -- The background chloride content of the concrete was 0.001%. All results were corrected by subtracting the background value from the chloride results.
(**) – All test results are the average of triplicate tests.

E. Relationship Between Water Absorption and Chloride Ion Content

Type of Treatment	Chloride Ion Content, % (0-2" Depth)	% Weight Gain 21 Days in 15% NaCl Solution	Calculated Percent Chloride Ion in Solution Absorbed
Control (Untreated)	0.263	2.89	9.1
Control (Untreated) (Exposed to U.V. light)	0.267	2.92	9.1
Penetron Treated	0.027	0.57	4.7
Treated (Exposed to U.V. light)	0.029	0.60	4.8

F. Reductions of Water Absorption and Chlorides Into Concrete

Type of Treatment	Reduction of Water Absorption into Concrete, %	Reduction in Chloride Content in Concrete, % (*)
Penetron Treated	80.2	89.7
Penetron Treated (Exposed to U.V. light)	79.5	89.1

(*) 0-2 inch depth.

III. TEST RESULTS OF ASTM C-672

Sample I.D.	After 100 Cycles of Freeze-Thaw (*)
Control (Untreated)	Moderate to Severe Scaling
Penetron Treated	Trace Scaling

(*)Three specimens per treatment.

IV. CONCLUSIONS

Based on these test results, the following conclusions were drawn:

1. The moisture loss of the untreated specimens at the age of 28 days was 2.10% by weight of the concrete. This amount of loss is normal for concrete exposed to 50% relative humidity at normal air temperatures.

   At the age of 7 days, the water loss was only 0.05%. This is expected since during the first 7 days the cubes were in 100% relative humidity.

2. The water losses of the treated specimens during the 14 days in the controlled room at 50% relative humidity were between 0.017 and 0.018 grams per Cm^2 area.

   It should be noted that the average reduction in the moisture loss, as compared to the control, was 81.1%.

   Exposure to ultraviolet light did not have any significant effect on the performance of the treated samples.

3. Water absorption of the treated specimens was considerably lower than the absorption of the control samples. Exposure of the treated cubes to ultraviolet light had very little effect (for example, 0.57% gain for unexposed vs. 0.60% for ultraviolet exposed) on the water absorption after soaking the cubes in 15% NaCl solution for 21 days. The reduction in weight gain was 79.5%.

4. There was considerable reduction in the chloride content in the specimens treated with the Penetron. The reductions in chloride absorption by weight percent were:

Treatment	% Reduction
Penetron Treated	89.7
Treated (Exposed to U.V.)	89.1

   It was noted that exposure to ultraviolet light had only a minor effect on the chloride absorption.

   In the control specimens, the depth of chloride penetration was very high at 0-1 inch depths and rather considerable at 1-2 inch depths. In the treated samples, chloride penetrations were measurable, but not high, at 0-1 inch depths. While at the 1-2 inch depth, the chloride penetrations were minimal.

5. It is concluded from these test results that treating concrete with Penetron admixture at the rate studied reduced considerably (at least 89%) the amounts of chloride penetrations to a concrete depth of 1 inch and practically eliminates the penetration of chlorides to depths beyond 1 inch.

6. The scaling resistance test results indicated that the Penetron treated concrete had only trace amount of scaling, while the control samples had moderate to severe scaling when exposed to chloride salts under freeze-thaw conditions.

Very truly yours,

SOR TESTING LABORATORIES, INC.

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President

KS/gs
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