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16. Abstract
Many entities currently use permeability specifications in portland cement concrete (PCC) pavements and structures. This project investigated the use of a surface resistivity device as an indication of concrete's ability to resist chloride ion penetration for use in quality assurance (QA) and acceptance of concrete.

ASTM C 1202 tests were conducted at various ages with the corresponding surface resistivity test and the results were compared. Samples tested included: field prepared samples, samples from the ongoing 09-4C: Evaluation of Ternary Cementitious Combinations project, and samples from the laboratory test matrix. The laboratory test matrix tested several mixtures common to Louisiana at a wide range of water to cementitious materials ratios to evaluate the range of the surface resistivity meter.

The surface resistivity measurements correlate well with rapid chloride permeability measurements across a wide range of permeability values and sample testing ages. Suitable correlations were found to exist between both the 14-day and 28-day surface resistivity values and the 56-day rapid chloride permeability values.

The standard deviation of the surface resistivity meter results are usually less than 3 kΩ-cm compared to 300 to 500 Coulombs from the rapid chloride permeability test. The surface resistivity meter was also able to identify great differences in water to cementitious materials (w/cm) ratios for the same mixtures.

The cost benefit analysis showed that implementation of the device will save the Department about $101,000 in personnel costs in the first year. It is estimated that contractors will save about $1.5 million in quality control costs. The cost benefit ratio for this project is estimated to be about 15. LADOTD TR Procedure, TR 233, has been developed and implementation of the surface resistivity device has begun.

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ABSTRACT

Many entities currently use permeability specifications in portland cement concrete (PCC) pavements and structures. This project investigated the use of a surface resistivity device as an indication of concrete's ability to resist chloride ion penetration for use in quality assurance (QA) and acceptance of concrete.

American Society for Testing and Materials (ASTM) C 1202 tests were conducted at various ages with the corresponding surface resistivity test and the results were compared. Samples tested included: field prepared samples, samples from the ongoing 09-4C: Evaluation of Ternary Cementitious Combinations project, and samples from the laboratory test matrix. The laboratory test matrix tested several mixtures common to Louisiana at a wide range of water to cementitious materials ratios to evaluate the range of the surface resistivity meter.

The surface resistivity measurements correlate well with rapid chloride permeability measurements across a wide range of permeability values and sample testing ages. Suitable correlations were found to exist between both the 14-day and 28-day surface resistivity values and the 56-day rapid chloride permeability values.

The standard deviation of the surface resistivity meter results are usually less than 3 kΩ-cm compared to 300 to 500 Coulombs from the rapid chloride permeability test. The surface resistivity meter was also able to identify great differences in water to cementitious materials (w/cm) ratios for the same mixtures.

The surface resistivity meter was found to be very user friendly even when several issues arose with the operation and maintenance of the surface resistivity meter. The issues have since been resolved with a redesign of the meter.

The cost benefit analysis showed that implementation of the device will save the Department about $101,000 in personnel costs in the first year. It is estimated that contractors will save about $1.5 million in quality control costs. The cost benefit ratio for this project is estimated to be about 15.

A Louisiana Department of Transportation and Development (LADOTD) Test Requirements (TR) Procedure, TR 233, has been developed and implementation of the surface resistivity device has begun.

ACKNOWLEDGMENTS

The U.S. Department of Transportation, Federal Highway Administration (FHWA), Louisiana Department of Transportation and Development (LADOTD), and Louisiana Transportation Research Center (LTRC) financially supported this research project.
The efforts of Randy Young, Matt Tircuit, Shane Laws, Scott Reech, Benjamin Shearer, Jacob Newgard, Anthony Saladino, Brandon Pitre, and Brennon Hughes in the concrete laboratory are greatly appreciated. The efforts of Mike Bailey are greatly appreciated for the chemical and physical testing of the cementitious materials used in the laboratory test matrix. The authors would like to thank Mike Ricca for his effort in coordinating field samples for inclusion in this study.

IMPLEMENTATION STATEMENT

The authors recommend full implementation of the surface resistivity meter and associated TR test method. Specifications should be developed around the test method for future design purposes. Implementation of the device will require the purchase of 11 surface resistivity meters, one for each district laboratory, central materials laboratory, and LTRC. A training program should be developed for training of district personnel. The training program should at a minimum include a short lecture detailing the background and theory of the surface resistivity meter, a tutorial video, and a proficiency exam.

The preliminary cost benefit analysis shows that implementation of surface resistivity measurements in lieu of rapid chloride permeability tests will save the Department about $101,000 in personnel costs in the first year of implementation. Additional savings to LADOTD through savings to suppliers and contractors is estimated to be about $1.5 million.

The total estimated savings for the project are about $1.6 million. The cost of the project was $102,878. The estimated cost benefit ratio for this project is about 15. Any ratio greater than two is considered excellent. The preliminary analysis shows that the Department will save money by switching to the newer, faster surface resistivity test method.

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INTRODUCTION

Many entities currently use permeability specifications in PCC pavements and structures. For those states using permeability specifications, the two test methods generally used are ASTM C1202 or ASTM C642 [*1*], [*2*]. This project investigated the use of a surface resistivity device as an indication of concrete's ability to resist chloride ion penetration for use in QA and acceptance of concrete.

Until recently, the rapid chloride permeability test was the only test that "quickly" determined concrete's ability to resist chloride ion penetration. Recent advances in surface resistivity measurements and their correlations to the rapid chloride permeability results have led many owners to use them for a variety of reasons: the first being low cost of the equipment and the second being a reduction in the number of man hours required to conduct the test.

Literature Review

This section will detail the current specifications and test procedures being developed using the surface resistivity technology as well as past research work completed investigating the use of this technology.

Since Morris et al. showed that concrete can be characterized by its surface resistivity, much work has been completed in this area [*3*]. Most recently, an AASHTO Technical Implementation Group (TIG) has developed a draft test method entitled, "Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration" that is currently being balloted [*4*]. This test method was drafted using data from the Florida Department of Transportation and a round robin study that is still currently underway with the help of the Federal Highway Administration. A draft version of the AASHTO test method can be found in the Appendix.

Chini et al. showed that a strong relationship exists between the rapid chloride permeability test and the surface resistivity test [*5*]. Kessler et al. have completed research in Florida noting the surface resistivity tool can be used as an indicator of chloride penetration resistance at 28 days for concretes that have reached a large portion of their total reaction such as those produced with silica fume or metakaolin [*6*]. The authors also noted that concretes containing fly ash or ground granulated blast furnace slag may not lend themselves to testing at 28 days but more likely 56 days. The Florida Department of Transportation used the results from this research to develop a test method [*7*].

Hamilton et al. conducted a rigorous study comparing surface resistivity measurements to bulk diffusion, rapid chloride permeability (ASTM C1202) measurements, and rapid migration test results [*8*]. They showed that a good correlation exists between all test methods at various ages of testing with the best correlations existing between 91 day rapid chloride permeability and the 364 day bulk diffusion test results.

Presuel-Moreno et al. characterized over 60 bridges in Florida using the surface resistivity test method [*9*]. The results showed that a correlation existed between samples tested in field conditions (i.e., non-saturated) and samples taken to the laboratory and subsequently tested in a wet (i.e., saturated) condition. The correlation showed that the field surface resistivity was generally three times that of the wet conditioned samples.

OBJECTIVE

The objectives of this research were twofold: (1) characterize the surface resistivity of concrete specimens produced in the laboratory and field conditions and (2) characterize the rapid chloride permeability of said concrete specimens.

SCOPE

To meet the objectives of this project, samples were produced in laboratory conditions from five mixtures at three different water to cementitious materials (w/cm) ratios to produce a wide range of permeability values. These mixtures were tested for both surface resistivity and rapid chloride permeability at 14, 28, and 56 days of age. Field cast specimens, generally from the Caminada Bay Bridge project, were also tested for surface resistivity and rapid chloride permeability at 28 and 56 days of age.

METHODOLOGY

This section is divided into the materials used for the project (including sample procurement from outside sources), test methods, and analysis techniques.

Materials

The cementitious materials used in the laboratory portion of the study included type I/II portland cement, class C and class F fly ash, grade 100 and grade 120 slag, and silica fume. The portland cement was a type I/II from Holcim Theodore, AL. The class C and class F fly ashes were from Headwaters Westlake, LA and Headwaters Dolet Hills, LA, respectively. The grade 100 slag was from Holcim Theodore, AL, and the grade 120 slag was from Buzzi Unicem New Orleans, LA. The silica fume was a dry powder from Grace.

X-ray fluorescence (XRF) was used to determine the chemical constituents of the cementitious materials used in the study. Table 1 shows the laboratory factorial to determine the effects of water to cement ratio on the rapid chloride permeability surface resistivity results. Three samples were tested at 14, 28, and 56 days of age. Note that TI, C, G120S, and SF stand for type I portland cement, class C fly ash, grade 120 slag, and silica fume, respectively.

Table 1
Laboratory test factorial

	w/cm		
Mixture ID	**0.35**	**0.50**	**0.65**
100TI	X	X	X
80TI-20C	X	X	X
50TI-50G120S	X	X	X
90TI-10SF	X	X	X
95TI-5SF	X	X	X

Test Methods

This section will detail the test methods used in characterizing the concrete properties. The section is divided into the fresh concrete properties and permeability test methods.

Fresh Concrete Property Test Methods

The following test methods were used in characterization of the fresh concrete properties of concrete produced for the laboratory test factorial.

- ASTM C138 [Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete] [*10*]
- ASTM C143/143M [Standard Test Method for Slump of Hydraulic-Cement Concrete] [*11*]
- ASTM C231 [Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method] [*12*]

Permeability Test Methods

Figure 1 shows the surface resistivity meter. The surface resistivity test was conducted in the following manner according to the draft AASHTO test procedure [*4*]:

1. Remove the sample from the humidity room and determine 0, 90, 180, and 270° marks on the ends of the cylinder.
2. Determine and mark the midpoint of the cylinder height (shown in Figure 2).
3. Measure and record the surface resistivity of the sample in kΩ-cm for each marking of 0, 90, 180, and 270°.
4. Repeat the measurements at each marking of 0, 90, 180, 270° for a total of eight readings.
5. Average the eight readings for reporting of the results.

Note that Figure 3 shows the test being conducted. A draft copy of the AASHTO procedure and a draft copy of the DOTD TR procedure can be found in the Appendix.

Figure 1
Surface resistivity meter

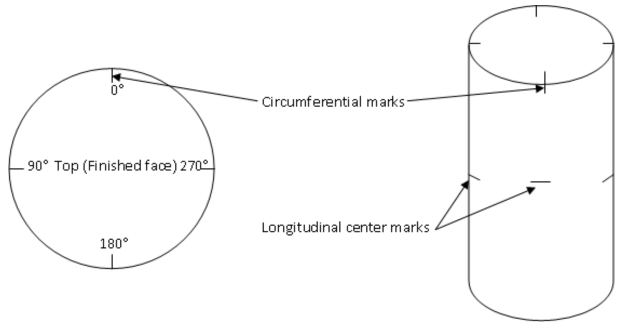

Figure 2
Cylinder markings

Figure 3
Surface resistivity test being conducted

For comparison purposes, ASTM C1202 [Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration] [*1*] was conducted.

Analysis Techniques

Microsoft Excel was used to determine average and standard deviations of the test results. Excel was also used to determine if a correlation existed between the rapid chloride permeability results and the surface resistivity results.

A preliminary cost-benefit analysis was also conducted to estimate the value of implementing the surface resistivity device on LADOTD construction projects. For the purposes of this report, the cost to conduct the research was used as the cost factor, and the benefit was determined using personnel and equipment savings. Table 2 shows the input values for the cost benefit analysis. Note the technician hourly wage is that of an engineering technician III and includes the benefits. The hourly wage is prevalent for both tests, but the $500 cost is the cost of the test if it were to be contracted in a QC regimen or if the Department were to outsource the testing.

Table 2
Input values for the cost benefit analysis

Equipment	Initial Cost ($)	Number of Man Hours Required	Technician Hourly Wage or Cost per Test ($)
ASTM C 1202	$18,000.00	8.0	$500.00
Surface Resistivity	$2,800.00	0.33	$23.38

DISCUSSION OF RESULTS

This section is divided into the materials results, fresh concrete properties, and the permeability results. For the purposes of this report, the permeability results are all inclusive including results from three field projects, the LTRC 09-4C – Evaluation of Ternary Cementitious Systems project, and the laboratory test factorial.

Materials Results

The XRF results show that the cementitious materials used in the study are representative of those used in everyday construction projects throughout the state of Louisiana and conform to applicable ASTM, AASHTO, and LADOTD standards and specifications. Table 3 shows the XRF results for the cementitious materials used in the laboratory test factorial. Note that all values are in percentage of the oxide.

Table 3
XRF results for the cementitious materials used in the laboratory test factorial

Oxide	Type I/II Portland Cement	Class C Fly Ash	Class F Fly Ash	Grade 100 GGBFS	Grade 120 GGBFS
SiO_2	20.24	35.04	60.74	38.59	34.77
Al_2O_3	4.45	19.30	19.41	7.61	10.73
Fe_2O_3	3.47	5.32	7.93	0.76	0.56
CaO	63.28	24.98	5.33	38.61	40.52
MgO	3.82	5.48	1.84	13.00	11.99
Na_2O	0.22	1.95	0.77	0.25	0.29
K_2O	0.44	0.46	1.19	0.38	0.38
TiO_2	0.28	1.36	1.01	0.36	0.60
SO_3	2.62	2.81	0.37	0.38	0.41
LOI	1.10	0.60	0.60	0.20	0.20

Fresh Concrete Properties

This section will detail the fresh concrete properties for the laboratory test matrix. Table 4 shows the fresh concrete properties of slump, air content, and unit weight for each mixture immediately after batching prior to casting cylinders for permeability testing. The results are as expected with the increase in slump as the w/cm increases.

Table 4
Fresh concrete properties for the laboratory test matrix mixtures

Mixture	w/cm	Slump (in.)	Air (%)	Unit Weight (pcf)
100TI	0.35	0.00	6.0	141.9
	0.50	4.50	1.3	150.4
	0.65	9.50	0.0	149.8
80TI-20C	0.35	1.00	4.5	149.8
	0.50	8.00	0.6	151.2
	0.65	9.00	0.8	148.2
80TI-20F	0.35	1.25	2.4	153.4
	0.50	7.25	0.9	150.0
	0.65	9.50	0.3	147.9
50TI-50G100S	0.35	3.00	2.8	154.2
	0.50	2.00	1.2	150.4
	0.65	9.50	0.4	147.2
50TI-50G120S	0.35	3.50	3.2	152.2
	0.50	2.00	1.3	150.0
	0.65	9.50	0.1	145.6
95TI-5SF	0.35	1.25	2.8	152.0
	0.50	1.25	1.8	149.6
	0.65	8.25	0.3	149.8
90TI-10SF	0.35	1.00	2.5	150.4
	0.50	0.75	2.3	148.8
	0.65	7.50	0.8	149.2

Permeability Results

The ASTM C1202 results were as expected for this study. In the laboratory test matrix, the increased w/cm mixtures showed increased permeability at all ages. Note that the increase in cement replacement percentage led to a decrease in permeability as expected. The surface resistivity meter showed results comparable to ASTM C1202.

Although the results were comparable in permeability classes, the standard deviations of the two test methods are not similar. The standard deviation of the rapid chloride permeability test can be on the order of 300 to 500 Coulombs, while the standard deviation of the surface resistivity meter is usually less than three kΩ-cm. This leads to a lower percentage of re-tests due to failing samples with the surface resistivity test method compared to the rapid chloride permeability test method.

To validate the relationship between rapid chloride permeability and surface resistivity, as suggested by others, the average surface resistivity (eight measurements) results were plotted against the average ASTM C1202 (four measurements) results as shown in Figure 4 [*6-8*]. Note the relationship is very good with a correlation coefficient of 0.89. Figure 4 also shows the AASHTO correlation and the data fit the proposed correlation very well.

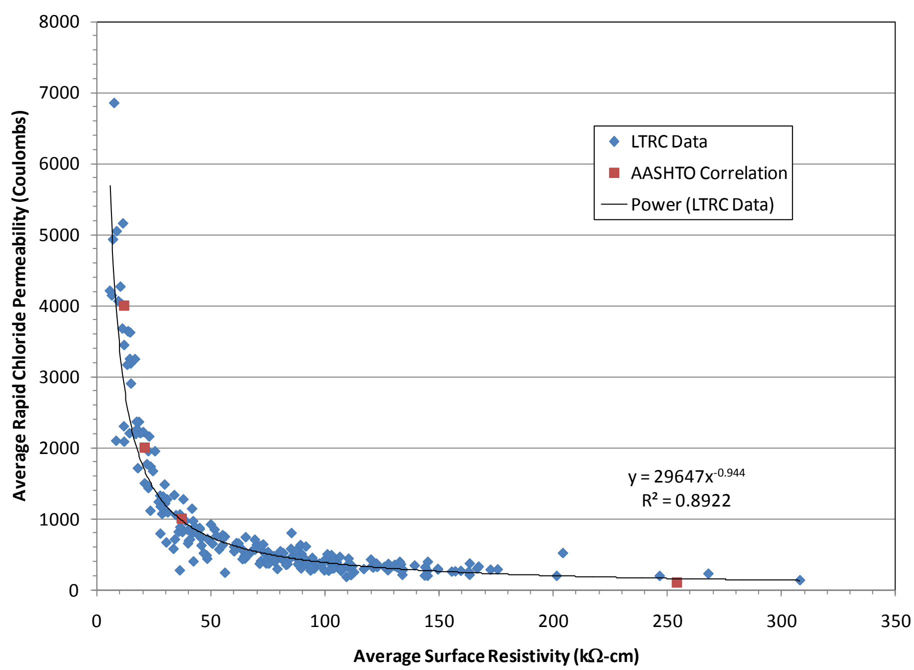

Figure 4
Relationship between surface resistivity and rapid chloride permeability at all ages and for all samples tested

Upon determining that the relationship was valid, the research team then plotted the average 28 day surface resistivity results versus the average 56 day rapid chloride permeability results to further evaluate the proposed AASHTO correlation. The results are shown in Figure 5. Note the correlation coefficient was reduced slightly from 0.89 to 0.87, but is still very good.

The laboratory test matrix tested some samples at a very early age of 14 days. The 14 day surface resistivity results were plotted against the 56 day rapid chloride permeability results and are shown in Figure 6. Note the correlation still is valid, but the correlation coefficient dropped from 0.87 to 0.80.

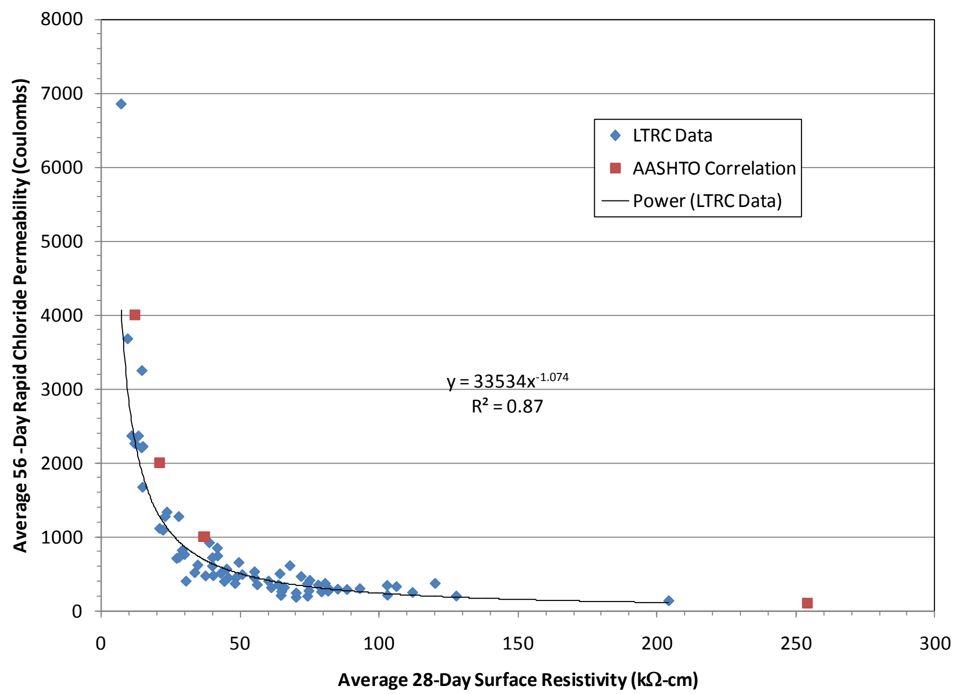

Figure 5
Relationship between the average 28-day surface resistivity and the average 56-day rapid chloride permeability results

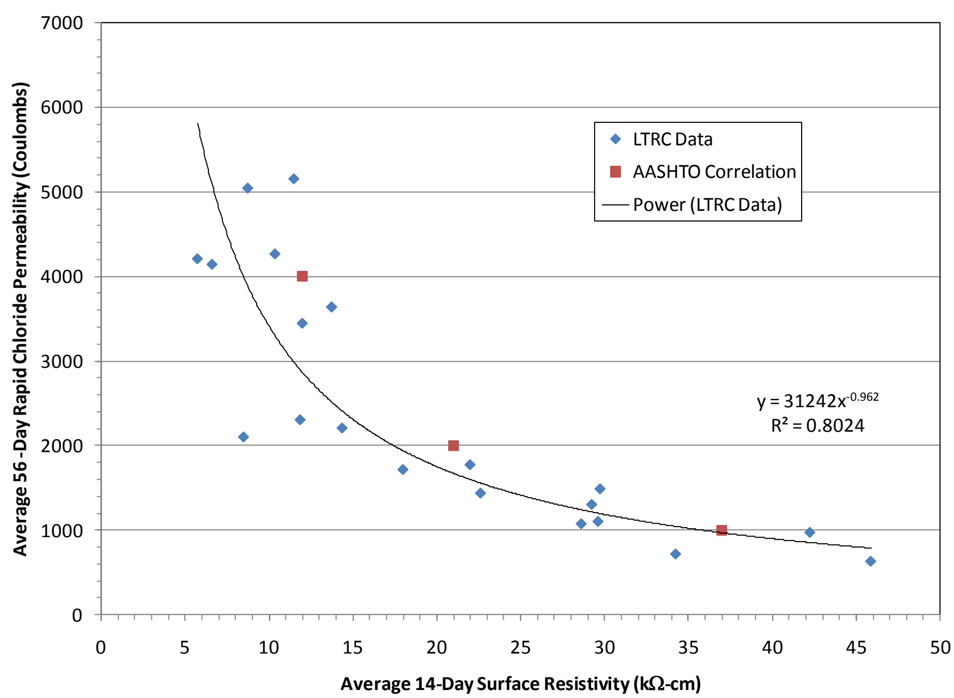

Figure 6
Relationship between the average 14-day surface resistivity and the average 56-day rapid chloride permeability results

The results of this study show that the proposed AASHTO correlation is valid across a wide range of permeability values. The results also show that the correlation is valid across several different testing ages. The surface resistivity results show that the device can be used effectively as a quality assurance and quality control tool for prediction of concrete permeability. Although the study shows that a valid correlation exists at 14 days of age, the authors suggest using the 28-day correlation for simplicity. Samples are routinely tested at 28 days of age for strength. Since the surface resistivity test is a non-destructive test, the same samples cast for strength can also be used for determination of permeability. The surface resistivity would be measured first and then the samples would be tested for compressive strength.

Next, the effect of w/cm on the results of the surface resistivity measurements was investigated. Figure 7 shows the effect of w/cm on the average 28-day surface resistivity results for the laboratory test matrix. Note the effect is as expected for all mixtures except those containing slag, where the increase in w/cm leads to a decrease in surface resistivity indicating a more permeable concrete. Note the results show that the results can be used to indicate a w/cm for a given mixture if past performance is documented.

After extensive evaluation of all the surface resistivity test results, the authors note that the slag mixtures are anomalies and are planning to investigate the phenomenon as the device is implemented.

Table 5 shows the proposed AASHTO and LADOTD permeability classes. The ASTM C1202 ranges are included for reference and the proposed ranges are valid for 28-day surface resistivity measurements.

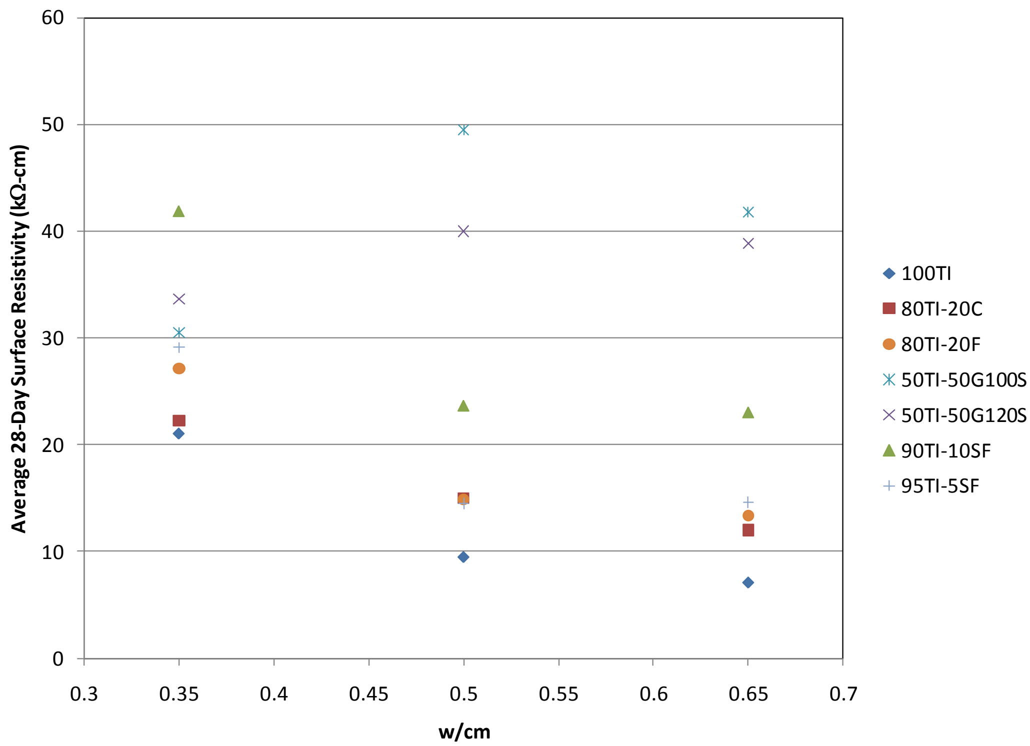

Figure 7
Effect of w/cm on the average 28-day surface resistivity results for laboratory test matrix

Table 5
Proposed AASHTO and LADOTD surface resistivity permeability classes for 4 x 8 inch cylinders

Permeability Class	56-Day Rapid Chloride Permeability Charge Passed (Coulombs)	28-Day Surface Resistivity (kΩ-cm)
High	> 4,000	< 12
Moderate	2,000 - 4,000	12 - 21
Low	1,000 - 2,000	21 - 37
Very Low	100 - 1,000	37 - 254
Negligible	< 100	> 254

While conducting this study, numerous issues regarding the nature of the surface resistivity test surfaced. It was determined that the batteries needed to be changed about every four months to prevent erratic readings due to low battery level. Other issues arose with the design of the meter and the cord connecting the meter to the probe. This design issue has been resolved with a redesign of the meter. The last issue that arose dealt with the wooden pegs used for contacting the surface of the concrete specimen. The pegs had a tendency to rot after a period of time and required constant maintenance and replacement. This issue has also been solved with the redesign of the meter. Taking the above issues into account, the users of this meter were very pleased with the timeliness and accuracy of the results and the ease in which it can be operated.

Cost Benefit Analysis

The preliminary cost benefit analysis results showed that implementation of surface resistivity measurements in lieu of rapid chloride permeability tests will save the Department about $101,000 in personnel costs in the first year of implementation. Table 6 shows the estimated cost savings to the Department for the first year of implementation. Note that, in an average year, the Department tests about 480 lots for quality assurance purposes.

Table 6
Comparison of one year QA costs for the surface resistivity and ASTM C1202 tests

Test Method	Number of Lots	Number of Hours Required	Technician Hourly Wage ($)	Tech. Cost ($)	Total Cost ($)	Cost Per Lot ($)
ASTM C 1202	480	3840	$23.38	$89,779.20	$107,779.20	$224.54
Surface Resistivity	480	158.4	$23.38	$3,703.39	$6,503.39	$13.55
				SAVINGS	**$101,275.81**	

The number of hours required for conducting the test was determined by taking the number of man hours required for each test times the number of lots. The technician costs were determined by taking the hourly wages times the number of hours required for each test. The total costs were derived by summing the technician costs and the initial cost of the equipment. The cost per lot was determined by taking the total cost and dividing it by the number of lots.

Table 7 shows the estimated costs savings for contractors conducting QC tests. The differences show the savings associated with the contractor purchasing the surface resistivity meter versus sending the QC testing to an independent laboratory. For the purposes of this analysis, it is assumed that the contractors are sending the ASTM C1202 samples to an independent laboratory for testing at a conservative (i.e., cost for testing only) cost of $500 per sample. Note the estimated cost savings total about $1.5 million.

Table 7
Comparison of one year QC costs for the surface resistivity and ASTM C1202 tests

Test Method	Number of Lots	Number of Hours Required	Hourly Wage/Cost per Test ($)	Tech. Cost/Test Cost ($)	Total Cost ($)	Cost Per Sample ($)
ASTM C 1202	3000	–	$500	$1,500,000	$1,518,000.00	$506.00
Surface Resistivity	3000	990	$23.38	$23,146	$25,946.20	$8.65
				SAVINGS	**$1,492,053.80**	

The total estimated savings for the project are about $1.6 million. The cost of the project was $102,878. The estimated cost benefit ratio for this project is about 15. Any ratio greater than two is considered excellent. The preliminary analysis shows that the Department will save money by switching to the newer, faster, surface resistivity test method.

CONCLUSIONS

The results of this study warrant the following conclusions. The surface resistivity measurements correlate well with rapid chloride permeability measurements across a wide range of permeability values and sample testing ages. Suitable correlations were found to exist between both the 14-day and 28-day surface resistivity values and the 56-day rapid chloride permeability values.

The standard deviation of the surface resistivity meter results are usually less than 3 kΩ-cm compared to 300 to 500 Coulombs from the rapid chloride permeability test. The surface resistivity meter is also able to identify great differences in w/cm ratios for the same mixtures.

The surface resistivity meter is very user friendly even when several issues arose with the operation and maintenance of the surface resistivity meter. The issues have since been resolved with a redesign of the meter.

The cost benefit analysis showed that implementation of the device will save the Department about $101,000 in personnel costs in the first year. It is estimated that contractors will save about $1.5 million in quality control costs. The cost benefit ratio for this project is estimated to be about 15.

RECOMMENDATIONS

The authors recommend full implementation of the surface resistivity meter and associated TR test method. It is recommended that the Department use the permeability classes shown in Table 8, and test surface resistivity at 28 days of age. Specifications should be developed around the test method for future design purposes. Implementation of the device will require the purchase of 11 surface resistivity meters, one for each district laboratory, central materials laboratory, and LTRC. A training program should be developed for training of district personnel. The training program should at a minimum include a video and a proficiency exam.

Table 8
Recommended surface resistivity permeability classes

Permeability Class	**28-Day Surface Resistivity (kΩ-cm)**
High	< 12
Moderate	12 - 21
Low	21 - 37
Very Low	37 - 254
Negligible	> 254

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society of Testing and Materials
FHWA	Federal Highway Administration
in.	inch(es)
LADOTD	Louisiana Department of Transportation and Development
LTRC	Louisiana Transportation Research Center
PCC	portland cement concrete
pcf	pounds per cubic foot
QA	quality assurance
QC	quality control
TIG	Technical Implementation Group
TR	Test Requirements
XRF	X-ray fluorescence
w/cm	water to cementitious materials

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10. ASTM C138/138M “Standard Test Method for Density (Unit Weight), Yield, and Air content (Gravimetric) of Concrete.” *Annual Book of ASTM Standards,* Vol. 04.02, ASTM, Philadelphia, PA, 2010.

11. ASTM C143/143M "Standard Test Method for Slump of Hydraulic-Cement Concrete." *Annual Book of ASTM Standards,* Vol. 04.02, ASTM, Philadelphia, PA, 2010.

12. ASTM C231 "Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method." *Annual Book of ASTM Standards,* Vol. 04.02, ASTM, Philadelphia, PA, 2010.

APPENDIX

Draft AASHTO Procedure

Standard Method of Test for

Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

AASHTO Designation: T XXX-08

1. SCOPE

1.1. This test method covers the determination of the electrical resistivity of concrete to provide a rapid indication of its resistance to the penetration of chloride ions. This test method is applicable to types of concrete where correlations have been established between this test procedure and long-term chloride ponding procedures such as those described in ASTM C 1556. Examples of such correlations are discussed in References (15.2.).[1]

1.2. The values stated in SI units are to be regarded as the standard.

1.3. *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:
R 39, Making and Curing Concrete Test Specimens in the Laboratory
T 23, Making and Curing Concrete Test Specimens in the Field
T 24M/T 24, Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

2.2. *ASTM Standard*:
C 670, Practice for Preparing Precision and Bias Statements for Test Methods for Construction Purposes
ASTM C 1556, Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion

3. SUMMARY OF TEST METHOD

3.1 This test method consists of measuring the resistivity of 200-mm (8-in.) or 300-mm (12-in.) nominal length and 100-mm (4-in.) or 150-mm (6-in.) nominal diameter cores or cylinders by use of a 4-pin Wenner probe array. An AC potential difference is applied in the outer pins of the Wenner array generating current flow in the concrete. The potential difference generated by this current is measured by the two inner probes. The current used and potential obtained along with the area affected are used to calculate the resistivity of the concrete. The resistivity, in Ohms-cm, has been found to be related to the resistance of the specimen to chloride ion penetration.

4. SIGNIFICANCE AND USE

4.1. This test method covers the laboratory evaluation of the electrical resistivity of concrete samples to provide a rapid indication of their resistance to chloride ion penetration. In most cases the electrical resistivity results have shown good correlation with chloride exposure tests, such as ASTM C-1556, on companion cylinders cast from the same concrete mixtures (References 15.2.).

4.2. This test method is suitable for evaluation of materials and material proportions for design purposes and research and development.

4.3. The numerical results (resistivity, in KOhm-cm) from this test method must be used with caution, especially in applications such as quality control and acceptance testing. The qualitative terms in the left-hand column of Table 1 should be used in most cases unless otherwise noted by the specifying agency.

Table 1—Chloride Ion Penetrability Based

Chloride Ion Penetrability	**Surface Resistivity Test**	
	100-mm X 200-mm (4 in. X 8 in.) Cylinder (KOhm-cm) a=1.5	**150-mm X 300-mm (6 in. X 12 in.) Cylinder (KOhm-cm) a=1.5**
High	< 12	< 9.5
Moderate	12 - 21	9.5 - 16.5
Low	21 - 37	16.5 – 29
Very Low	37 - 254	29 – 199
Negligible	> 254	> 199

a = Wenner probe tip spacing

4.4. The details of the test method apply to 100-mm (4 in.) and 150-mm (6 in.) nominal diameter specimens. Other specimen diameters may be tested with appropriate changes to the Wenner probe tip spacing and the correction factor in the calculating equation. (See Reference 15.3.)

4.5. Sample age may have significant effects on the test results, depending on the type of concrete and the curing procedure. Most concretes, if properly cured, become progressively and significantly less permeable with time.

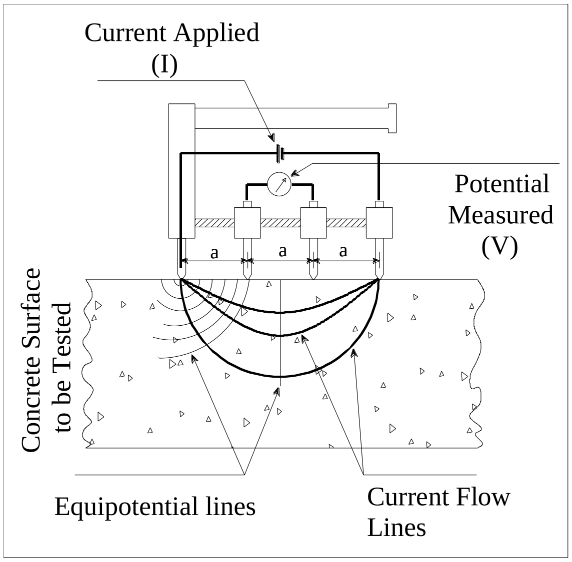

Figure 1 Four-point Wenner Array Probe Test Setup

5. INTERFERENCES

5.1. This test method can produce misleading results when calcium nitrite has been admixed into a concrete. The results from this test on some such concretes indicate lower resistivity values, that is, lower resistance to chloride ion penetration, than from tests on identical concrete mixtures (controls) without calcium nitrite. However, long-term chloride diffusion tests indicate the concretes with calcium nitrite were at least as resistant to chloride ion penetration as the control mixtures.

Note 1—Other admixtures might affect results of this test similarly. Long-term diffusion tests are recommended if an admixture effect is suspected.

5.2. Specimen curing condition is known to affect the resistivity of the solution in the pore structure (References 15.4.). Lime water curing on average reduces resistivity by 10%.

5.3. Since the test results are a function of the electrical resistance of the specimen, the presence of reinforcing steel or other embedded electrically conductive materials may have a significant effect. The test is not valid for specimens containing reinforcing.

6. APPARATUS

6.1. *Surface Resistivity Apparatus*: (See Figure 2 for example.) Apparatus with Wenner array probe capable of adjustment of the probe tip spacing to 38.1-mm. (1.5-in.).

Figure 2 Surface Resistivity Apparatus

6.2. *Specimen holder* to prevent specimen rotation while under test. (See figure 3 for example)

Figure 3 Specimen holder

7. REAGENTS, and MATERIALS

None

8. TEST SPECIMENS

8.1. A set is composed of a minimum of three (3) specimens samples. Sample preparation and selection depends on the purpose of the test. For evaluation of materials or their proportions, samples may be (a) cores from test slabs or from large diameter cylinders or (b) 100-mm (4-in.) diameter cast cylinders or (c) 150-mm (6-in.) diameter cast cylinders. For evaluation of structures, samples may be (a) 100-mm (4-in.) diameter cylinders cast and cured at the field site or (b) 150-mm (6-in.) diameter cylinders cast and cured at the field site. Cylinders cast in the laboratory shall be prepared following procedures in R 39. Unless specified otherwise, moist cure test specimens for 28 days prior to the start of specimen preparation (Note 3). When cylinders are cast in the field to evaluate a structure, care must be taken that the cylinders receive the same treatment as the structure, for example, similar degree of consolidation, curing, and temperature history during curing.

Note 3—This test method has been used with various test durations and curing regimens to meet agency guidelines or specifications. Care should be exercised when comparing results obtained from specimens subjected to differing conditions.

Note 4—The maximum allowable aggregate size has not been established for this test. Users have indicated that test repeatability is satisfactory on specimens from the same concrete batch for aggregates up to 37.0-mm (1.5-in.) nominal maximum size.

8.2. Transport the cores or field-cured cylinders to the laboratory in moist condition in sealed (tied) plastic bags. If specimens must be shipped, they should be packed to be properly protected from freezing and damage in transit or storage.

8.3. Special processing is necessary for core samples where the surface has been modified, for example, by texturing or by applying curing compounds, sealers, or other surface treatments, and where the intent of the test is not to include the effect of the modifications. In those cases, the modified portion of the core shall be removed.

8.4 Immediately after sample removal from the mold, make four indelible marks on the top (finish face) circular face of the specimen marking the 0, 90, 180, and 270 degree points of the circumference of the circle. Randomly assign one of the marks as o°, then counter clock wise assign the next mark 90°, and so on. Extend the marks into the longitudinal sides of the specimens. On the longitudinal sides mark the center of the longitudinal length of the specimen in order to use as a visual reference during testing. (Figure 4 for example)

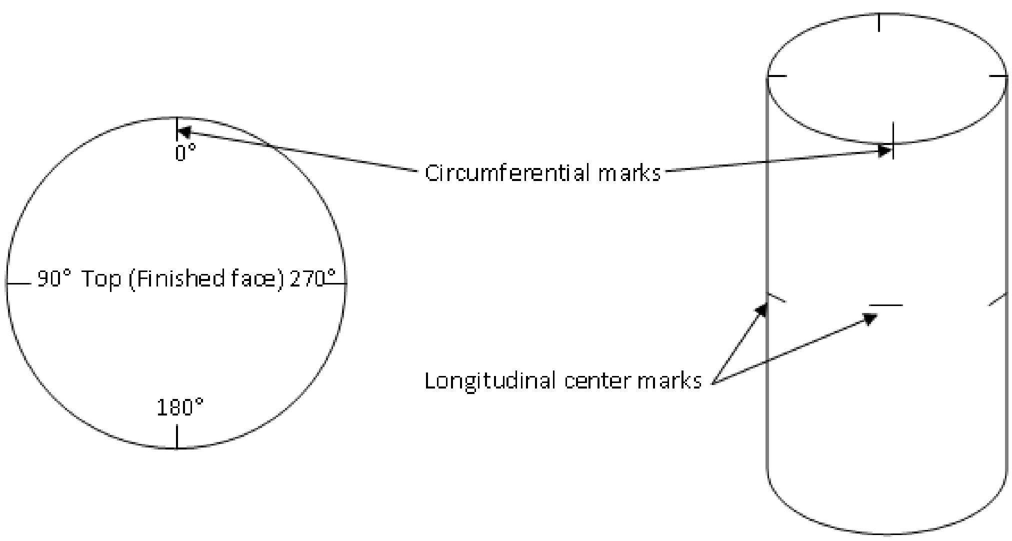

Figure 4 Specimen marking

9. CONDITIONING

In order to saturate concrete cylinder with water, specimen must remain in a 100% humidity condition for at least 7 days prior to testing.

10. PROCEDURE

10.1. During the test, the air temperature around the specimens shall be maintained in the range of 20 to 25ºC (68 to 77ºF).

10.2. Remove specimen from water, blot off excess water, and transfer specimen to holder with the 0 degree mark on top.

10.3. Place Wenner array probe on longitudinal side on the specimen making sure longitudinal center mark is equidistant between the two inner probes. (See figure 5)

Figure 5 Wenner array placement

10.4. Take measurement of display unit when the number becomes stable.

10.5. Rotate specimen 90° to 90 degree mark, and repeat 10.2 and 10.3 above.

10.6. Rotate specimen 90° to 180 degree mark, and repeat 10.2 and 10.3.

10.7. Rotate specimen 90° to 270 degree mark, and repeat 10.2 and 10.3.

10.8. Repeat last four readings at 0°, 90°, 180°, and 270° marks.

10.9. Repeat 10.1 to 10.8 for the other specimens in the set.

11. CALCULATION AND INTERPRETATION OF RESULTS

11.1. Calculate the average resistivity for each specimen in the set. Calculate average resistivity of the set.

Surface Resistivity (SR) Readings (Kohm-cm)									
Sample	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**Average**
A									
B									
C									
Set Average									
Curing Condition Correction (x 1.1 lime tank or 1.0 for moist room)									
Penetrability Based on Test									

11.2 If specimens were cured in lime water tank, multiply set average by 1.1. If specimens were cured in moist room, multiply set average by 1.0.

11.3. Use Table 1 and the size of the specimens to evaluate the test results based on the resistivity. These values were developed from data on various types of concretes.

11.3.1. Factors which are known to affect chloride ion penetration include: water-cement ratio, pozzolans, the presence of polymeric admixtures, sample age, air-void system, aggregate type, degree of consolidation, and type of curing.

12. REPORT

12.1. *Report the following, if known*:

12.1.1. Source of core or cylinder, in terms of the particular location the core or cylinder represents.

12.1.2. Identification number of core or cylinder and specimen.

12.1.3. Location of specimen within core or cylinder.

12.1.4. Type of concrete, including binder type, water–cement ratio, and other relevant data supplied with samples.

12.1.5. Description of specimen, including presence and location of reinforcing steel, presence and thickness of overlay, and presence and thickness of surface treatment.

12.1.6. Curing history of specimen.

12.1.7. Unusual specimen preparation, for example, removal of surface treatment.

12.1.8. Test results, reported as the surface resistivity measured, and

12.1.9. The qualitative chloride ion penetrability equivalent to the surface resistivity measured (from Table 1).

13. PRECISION AND BIAS[2]

13.1. *Precision*:

13.1.1. *Single-Operator Precision*—The single operator coefficient of variation of a single test result has been found to be 6.3 percent (Note 7). Therefore, the results of two properly conducted tests by the same operator on concrete samples from the same batch and of the same diameter should not differ by more than 21 percent (Note 7).

13.1.2. *Multilaboratory Precision*—The multilaboratory coefficient of variation of a single test result has been found to be X.X percent (Note 7). Therefore results of two properly conducted tests in different laboratories on the same material should not differ by more than XX percent (Note 7). The average of three test results in two different laboratories should not differ by more than XX percent (Note 8).

Note 7—These numbers represent, respectively, the (1s percent) and (d2s percent) limits as described in ASTM C 670. The precision statements are based on the variations in tests on three different concretes, each tested in triplicate in 11 laboratories. All specimens had the same actual diameters, but lengths varied within the range 50 ± 3 mm (2 ± 0.125 in.).

Note 8—Although the test method does not require the reporting of more than one test result, testing of replicate specimens is usually desirable. The precision statement for the averages of three results is given since laboratories frequently will run this number of specimens. When averages of three results are established in each laboratory, the multilaboratory coefficient of variation SML is calculated as:

S_{ML} = Square Root of $(S^2_{WL} / 3) + S^2_{BL}$ *(3)*

where:

S^2_{WL} = within-laboratory variance and

S^2_{BL} = between-laboratory variance

The percentage cited represents the (d2s %) limit based on the value for the multilaboratory coefficient of variation.

13.2. *Bias*—The procedure of this test method for measuring the resistance of concrete to chloride ion penetration has no bias because the value of this resistance can be defined only in terms of a test method.

14. KEYWORDS

14.1. Chloride content; corrosion; deicing chemicals; resistance-chloride penetration.

15. REFERENCES

15.1. Chini, A.R., Muszynski, L.C., Hicks, J., "Determination of Acceptance Permeability Characteristics for Performance-Related Specifications for Portland Cement Concrete", Final Report submitted to Florida Department of Transportation (Contract No. BC 354-41)

15.2 Hamilton, H.R., Boyd, A.J., Vivas, E.A., "Permeability of Concrete – Comparison of Conductive and Diffusion Methods", Final Report submitted to Florida Department of

Transportation” (Contract No. BD536)

15.3 Morris, W., Moreno, E.I. and Sagues, A.A., "Practical Evaluation of Resistivity of Concrete in Test Cylinders using a Wenner Array Probe", *Cement and Concrete Research*, Vol. 26, No. 12, 1996, pp. 1779- 1787.

15.4 Kessler, R.J., Powers, R.G., and Paredes, M.A., “Resistivity Measurements of Water Saturated Concrete as an Indicator of Permeability”, Paper 05261, Corrosion 2005, NACE International.

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[1] The numbers in parentheses refer to the list of references at the end of this standard.

[2] Supporting data have been filed at ASTM headquarters (100 Barr Harbor Drive, Conshohocken, PA 19428-2959) and may be obtained by requesting RR: C-9-1004.

Test Method for

SURFACE RESISTIVITY INDICATION OF CONCRETE'S ABILITY TO RESIST CHLORIDE ION PENETRATION

DOTD Designation: TR 233

I. Scope

A. This test method covers the determination of the electrical resistivity of concrete to provide a rapid indication of its resistance to the penetration of chloride ions. This test method is applicable for evaluating individual materials or their proportions for resistance to chloride ion penetration. This test method is applicable to type of concrete where established correlations between this test procedure and other permeability measurement procedures such as those described in ASTM C 1202.

Note 1: *This test method can produce misleading results when calcium nitrite has been admixed into a concrete. The results from this test on some such concretes indicate lower resistivity values, that is, lower resistance to chloride ion penetration, than from tests on identical concrete mixtures (controls) without calcium nitrite were at least as resistant to chloride ion penetration as control mixtures.*

Note 2: *Since the test results are a function of electrical resistance of the specimen, the presence of reinforcing steel or other embedded electrically conductive materials might have a significant effect. The test is not valid for specimens containing reinforcing.*

B. Reference Documents

1. ASTM Standard C 1556, Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion
2. DOTD TR 225, Obtaining and Testing Core Specimens from Hardened Concrete.
3. DOTD TR 226, Making, Field Curing, and Transporting Concrete Test Specimens.

II. Apparatus

A. **Surface Resistivity Apparatus** – Apparatus with Wenner array probe capable of adjustment of the probe tip spacing to 1.5-in. (38.1-mm) (Figure 1)

B. **Specimen Holder** – to prevent specimen rotation while under test (Figure 2).

C. **Moist Room** – to condition retain the sample prior to testing at specified age

D. Marking Device – Any device capable of producing an indelible mark on a wet concrete surface

E. Permanent Marker

F. **Towel** – to dry the excess moisture from the sample before marking and conducting the test

G. **End Grinder** – to remove surface treatments if necessary

H. **Saw** – to remove surface treatments if necessary

I. **Thermometer** – to measure air temperature at time of testing

J. DOTD Surface Resistivity Test Report , 22-2000-11, Figure 6

K. Shallow Pan - to hold a small amount of water to dip the tips into

Figure 1
Surface Resistivity Apparatus

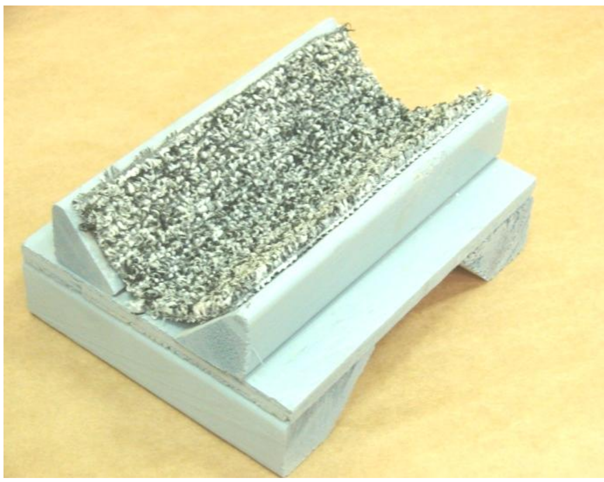

Figure 2
Specimen Holder

III. Samples, Test Specimens, Test Locations, etc.

A. A set is composed of a minimum of three (3) specimen samples. Sample preparation and selection depends on the purpose of the test.

B. Samples may be

1. 4-in. cores from test slabs or from large diameter cylinders (6-in. (150 mm.) diameter or greater)
2. 4-in. (100-mm.) diameter cast cylinders
3. 6-in. (150-mm.) diameter cast cylinders

C. For evaluation of structures, samples may be

1. 4-in. (100-mm.) diameter cylinders cast and cured at the field site
2. 6-in. (150-mm.) diameter cylinders cast and cured at the field site

D. Cylinders cast in the laboratory shall be prepared following procedures in DOTD TR 226. Unless specified otherwise, moist cure test specimens for 28 days prior to the start of specimen preparation.

E. When casting cylinders in the field to evaluate a structure, take care that the cylinders receive the same treatment as the structure, for example, similar degree of consolidation, curing, and temperature history during curing.

Note 3: *This test method has been used with various test durations and curing regimens to meet agency guidelines or specifications. Exercise care when comparing results obtained from specimens subjected to differing conditions.*

Note 4: *There is no maximum allowable aggregate size established for this test. Users have indicated that the test repeatability is satisfactory on specimens from the same concrete batch for aggregates up to 1.5-in. (37.0-mm) nominal maximum size.*

F. Transport the cores of field-cured cylinders to the laboratory in moist condition in sealed (tied) plastic bags. If shipping specimens, properly package specimens to protect from freezing and damage in transit or storage. Use boxes to transport in accordance with TR 226.

G. Where the surface has been modified, special processing is necessary for core samples, for example, by texturing or by applying curing compounds, sealers, or other surface treatments where the intent of the test is not to include the effect of the modifications. In those cases, remove the modified portion of the core by means of end grinding or sawing.

H. Immediately after sample removal from the mold, make four indelible marks on top (finish face) circular face of the specimen marking the 0, 90, 180, 270 degree points of the circumference of the circle. Randomly assign one of the marks as 0°, then counter clockwise assign the next mark 90°, and so on. Extend the marks into the longitudinal sides of the specimens. On the longitudinal sides, mark the center of the longitudinal length of the specimen in order to use as a visual reference during testing. (Figure 3)

I. Conditioning

1. In order to saturate, the concrete cylinder specimen must remain in a condition of 100% relative humidity for at least 7 days prior to testing.

Note 5: *The room should be a complete fog when entering.*

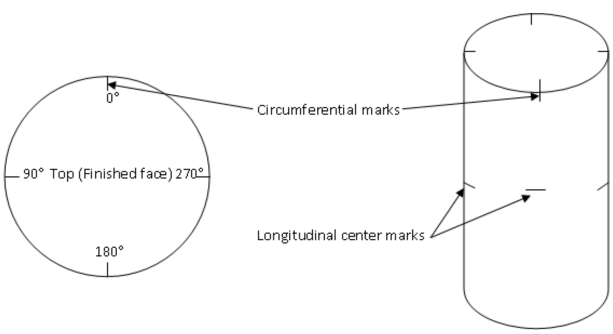

Figure 3
Specimen Marking

IV. Procedure

A. During the test, maintain the air temperature around the specimens in the range of 20 to 25°C (68 to 77°F).

B. Remove specimen from humidity room or water, blot off excess water, and transfer specimen to holder with the 0-degree mark on top.

C. Dip the Wenner array probe tips into the pan of water several times. Be sure to press against the bottom of the pan to fill the reservoirs.

D. Place Wenner array probe on longitudinal side on the specimen making sure longitudinal center mark is equidistance between the two inner probes (Figure 4).

E. Take reading to the nearest tenth on display unit when the number becomes stable and record it on the calculation report shown in Figure 5 or in the test results report shown in Figure 6.

F. Rotate specimen 0-degree to 90-degree mark, and repeat steps D and E.

G. Rotate specimen 90-degree to 180-degree mark, and repeat steps D and E.

H. Rotate specimen 180-degree to 270-degree mark, and repeat steps D and E.

I. Repeat last four readings at 0°, 90°, 180°, 270° marks.

J. Repeat steps A to I for other specimens in the set.

Figure 4
Wenner Array Placement

V. Calculation and Interpretation of Results

A. Calculate the average resistivity for each specimen in the set.

$$Avg.S_{Avg.A} = \frac{S_{0.1} + S_{90.1} + S_{180.1} + S_{270.1} + S_{0.2} + S_{90.2} + S_{180.2} + S_{270.2}}{8}$$

$$Avg.S_{Avg.A} = \frac{177 + 195 + 168 + 184 + 178 + 193 + 171 + 183}{8}$$

$$Avg.S_{Avg.A} = 181.1 \text{ KOhm-cm}$$

B. Calculate Average Resistivity for Set

$$Avg.SR = C \times \frac{S_{Avg.A} + S_{Avg.B} + S_{Avg.C}}{3}$$

$$Avg.SR = 1 \times \frac{181.1 + 154.6 + 195.8}{3}$$

$$Avg.SR = 177.2 \text{ KOhm-cm}$$

Where:

S = Individual Surface Resistivity Measurement (KOhm-cm)

S_{Avg} = Average Surface Resistivity for Specimen (KOhm-cm)

C = Curing Condition Correction Factor

C. If cured specimens are in limewater, multiply set average by 1.1 to account for reduction caused by limewater curing. If cured specimens were in moist room, multiply set average by 1.0.

Note 6: *Specimen curing condition affects the resistivity of the solution in the pore structure. Limewater curing on average reduces resistivity by 10%.*

D. Use Table 1 and the size of specimens to evaluate the test results based on the resistivity. These developed values resulted from data on various types of concrete.

Note 7: *Factors that are known to affect chloride ion penetration include: water-cement ratio, pozzolans, the presence of polymeric admixtures, sample age, air-void systems, aggregate type, degree of consolidation, and type of curing.*

VI. Report

A. Source of core or cylinder, in terms of particular location the core or cylinder represents.

B. Identification number of core or cylinder and specimen.

C. Location of specimen within core or cylinder.

D. Type of concrete, including type and quantity of cementitious materials, water-cement ratio, and other relevant information supplied with samples.

E. Description of specimen, including presence and location of reinforcing steel, presence and thickness of overlay, and presence and thickness of surface treatment.

F. Curing history of specimen.

G. Unusual specimen preparation, for example, removal of surface treatment.

H. Test results, reported as the surface resistivity measured

I. The qualitative chloride- ion penetrability equivalent to the surface resistivity measured from Table 1.

VII. Normal Test Reporting Time

A. The normal test reporting time is 4 hours from the time of test.

Chloride Ion Penetrability Based

Chloride Ion Penetrability	Surface Resistivity Test	
	100-mm X 200-mm (4 in. X 8 in.) Cylinder (KOhm-cm) a=1.5	150-mm X 300-mm (6 in. X 12 in.) Cylinder (KOhm-cm) a=1.5
High	< 12	< 9.5
Moderate	12 - 21	9.5 - 16.5
Low	21 - 37	16.5 – 29
Very Low	37 - 254	29 – 199
Negligible	> 254	> 199

a = Wenner probe tip spacing

Table

Surface Resistivity (SR) Readings (KOhm-cm)									
Sample	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**Average**
A	177	195	168	184	178	193	171	183	181.1
B	161	134	151	170	161	143	148	169	154.6
C	181	212	202	195	179	203	200	194	195.8
Set Average (KOhm-cm)									177.2
Curing Condition Correction (Multiply by x 1.1 lime tank or 1.0 for moist room)									177.2
Penetrability Based on Test									Very Low

Figure 5
Calculation Report

DOTD 22-2000-11
3/11

Louisiana Department of Transportation and Development
SURFACE RESISTIVITY OF CONCRETE
(DOTD TR 226 and TR 233)

Project No. 4 5 0 - 3 0 - 0 0 2 5 | Material Code 4 2 5 | Lot No. 0 1 4

Date Sampled 0 7 - 2 9 - 9 2 | Submitted By 0 7 2 2 | Quantity 4 0 0 0 - 0

Purpose Code 3 (1. Quality Control, 2. Verification, 3. Acceptance, 4. Check, 5. Resample, 6. Source Appr., 7. Design, 8. Indep. Assur, 9. Preliminary Source Test) | Plant Code 0 7 2 3 | Spec Code 1

Mix Design No. 0 0 1 | Admixture: Air Y (Y = Yes, N = No)

Date Received (Lab) 0 7 - 3 0 - 9 2

Remarks U S E D I N S P A N 5

WR-NS N

Item No. 8 0 5

WR=SR N

Cylinders Made By ______ Acceptance Tests By ______

Batch Number 0 2

Date Tested 0 8 - 2 6 9 2

Acceptance Tests: Slump, in. (TR 207) 3 . 7 5 | Air Content, % (TR 202) 4 . 5

Sample No.	Laboratory No.	0°	90°	180°	270°	0°	90°	180°	270°	Specimen Avg
14-3A	07-162533	177	195	168	184	178	193	171	183	181.1
14-38	07-162534	161	134	151	170	161	143	148	169	154.6
14-30	07-162535	181	212	202	195	179	203	200	194	195.8

(SURFACE RESISTIVITY READINGS)

Samples Cured in Lime Water ☐ (Y = Yes, N = No)

Curing Condition Correction 1

Batch Avg 177.2

Penetrability Very Low

Batch Number ______

Date Tested ______

Acceptance Tests: Slump, in. (TR 207) ______ | Air Content, % (TR 202) ______

Sample No.	Laboratory No.	0°	90°	180°	270°	0°	90°	180°	270°	Specimen Avg

(SURFACE RESISTIVITY READINGS)

Samples Cured in Lime Water ☐ (Y = Yes, N = No)

Curing Condition Correction ______

Batch Avg ______

Penetrability ______

Penetrability Table

Penetrability	4 in. X 8 in. Cylinder (KOhm-cm)	6 in. X 12 in. Cylinder (KOhm-cm)
High	< 12	< 9.5
Moderate	12 - 21	9.5 - 16.5
Low	21 - 37	16.5 - 29
Very Low	37 - 254	29 - 199
Negligible	> 254	> 199

Tested By CD

Checked By KC

Remarks 2 ______

Approved By District Lab Engineer

Figure 6
Surface Resistivity of Concrete
Test Report

Raw Data – Lab Test Matrix

564 lbs cementitious, 0.35 w/c ratio, 60% coarse, 40% fine							
LTRC Lab. No.	**C-3556**	**C-3557**	**C-3584**	**C-3598**	**C-3599**	**C-3601**	**C-3602**
Mixture ID	100TI	80TI-20C	80TI-20F	50TI-50G100S	50TI-50G120S	95TI-5SF	90TI-10SF
Date Made	7/29/2010	7/29/2010	8/31/2010	9/21/2010	9/21/2010	9/22/2010	9/22/2010
Type I Portland Cement (%	100	80	80	50	50	95	90
Class C Fly Ash (%)		20					
Class F Fly Ash (%)			20				
Grade 100 Slag (%)				50			
Grade 120 Slag (%)					50		
Silica Fume (%)						5	10
Daravair 1000 (oz/100ct)	0.5	0.5	0.5				
ZYLA 620 (oz/100ct)	16.2	16.2					
ADVA 190 (oz/100ct)			9.0	15.0	7.0	10.0	15.0
Fresh Concrete Tests							
Slump (inches)	0.00	1.00	1.25	3.00	3.50	1.25	1.00
Air Content (%)	6.00	4.50	2.40	2.80	3.20	2.80	2.50
Unit Weight (lbs/ft³)	141.9	149.8	153.4	154.2	152.2	152.0	150.4
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or							
Coulombs at 14 days							
Cylinder #1 (Top)	1796	1904	1315	958	597	1059	903
Cylinder #1 (Middle)	2110	2195	1972	982	602	1525	1010
Cylinder #1 (Bottom)	1240	2522	2030	973	688	1724	1306
Average	**1715**	**2207**	**1772**	**971**	**629**	**1436**	**1073**
Chloride Ion Penetrability	**Low**	**Moderate**	**Low**	**Very Low**	**Very Low**	**Low**	**Low**
Standard Deviation	**440.57**	**309.17**	**397.12**	**12.12**	**51.16**	**341.32**	**208.76**
Coefficient of Variance	***25.68***	***14.01***	***22.41***	***1.25***	***8.13***	***23.77***	***19.46***
Coulombs at 28 days							
Cylinder #2 (Top)	1654	1470	952	710	580	1401	714
Cylinder #2 (Middle)	1554	1388	1288	668	581	1351	882
Cylinder #2 (Bottom)	1301	1554	1485	637	584	1196	811
Average	**1503**	**1471**	**1242**	**672**	**582**	**1316**	**802**
Chloride Ion Penetrability	**Low**	**Low**	**Low**	**Very Low**	**Very Low**	**Low**	**Very Low**
Standard Deviation	**181.94**	**83.00**	**269.50**	**36.64**	**2.08**	**106.89**	**84.33**
Coefficient of Variance	***12.11***	***5.64***	***21.71***	***5.45***	***0.36***	***8.12***	***10.51***
Coulombs at 56 days							
Cylinder #3 (Top)	1117	1343	731	337	533	1003	605
Cylinder #3 (Middle)	1196	774	744	515	532	982	971
Cylinder #3 (Bottom)	1037	1165	664	364	495	477	661
Average	**1117**	**1094**	**713**	**405**	**520**	**821**	**746**
Chloride Ion Penetrability	**Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**79.50**	**291.07**	**42.93**	**95.93**	**21.66**	**297.81**	**197.14**
Coefficient of Variance	***7.12***	***26.61***	***6.02***	***23.67***	***4.16***	***36.29***	***26.44***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864							
Resistivity (kΩ-cm) at 14 days							
Cylinder #4 (0°)	18.00	16.00	22.00	41.50	47.50	22.00	28.00
Cylinder #4 (90°)	19.50	14.00	23.00	41.50	47.00	24.50	31.50
Cylinder #4 (180°)	19.00	14.00	21.00	40.50	48.00	24.00	27.00
Cylinder #4 (270°)	15.50	13.50	22.00	45.50	41.00	20.00	28.00
Average	**18.00**	**14.38**	**22.00**	**42.25**	**45.88**	**22.63**	**28.63**
Surface Resistivity - Permeabili	**Moderate**	**Moderate**	**Low**	**Very Low**	**Very Low**	**Low**	**Low**
Standard Deviation	**1.78**	**1.11**	**0.82**	**2.22**	**3.28**	**2.06**	**1.97**
Coefficient of Variance	***9.89***	***7.71***	***3.71***	***5.25***	***7.14***	***9.09***	***6.90***
Resistivity (kΩ-cm) at 28 days							
Cylinder #4 (0°)	20.00	22.00	25.50	32.00	33.50	28.50	41.50
Cylinder #4 (90°)	24.00	22.50	30.00	32.50	30.00	32.00	46.50
Cylinder #4 (180°)	21.00	20.00	25.50	29.50	38.00	30.50	39.00
Cylinder #4 (270°)	19.00	24.50	27.50	28.00	33.00	25.50	40.50
Average	**21.00**	**22.25**	**27.13**	**30.50**	**33.63**	**29.13**	**41.88**
Surface Resistivity - Permeabili	**Low**	**Low**	**Low**	**Low**	**Low**	**Low**	**Very Low**
Standard Deviation	**2.16**	**1.85**	**2.14**	**2.12**	**3.30**	**2.81**	**3.25**
Coefficient of Variance	***10.29***	***8.31***	***7.87***	***6.96***	***9.82***	***9.65***	***7.76***
Resistivity (kΩ-cm) at 56 days							
Cylinder #4 (0°)	24.50	29.50	39.50	45.50	48.50	35.00	73.00
Cylinder #4 (90°)	26.50	33.00	42.50	41.50	48.00	35.00	62.50
Cylinder #4 (180°)	29.50	32.50	40.00	41.00	49.00	38.50	63.00
Cylinder #4 (270°)	13.50	29.50	41.50	41.50	42.00	35.00	62.50
Average	**23.50**	**31.13**	**40.88**	**42.38**	**46.88**	**35.88**	**65.25**
Surface Resistivity - Permeabili	**Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Low**	**Very Low**
Standard Deviation	**6.98**	**1.89**	**1.38**	**2.10**	**3.28**	**1.75**	**5.17**
Coefficient of Variance	***29.69***	***6.06***	***3.37***	***4.95***	***6.99***	***4.88***	***7.93***

564 lbs cementitious, 0.50 w/c ratio, 60%coarse, 40%fine							
LTRC Lab. No.	**C-3525**	**C-3529**	**C-3530**	**C-3542**	**C-3541**	**C-3545**	**C-3546**
Mixture ID	100TI	80TI-20C	80TI-20F	50TI-50G100S	50TI-50G120S	95TI-5SF	90TI-10SF
Date Made	6/23/2010	7/1/2010	7/1/2010	7/12/2010	7/12/2010	7/14/2010	7/14/2010
Type I Portland Cement (%	100	80	80	50	50	95	90
Class C Fly Ash (%)		20					
Class F Fly Ash (%)			20				
Grade 100 Slag (%)				50			
Grade 120 Slag (%)					50		
Silica Fume (%)						5	10
Fresh Concrete Tests							
Slump (inches)	4.50	8.00	7.25	2.00	2.00	1.25	0.75
Air Content (%)	1.3	0.6	0.9	1.2	1.3	1.8	2.3
Unit Weight (lbs/ft³)	150.4	151.2	150.0	150.4	150.0	149.6	148.8
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or							
Coulombs at 14 days							
Cylinder #1 (Top)	5090	2522	5167	1071	1225	3921	3531
Cylinder #1 (Middle)	4873	2065	5834	643	1236	3291	4014
Cylinder #1 (Bottom)	5180	2327	4472	431	840	3129	3374
Average	**5048**	**2305**	**5158**	**715**	**1100**	**3447**	**3640**
Chloride Ion Penetrability	**High**	**Moderate**	**High**	**Very Low**	**Low**	**Moderate**	**Moderate**
Standard Deviation	**157.82**	**229.32**	**681.05**	**326.02**	**225.52**	**418.41**	**333.55**
Coefficient of Variance	***3.13***	***9.95***	***13.20***	***45.60***	***20.50***	***12.14***	***9.16***
Coulombs at 28 days							
Cylinder #2 (Top)	4195	3246	3930	671	710	3520	1806
Cylinder #2 (Middle)	4059	2905	3409	756	935	3218	1728
Cylinder #2 (Bottom)	3937	2564	2222	657	890	3018	1677
Average	**4064**	**2905**	**3187**	**695**	**845**	**3252**	**1737**
Chloride Ion Penetrability	**High**	**Moderate**	**Moderate**	**Very Low**	**Very Low**	**Moderate**	**Low**
Standard Deviation	**129.06**	**341.00**	**875.37**	**53.58**	**119.06**	**252.72**	**64.97**
Coefficient of Variance	***3.18***	***11.74***	***27.47***	***7.71***	***14.09***	***7.77***	***3.74***
Coulombs at 56 days							
Cylinder #3 (Top)	3930	2605	1517	686	749	2769	1438
Cylinder #3 (Middle)	3680	2224	1831	630	729	2062	1557
Cylinder #3 (Bottom)	3427	1843	1675	657	689	1789	1019
Average	**3679**	**2224**	**1674**	**658**	**722**	**2207**	**1338**
Chloride Ion Penetrability	**Moderate**	**Moderate**	**Low**	**Very Low**	**Very Low**	**Moderate**	**Low**
Standard Deviation	**251.50**	**381.00**	**157.00**	**28.01**	**30.55**	**505.76**	**282.60**
Coefficient of Variance	***6.84***	***17.13***	***9.38***	***4.26***	***4.23***	***22.92***	***21.12***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864							
Resistivity (kΩ-cm) at 14 days							
Cylinder #4 (0°)	9.0	11.5	12.0	31.0	28.0	12.0	14.5
Cylinder #4 (90°)	8.0	12.0	11.0	34.0	27.0	12.0	14.5
Cylinder #4 (180°)	9.0	11.5	12.0	36.0	35.0	12.0	13.0
Cylinder #4 (270°)	9.0	12.5	11.0	36.0	28.5	12.0	13.0
Average	**8.8**	**11.9**	**11.5**	**34.3**	**29.6**	**12.0**	**13.8**
Surface Resistivity - Permeabili	**High**	**High**	**High**	**Low**	**Low**	**Moderate**	**Moderate**
Standard Deviation	**0.50**	**0.48**	**0.58**	**2.36**	**3.64**	**0.00**	**0.87**
Coefficient of Variance	***5.71***	***4.03***	***5.02***	***6.90***	***12.28***	***0.00***	***6.30***
Resistivity (kΩ-cm) at 28 days							
Cylinder #4 (0°)	9.0	14.5	16.0	46.0	38.5	15.0	26.0
Cylinder #4 (90°)	9.0	15.0	14.0	49.0	37.5	14.0	23.0
Cylinder #4 (180°)	10.0	14.5	15.5	52.0	47.0	14.0	22.0
Cylinder #4 (270°)	10.0	16.0	14.0	51.0	37.0	15.0	23.5
Average	**9.5**	**15.0**	**14.9**	**49.5**	**40.0**	**14.5**	**23.6**
Surface Resistivity - Permeabili	**High**	**Moderate**	**Moderate**	**Very Low**	**Very Low**	**Moderate**	**Low**
Standard Deviation	**0.58**	**0.71**	**1.03**	**2.65**	**4.71**	**0.58**	**1.70**
Coefficient of Variance	***6.08***	***4.71***	***6.93***	***5.34***	***11.77***	***3.98***	***7.20***
Resistivity (kΩ-cm) at 56 days							
Cylinder #4 (0°)	11.0	20.0	26.5	59.0	46.5	19.5	33.0
Cylinder #4 (90°)	11.0	20.0	22.5	60.5	47.0	19.0	35.0
Cylinder #4 (180°)	12.0	19.5	26.0	64.5	53.5	20.0	34.5
Cylinder #4 (270°)	11.0	22.0	23.5	64.5	47.0	18.0	33.5
Average	**11.3**	**20.4**	**24.6**	**62.1**	**48.5**	**19.1**	**34.0**
Surface Resistivity - Permeabili	**High**	**Moderate**	**Low**	**Very Low**	**Very Low**	**Moderate**	**Low**
Standard Deviation	**0.50**	**1.11**	**1.93**	**2.81**	**3.34**	**0.85**	**0.91**
Coefficient of Variance	***4.44***	***5.44***	***7.84***	***4.52***	***6.89***	***4.46***	***2.68***

564 lbs cementitious, 0.65 w/c ratio, 60% coarse, 40% fine							
LTRC Lab. No.	**C-3513**	**C-3520**	**C-3515**	**C-3517**	**C-3518**	**C-3521**	**C-3524**
Mixture ID	100TI	80TI-20C	80TI-20F	50TI-50G100S	50TI-50G120S	95TI-5SF	90TI-10SF
Date Made	6/14/2010	6/21/2010	6/14/2010	6/17/2010	6/17/2010	6/21/2010	6/23/2010
Type I Portland Cement (%	100	80	80	50	50	95	90
Class C Fly Ash (%)		20					
Class F Fly Ash (%)			20				
Grade 100 Slag (%)				50			
Grade 120 Slag (%)					50		
Silica Fume (%)						5	10
Fresh Concrete Tests							
Slump (inches)	9.50	9.00	9.50	9.50	9.50	8.25	7.50
Air Content (%)	0.0	0.8	0.3	0.4	0.1	0.3	0.8
Unit Weight (lbs/ft³)	149.8	148.2	147.9	147.2	145.6	149.8	149.2
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or							
Coulombs at 14 days							
Cylinder #1 (Top)	6158	2785	8002	1594	1970	4951	3531
Cylinder #1 (Middle)	4625	2101	2663	1369	1419	4194	4014
Cylinder #1 (Bottom)	1849	1417	1769	942	1070	3660	3374
Average	**4211**	**2101**	**4145**	**1302**	**1486**	**4268**	**3640**
Chloride Ion Penetrability	**High**	**Moderate**	**High**	**Low**	**Low**	**High**	**Moderate**
Standard Deviation	**2184.18**	**684.00**	**3370.32**	**331.17**	**453.76**	**648.70**	**333.55**
Coefficient of Variance	***51.87***	***32.56***	***81.32***	***25.44***	***30.53***	***15.20***	***9.16***
Coulombs at 28 days							
Cylinder #2 (Top)	6790	3974	4580	1372	1284	4315	2453
Cylinder #2 (Middle)	4581	1666	3899	1112	935	3549	2077
Cylinder #2 (Bottom)	3425	624	1029	954	706	3006	1953
Average	**4932**	**2088**	**3169**	**1146**	**975**	**3623**	**2161**
Chloride Ion Penetrability	**High**	**Moderate**	**Moderate**	**Low**	**Very Low**	**Moderate**	**Moderate**
Standard Deviation	**1709.74**	**1714.41**	**1884.60**	**211.06**	**291.07**	**657.66**	**260.37**
Coefficient of Variance	***34.67***	***82.11***	***59.46***	***18.42***	***29.85***	***18.15***	***12.05***
Coulombs at 56 days							
Cylinder #3 (Top)	7810	2693	2901	1102	988	4266	1687
Cylinder #3 (Middle)	6851	2336	2109	677	898	2936	1437
Cylinder #3 (Bottom)	5890	1764	2091	780	889	2547	710
Average	**6850**	**2264**	**2367**	**853**	**925**	**3250**	**1278**
Chloride Ion Penetrability	**High**	**Moderate**	**Moderate**	**Very Low**	**Very Low**	**Moderate**	**Low**
Standard Deviation	**960.00**	**468.63**	**462.55**	**221.70**	**54.74**	**901.40**	**507.54**
Coefficient of Variance	***14.01***	***20.70***	***19.54***	***25.99***	***5.92***	***27.74***	***39.71***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864							
Resistivity (kΩ-cm) at 14 days							
Cylinder #4 (0°)	5.50	8.50	7.00	29.00	30.50	10.00	14.50
Cylinder #4 (90°)	6.00	8.50	6.00	29.50	29.00	11.00	14.50
Cylinder #4 (180°)	6.50	9.00	6.50	30.00	30.50	10.00	13.00
Cylinder #4 (270°)	5.00	8.00	7.00	28.50	29.00	10.50	13.00
Average	**5.75**	**8.50**	**6.63**	**29.25**	**29.75**	**10.38**	**13.75**
Surface Resistivity - Permeabili	**High**	**High**	**High**	**Low**	**Low**	**High**	**Moderate**
Standard Deviation	**0.65**	**0.41**	**0.48**	**0.65**	**0.87**	**0.48**	**0.87**
Coefficient of Variance	***11.23***	***4.80***	***7.23***	***2.21***	***2.91***	***4.61***	***6.30***
Resistivity (kΩ-cm) at 28 days							
Cylinder #4 (0°)	6.00	12.00	14.00	43.50	40.50	14.00	23.50
Cylinder #4 (90°)	8.00	12.00	11.50	42.00	37.00	15.00	22.50
Cylinder #4 (180°)	8.00	12.00	13.50	43.00	39.00	16.00	23.00
Cylinder #4 (270°)	6.50	12.00	14.50	38.50	39.00	13.50	23.00
Average	**7.13**	**12.00**	**13.38**	**41.75**	**38.88**	**14.63**	**23.00**
Surface Resistivity - Permeabili	**High**	**Moderate**	**Moderate**	**Very Low**	**Very Low**	**Moderate**	**Low**
Standard Deviation	**1.03**	**0.00**	**1.31**	**2.25**	**1.44**	**1.11**	**0.41**
Coefficient of Variance	***14.47***	***0.00***	***9.83***	***5.40***	***3.69***	***7.58***	***1.77***
Resistivity (kΩ-cm) at 56 days							
Cylinder #4 (0°)	7.00	18.00	19.00	50.50	51.50	16.50	31.50
Cylinder #4 (90°)	8.00	16.50	17.00	54.00	46.50	16.00	30.00
Cylinder #4 (180°)	8.50	18.50	18.50	53.00	52.50	18.50	31.50
Cylinder #4 (270°)	7.00	17.50	19.50	49.00	49.50	16.00	30.50
Average	**7.63**	**17.63**	**18.50**	**51.63**	**50.00**	**16.75**	**30.88**
Surface Resistivity - Permeabili	**High**	**Moderate**	**Moderate**	**Very Low**	**Very Low**	**Moderate**	**Low**
Standard Deviation	**0.75**	**0.85**	**1.08**	**2.29**	**2.65**	**1.19**	**0.75**
Coefficient of Variance	***9.84***	***4.84***	***5.84***	***4.43***	***5.29***	***7.11***	***2.43***

Raw Data – Field Prepared Samples

LTRC Lab. No.	C-3440	C-3441	C-3461	C-3462	C-3464	C-3477	C-3488	C-3493	C-3494	C-3495	C-3496	C-3496	C-3496	C-3497
State Project Number	450-17-0025	450-17-0025	713-38-0001	713-38-0001	450-17-0025	713-38-0001	064-01-0040	064-01-0040	064-01-0040	064-30-0035	064-30-0035	064-30-0035	064-30-0035	713-38-001
Submitter ID	T120	T130	Lot # 004	Lot # 005	T134	Lot # 006	P-4-C	P-7-N	5 Star	Lot # 005	Lot # 006 (A)	Lot # 006 (B)	Lot # 006 (C)	Lot # 008
Date Made	12/10/2009	12/18/2009	12/22/2009	12/22/2009	12/22/2009	3/1/2010	3/16/2010	3/26/2010	4/2/2010	4/26/2010	4/28/2010	4/28/2010	4/28/2010	4/27/2010
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or 1075877)														
Coulombs														
Date Tested	2/4/2010	2/12/2010	2/16/2010	2/16/2010	2/16/2010	4/26/2010	5/11/2010	5/21/2010	5/28/2010	6/21/2010	6/23/2010	6/23/2010	6/23/2010	6/22/2010
Age at Test	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Sample #1	231	252	1673	1757	272	287	344	369	1299	280	1990	888	789	254
Sample #2	218	237	1893	2233	232	344	219	396	1321	119	2299	891	912	338
Sample #3	200	252	2298	1805	333	239	268	332	1489	413	2296	880	766	304
Sample #4	216	306		2020	318	341	396	367	1207					303
Average	**216**	**262**	**1955**	**1954**	**289**	**303**	**307**	**366**	**1329**	**271**	**2195**	**886**	**822**	**300**
Chloride Ion Penetrability	**Very Low**	**Very Low**	**Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Low**	**Very Low**	**Moderate**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**12.71**	**30.34**	**317.03**	**218.48**	**45.88**	**49.92**	**78.64**	**26.24**	**117.54**	**147.22**	**177.54**	**5.69**	**78.50**	**34.57**
Coefficient of Variance	***5.88***	***11.59***	***16.22***	***11.18***	***15.89***	***16.49***	***25.64***	***7.17***	***8.84***	***54.39***	***8.09***	***0.64***	***9.55***	***11.53***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864														
Resistivity (kΩ-cm)														
Date Tested	2/4/2010	2/12/2010	2/16/2010	2/16/2010	2/16/2010	4/26/2010	5/11/2010	5/21/2010	5/28/2010	6/21/2010	6/23/2010	6/23/2010	6/23/2010	6/22/2010
Age at Test	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Cylinder #1	158.6	153.9	23.3	27.4	181.1	104.1	102.3	106.5	29.4	98.9	17.1			143.9
Cylinder #2	160.6	152.8	21.9	25.8	154.6	87.5	104.1	111.8	35.9	114.1		36.6		147.5
Cylinder #3	164.6	156.3	23.4	24.9	195.8	95.1	103.9	112.3	23.0	108.1			43.5	154.1
Cylinder #4	169.5	159.1	21.8	24.0	158.6	94.4	105.1	111.6	22.8					152.3
Average	**163.3**	**155.5**	**22.6**	**25.5**	**172.5**	**95.3**	**103.9**	**110.6**	**27.8**	**107.0**	**17.1**	**36.6**	**43.5**	**149**
Surface Resistivity - Permeabili	**Very Low**	**Very Low**	**Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Low**	**Very Low**	**Moderate**	**Low**	**Very Low**	**Very Low**
Standard Deviation	**4.80**	**2.80**	**0.87**	**1.45**	**19.41**	**6.81**	**1.16**	**2.72**	**6.22**	**7.66**	**0.00**	**0.00**	**0.00**	**4.63**
Coefficient of Variance	***2.94***	***1.80***	***3.84***	***5.68***	***11.25***	***7.15***	***1.12***	***2.46***	***22.41***	***7.15***	***0.00***	***0.00***	***0.00***	***3.10***

LTRC Lab. No.	C-3498	C-3499	C-3500	C-3502	C-3503	C-3504	C-3505	C-3514	C-3514	C-3519	C-3522	C-3522	C-3523	C-3523
State Project Number	064-01-0040	064-01-0040	064-30-0035	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040
Submitter ID	P-8-S	P-10-AE	HPC-8	P-12-AR	P-14B-BE	P-16-BM	P-18-C	Lot 001 Batch 1	Lot 001 Batch 3	P-21-F	Lot 002 Batch 1	Lot 002 Batch 4	Lot 003 Batch 1	Lot 003 Batch 2
Date Made	3/30/2010	4/2/2010	5/12/2010	4/8/2010	4/13/2010	4/16/2010	4/23/2010	6/11/2010	6/11/2010	5/5/2010	6/15/2010	6/15/2010	6/17/2010	6/17/2010
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or 1075877)														
Coulombs														
Date Tested	5/25/2010	5/28/2010	7/7/2010	6/3/2010	6/8/2010	6/11/2010	6/18/2010	8/6/2010	8/6/2010	6/30/2010	8/10/2010	8/10/2010	8/12/2010	8/12/2010
Age at Test	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Sample #1	425	418	494	356	387	403	555	404	370	322	451	456	270	357
Sample #2	449	406	411	346	361	360	471	354	444	286	445	546	311	428
Sample #3	373	395	429	345	342	366	644	454	293	258	436	364	312	310
Sample #4	383	396	412	311	324	442	494			294				
Average	**408**	**404**	**437**	**340**	**354**	**393**	**541**	**404**	**369**	**290**	**444**	**455**	**298**	**365**
Chloride Ion Penetrability	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**35.68**	**10.72**	**39.21**	**19.64**	**26.96**	**37.94**	**77.27**	**50.00**	**75.50**	**26.33**	**7.55**	**91.00**	**23.97**	**59.41**
Coefficient of Variance	***8.76***	***2.66***	***8.98***	***5.78***	***7.63***	***9.66***	***14.28***	***12.38***	***20.46***	***9.08***	***1.70***	***19.99***	***8.05***	***16.28***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864														
Resistivity (kΩ-cm)														
Date Tested	5/25/2010	5/28/2010	7/7/2010	6/3/2010	6/8/2010	6/11/2010	6/18/2010	8/6/2010	8/6/2010	6/30/2010	8/10/2010	8/10/2010	8/12/2010	8/12/2010
Age at Test	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Cylinder #1	98.1	81.8	69.8	126.4	117.9	100.4	92.8	85.0	97.5	134.1	125.6	92.8	87.4	84.1
Cylinder #2	102.1	89.0	57.1	130.8	122.9	106.1	87.6	93.6	93.1	150.0	114.9	91.6	73.9	85.6
Cylinder #3	104.0	90.8	70.8	130.5	124.9	108.6	83.0	98.1	103.5	157.5	90.5	98.9	76.1	81.0
Cylinder #4	101.4	93.9	57.8	134.3	122.9	105.5	87.3			156.3				
Average	**101.4**	**88.9**	**63.9**	**130.5**	**122.2**	**105.2**	**87.7**	**92.2**	**98.0**	**149.5**	**110.3**	**94.4**	**79.1**	**83.6**
Surface Resistivity - Permeabili	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**2.46**	**5.13**	**7.44**	**3.23**	**2.99**	**3.44**	**4.01**	**6.66**	**5.22**	**10.76**	**17.99**	**3.91**	**7.24**	**2.35**
Coefficient of Variance	***2.43***	***5.77***	***11.64***	***2.48***	***2.44***	***3.27***	***4.57***	***7.22***	***5.33***	***7.20***	***16.31***	***4.15***	***9.15***	***2.81***

LTRC Lab. No.	C-3531	C-3533	C-3533	C-3535	C-3537	C-3538	C-3538	C-3539	C-3539	C-3540	C-3540	C-3548	C-3549	C-3549
State Project Number	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040
Submitter ID	P-25-E	Lot 004 Batch 1	Lot 004 Batch 3	P1	P-27-E	Lot 005 Batch 1	Lot 005 Batch 2	Lot 006 Batch 1	Lot 006 Batch 2	Lot 007 Batch 1	Lot 007 Batch 2	P-29-F	Lot 008 Batch 1	Lot 008 Batch 3
Date Made	5/20/2010	6/24/2010	6/24/2010	6/29/2010	5/26/2010	7/7/2010	7/7/2010	7/7/2010	7/7/2010	7/9/2010	7/9/2010	6/1/2010	7/14/2010	7/14/2010
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or 1075877)														
Coulombs														
Date Tested	7/15/2010	8/19/2010	8/19/2010	7/27/2010	7/21/2010	9/1/2010	9/1/2010	9/1/2010	9/1/2010	9/3/2010	9/3/2010	7/27/2010	9/8/2010	9/8/2010
Age at Test	56	56	56	28	56	56	56	56	56	56	56	56	56	56
Sample #1	281	477	436	141	346	573	361	717	644	533	505	354	805	388
Sample #2	341	559	567	248	254	430	197	677	650	582	459	337	769	769
Sample #3	336	392	561	530	220	503	566	737	637	529	476	319	838	749
Sample #4	355			499	367							341		
Average	**328**	**476**	**521**	**306**	**273**	**502**	**375**	**710**	**644**	**548**	**480**	**337**	**804**	**635**
Chloride Ion Penetrability	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**32.51**	**83.50**	**73.96**	**200.95**	**65.19**	**71.51**	**184.88**	**30.55**	**6.51**	**29.51**	**23.26**	**17.50**	**34.51**	**214.43**
Coefficient of Variance	***9.90***	***17.54***	***14.19***	***65.60***	***23.85***	***14.24***	***49.34***	***4.30***	***1.01***	***5.39***	***4.85***	***5.20***	***4.29***	***33.75***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864														
Resistivity (kΩ-cm)														
Date Tested	7/15/2010	8/19/2010	8/19/2010	8/24/2010	7/21/2010	9/1/2010	9/1/2010	9/1/2010	9/1/2010	9/3/2010	9/3/2010	7/27/2010	9/8/2010	9/8/2010
Age at Test	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Cylinder #1	124.5	75.9	81.8	102.4	103.3	70.4	88.9	74.0	77.1	79.5	76.9	121.3	83.1	87.9
Cylinder #2	128.5	72.0	82.9	100.4	101.5	94.0	66.1	69.8	72.9	81.5	77.6	122.5	84.8	87.6
Cylinder #3	124.9	82.6	80.6	76.1	100.0	97.0	67.8	64.0	68.8	80.4	78.5	117.6	88.1	92.3
Cylinder #4	126.1			79.3	100.0							125.5		
Average	**126.0**	**76.8**	**81.8**	**89.6**	**101.6**	**87.1**	**74.3**	**69.3**	**72.9**	**80.5**	**77.7**	**120.5**	**85.3**	**89.3**
Surface Resistivity - Permeabili	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**1.80**	**5.36**	**1.15**	**13.77**	**1.65**	**14.57**	**12.70**	**5.02**	**4.15**	**1.00**	**0.80**	**2.55**	**2.54**	**2.63**
Coefficient of Variance	***1.43***	***6.98***	***1.41***	***15.38***	***1.63***	***16.72***	***17.10***	***7.25***	***5.69***	***1.24***	***1.03***	***2.12***	***2.98***	***2.95***

LTRC Lab. No.	C-3550	C-3550	C-3553	C-3554	C-3554	C-3558	C-3558	C-3562	C-3570	C-3570	C-3571	C-3571	C-3575
State Project Number	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-30-0035	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040
Submitter ID	Lot 009 Batch 1	Lot 009 Batch 2	P-34-C	Lot 010 Batch 1	Lot 010 Batch 3	Lot 011 Batch 1	Lot 011 Batch 2	P2	Lot 012 Batch 1	Lot 012 Batch 2	Lot 013 Batch 1	Lot 013 Batch 3	P-37-F
Date Made	7/17/2010	7/17/2010	6/11/2010	7/20/2010	7/20/2010	7/28/2010	7/28/2010	7/21/2010	8/2/2010	8/2/2010	8/4/2010	8/4/2010	6/23/2010
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or 1075877)													
Coulombs													
Date Tested	9/11/2010	9/11/2010	8/6/2010	9/14/2010	9/14/2010	9/22/2010	9/22/2010	8/18/2010	9/27/2010	9/27/2010	9/29/2010	9/29/2010	8/18/2010
Age at Test	56	56	56	56	56	56	56	28	56	56	56	56	56
Sample #1	245	1114	396	325	399	475	324	250	376	397	455	437	271
Sample #2	303	1117	320	350	350	412	201	281	326	447	426	310	268
Sample #3	283	966	246	300	449	445	310	338	392	458	395	357	249
Sample #4			317					252					300
Average	**277**	**1066**	**321**	**325**	**399**	**444**	**278**	**280**	**365**	**434**	**425**	**368**	**272**
Chloride Ion Penetrability	**Very Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**29.46**	**86.33**	**75.00**	**25.00**	**49.50**	**31.51**	**67.34**	**41.02**	**34.43**	**32.51**	**30.01**	**64.21**	**21.06**
Coefficient of Variance	***10.64***	***8.10***	***23.39***	***7.69***	***12.40***	***7.10***	***24.19***	***14.64***	***9.44***	***7.49***	***7.05***	***17.45***	***7.74***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864													
Resistivity (kΩ-cm)													
Date Tested	9/11/2010	9/11/2010	8/6/2010	9/14/2010	9/14/2010	9/22/2010	9/22/2010	8/18/2010	9/27/2010	9/27/2010	9/29/2010	9/29/2010	8/18/2010
Age at Test	56	56	56	56	56	56	56	28	56	56	56	56	56
Cylinder #1	89.4	38.4	90.6	140.9	131.9	80.4	105.6	132.5	91.1	100.5	99.8	79.0	147.0
Cylinder #2	95.5	34.4	92.6	145.5	129.3	85.0	100.0	162.1	85.3	103.3	94.4	91.6	157.9
Cylinder #3	96.1	36.6	99.1	145.3	137.1	88.6	93.6	112.4	88.9	96.6	89.5	94.1	159.6
Cylinder #4			99.1					103.3					173.6
Average	**93.7**	**36.5**	**94**	**143.9**	**132.8**	**84.7**	**99.7**	**127.6**	**88.4**	**100.1**	**94.6**	**88.2**	**159.5**
Surface Resistivity - Permeabili	**Very Low**	**Low**	**Negligible**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**3.71**	**2.00**	**4.44**	**2.60**	**3.97**	**4.11**	**6.00**	**26.05**	**2.93**	**3.37**	**5.15**	**8.09**	**10.92**
Coefficient of Variance	***3.96***	***5.49***	***4.72***	***1.81***	***2.99***	***4.85***	***6.02***	***20.42***	***3.31***	***3.36***	***5.45***	***9.17***	***6.84***

LTRC Lab. No.	C-3576	C-3576	C-3577	C-3579	C-3579	C-3582	C-3583	C-3589	C-3590	C-3590	C-3593	C-3593	C-3594	C-3594
State Project Number	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040
Submitter ID	Lot 014 A,B,C	Lot 014 D,E,F	P-40-C	Lot 015 A,B,C	Lot 015 D,E,F	P-46-C	P-49-C	P-52-C	P-55A-C	P-55A-C	P-57-C	P-57-C	P-3-C	P-3-C
Date Made	8/14/2010	8/14/2010	7/1/2010	8/18/2010	8/18/2010	7/20/2010	7/28/2010	8/6/2010	8/18/2010	8/18/2010	8/24/2010	8/24/2010	8/27/2010	8/27/2010
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or 1075877)														
Coulombs														
Date Tested	10/9/2010	10/9/2010	8/26/2010	10/13/2010	10/13/2010	9/14/2010	9/22/2010	10/1/2010	9/15/2010	10/13/2010	10/6/2010	11/3/2010	10/6/2010	11/3/2010
Age at Test	56	56	56	56	56	56	56	56	28	56	28	56	28	56
Sample #1	386	309	269	213	246	364	292	304	559	359	265	200	275	137
Sample #2	335	363	149	213	207	362	272	349	485	311	256	147	257	216
Sample #3	258	356	189	180	246	375	283	303	153	306	230	214	239	250
Sample #4			244			355	314	350	133	353				
Average	**326**	**343**	**202**	**202**	**233**	**364**	**290**	**327**	**333**	**332**	**250**	**187**	**257**	**201**
Chloride Ion Penetrability	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**64.44**	**29.37**	**61.10**	**19.05**	**22.52**	**8.29**	**17.82**	**26.56**	**221.04**	**27.61**	**18.18**	**35.34**	**18.00**	**57.97**
Coefficient of Variance	***19.75***	***8.57***	***30.20***	***9.43***	***9.66***	***2.28***	***6.14***	***8.14***	***66.48***	***8.31***	***7.26***	***18.90***	***7.00***	***28.84***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864														
Resistivity (kΩ-cm)														
Date Tested	10/9/2010	10/9/2010	8/26/2010	10/13/2010	10/13/2010	9/14/2010	9/22/2010	10/1/2010	9/15/2010	10/13/2010	10/6/2010	11/3/2010	10/6/2010	11/3/2010
Age at Test	56	56	56	56	56	56	56	56	28	56	28	56	28	56
Cylinder #1	105.4	103.1	141.8	225.6	281.8	130.4	133.3	114.3	107.0	166.8	146.9	159.9	122.8	182.9
Cylinder #2	105.8	97.1	145.8	189.5	256.0	134.6	142.8	127.3	103.9	171.0	122.9	127.4	122.1	379.0
Cylinder #3	119.0	94.9	147.3	189.4	266.0	130.9	128.4	124.8	104.8	170.1	129.1	40.9	123.3	177.9
Cylinder #4			135.0			137.3	132.1	125.1	109.1	161.4				
Average	**110**	**98**	**142**	**202**	**267.9**	**133.3**	**134.2**	**122.9**	**106.2**	**167.3**	**133.0**	**109.4**	**122.7**	**246.6**
Surface Resistivity - Permeabili	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Negligible**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**7.74**	**4.24**	**5.50**	**20.87**	**13.01**	**3.26**	**6.13**	**5.82**	**2.33**	**4.34**	**12.46**	**61.51**	**0.60**	**114.69**
Coefficient of Variance	***7.03***	***4.31***	***3.86***	***10.36***	***4.86***	***2.44***	***4.57***	***4.74***	***2.19***	***2.60***	***9.37***	***56.22***	***0.49***	***46.51***

LTRC Lab. No.	C-3592	C-3592	C-3593	C-3593	C-3594	C-3594	C-3596	C-3596	C-3600	C-3600	C-3606	C-3606	C-3607
State Project Number	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-30-0035	064-30-0035	450-17-0025
Submitter ID	Lot 015	Lot 015	P-57-C	P-57-C	P-3-C	P-3-C	Lot 016	Lot 016	P-60-C	P-60-C	HPC 4-3	HPC 4-3	C 072
Date Made	9/8/2010	9/8/2010	8/24/2010	8/24/2010	8/27/2010	8/27/2010	9/16/2010	9/16/2010	9/1/2010	9/1/2010	9/3/2010	9/3/2010	8/23/2010
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or 1075877)													
Coulombs													
Date Tested	10/6/2010	11/3/2010	9/21/2010	10/19/2010	9/24/2010	10/22/2010	10/14/2010	11/11/2010	9/29/2010	10/27/2010	10/1/2010	10/29/2010	10/18/2010
Age at Test	28	56	28	56	28	56	28	56	28	56	28	56	56
Sample #1	579	416	780	247	539	424	4350	2409	324	231	1155	926	269
Sample #2	480	359	586	257	446	354	4267	2368	310	225	849	1453	194
Sample #3	553	475	677	254	533	340	3773	2225	312	204	433	1336	299
Sample #4			508	226	468	369	3701	2470	269	205	745	1396	356
Average	**537**	**417**	**638**	**246**	**497**	**372**	**4023**	**2368**	**304**	**216**	**796**	**1278**	**280**
Chloride Ion Penetrability	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**High**	**Moderate**	**Very Low**	**Very Low**	**Very Low**	**Low**	**Very Low**
Standard Deviation	**51.33**	**58.00**	**117.32**	**13.98**	**46.55**	**36.79**	**332.99**	**104.14**	**23.98**	**13.79**	**297.80**	**239.32**	**67.46**
Coefficient of Variance	***9.55***	***13.92***	***18.40***	***5.68***	***9.38***	***9.90***	***8.28***	***4.40***	***7.89***	***6.38***	***37.44***	***18.73***	***24.14***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864													
Resistivity (kΩ-cm)													
Date Tested	10/6/2010	11/3/2010	9/21/2010	10/19/2010	9/24/2010	10/22/2010	10/14/2010	11/11/2010	9/29/2010	10/27/2010	10/1/2010	10/29/2010	10/18/2010
Age at Test	28	56	28	56	28	56	28	56	28	56	28	56	56
Cylinder #1	76.3	96.5	67.4	37.6	73.3	40.6	12.0	18.1	100.4	155.3	27.4	35.4	20.8
Cylinder #2	72.0	92.8	69.5	41.0	74.4	53.8	10.5	18.0	101.9	159.3	26.5	40.0	44.3
Cylinder #3	76.8	86.1	70.1	63.0	74.3	102.5	10.9	16.5	104.3	110.6	27.1	40.3	35.1
Cylinder #4			73.5	83.1	75.0	88.6	10.4	17.3	105.3	110.4	30.5	36.1	45.4
Average	**75.0**	**91.8**	**70.1**	**56.2**	**74.3**	**71.4**	**11.0**	**17.5**	**103.0**	**133.9**	**27.9**	**38.0**	**36.4**
Surface Resistivity - Permeabili	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**High**	**Moderate**	**Very Low**	**Very Low**	**Low**	**Very Low**	**Low**
Standard Deviation	**2.64**	**5.27**	**2.53**	**21.19**	**0.70**	**28.99**	**0.73**	**0.74**	**2.23**	**27.07**	**1.79**	**2.56**	**11.38**
Coefficient of Variance	***3.52***	***5.74***	***3.61***	***37.72***	***0.95***	***40.62***	***6.69***	***4.24***	***2.17***	***20.22***	***6.42***	***6.74***	***31.26***

LTRC Lab. No.	C-3608	C-3608	C-3609	C-3609	C-3610	C-3610	C-3611	C-3611	C-3612	C-3612	C-3613	C-3613	C-3615	C-3615
State Project Number	450-17-0025	450-17-0025	450-17-0025	450-17-0025	450-17-0025	450-17-0025	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-30-0035	064-30-0035	064-01-0040	064-01-0040
Submitter ID	C 075	C 075	C 080	C 080	C 083	C 083	P-6-C	P-6-C	P-63-C	P-63-C	P3	P3	P-65-B	P-65-B
Date Made	9/2/2010	9/2/2010	9/9/2010	9/9/2010	9/16/2010	9/16/2010	9/10/2010	9/10/2010	9/10/2010	9/10/2010	9/13/2010	9/13/2010	9/16/2010	9/16/2010
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or 1075877)														
Coulombs														
Date Tested	9/30/2010	10/28/2010	10/7/2010	11/4/2010	10/14/2010	11/11/2010	10/8/2010	11/5/2010	10/8/2010	11/5/2010	10/11/2010	11/8/2010	10/14/2010	11/11/2010
Age at Test	28	56	28	56	28	56	28	56	28	56	28	56	28	56
Sample #1	354	322	417	321	522	307	374	329	272	290	425	214	880	479
Sample #2	366	237	362	363	376	259	436	280	313	304	377	200	863	490
Sample #3	307	240	507	358	378	250	455	282	357	332	545	163	767	474
Sample #4	317	213	440	365	434	279	378	303	411	291	569	272	758	462
Average	**336**	**253**	**432**	**352**	**428**	**274**	**411**	**299**	**338**	**304**	**479**	**212**	**817**	**476**
Chloride Ion Penetrability	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**28.44**	**47.56**	**60.04**	**20.71**	**68.50**	**25.26**	**40.90**	**22.84**	**59.64**	**19.57**	**92.69**	**45.27**	**63.42**	**11.62**
Coefficient of Variance	***8.46***	***18.80***	***13.91***	***5.89***	***16.02***	***9.23***	***9.96***	***7.65***	***17.63***	***6.43***	***19.35***	***21.33***	***7.76***	***2.44***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864														
Resistivity (kΩ-cm)														
Date Tested	9/30/2010	10/28/2010	10/7/2010	11/4/2010	10/14/2010	11/11/2010	10/8/2010	11/5/2010	10/8/2010	11/5/2010	10/11/2010	11/8/2010	10/14/2010	11/11/2010
Age at Test	28	56	28	56	28	56	28	56	28	56	28	56	28	56
Cylinder #1	113.3	131.8	78.4	118.1	86.3	143.4	90.4	56.6	90.3	171.8	80.5	131.1	42.1	91.8
Cylinder #2	97.3	109.3	81.5	93.8	79.1	146.4	92.3	85.6	92.5	161.3	81.6	132.4	37.1	87.0
Cylinder #3	120.4	110.8	73.4	81.4	69.4	150.8	77.6	123.3	94.6	172.9	47.8	91.0	44.4	92.6
Cylinder #4	117.0	99.0	79.1	78.9	64.0	139.0	67.5	162.0	94.8	160.5	48.8	91.0	26.5	88.9
Average	**112.0**	**112.7**	**78.1**	**93.1**	**74.7**	**144.9**	**82.0**	**106.9**	**93.1**	**166.6**	**64.7**	**111.4**	**37.5**	**90.1**
Surface Resistivity - Permeabili	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**10.22**	**13.76**	**3.40**	**17.93**	**9.94**	**4.97**	**11.64**	**45.78**	**2.11**	**6.63**	**18.92**	**23.53**	**7.96**	**2.59**
Coefficient of Variance	***9.12***	***12.20***	***4.36***	***19.26***	***13.31***	***3.43***	***14.20***	***42.84***	***2.27***	***3.98***	***29.25***	***21.13***	***21.20***	***2.88***

LTRC Lab. No.	C-3616	C-3616	C-3623	C-3623	C-3624	C-3624	C-3625	C-3625	C-3626	C-3626	C-3629	C-3629	C-3632
State Project Number	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040
Submitter ID	Lot 017	Lot 017	P-69-C	P-69-C	P-9-C	P-9-C	Lot 018	Lot 018	Lot 019	Lot 019	P-72-C	P-72-C	Lot 020
Date Made	9/30/2010	9/30/2010	10/1/2010	10/1/2010	10/2/2010	10/2/2010	10/14/2010	10/14/2010	10/22/2010	10/22/2010	10/18/2010	10/18/2010	10/25/2010
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or 1075877)													
Coulombs													
Date Tested	10/28/2010	11/25/2010	10/29/2010	11/26/2010	10/30/2010	11/27/2010	11/11/2010	12/9/2010	11/19/2010	12/17/2010	11/15/2010	12/13/2010	11/22/2010
Age at Test	28	56	28	56	28	56	28	56	28	56	28	56	28
Sample #1	330	435	449	258	368	230	343	259	438	468	453	268	637
Sample #2	381	407	439	277	463	291	512	535	182	554	507	252	560
Sample #3	488	516	446	274	457	262	389	448	664	497	500	254	501
Sample #4	568	438	469	272	484	278	481	260	353	355	494	268	595
Average	**442**	**449**	**451**	**270**	**443**	**265**	**431**	**376**	**409**	**469**	**489**	**261**	**573**
Chloride Ion Penetrability	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**106.86**	**46.80**	**12.87**	**8.42**	**51.32**	**26.32**	**78.67**	**138.57**	**200.44**	**83.68**	**24.26**	**8.70**	**57.54**
Coefficient of Variance	***24.19***	***10.42***	***2.85***	***3.12***	***11.59***	***9.92***	***18.24***	***36.90***	***48.98***	***17.86***	***4.97***	***3.34***	***10.04***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864													
Resistivity (kΩ-cm)													
Date Tested	10/28/2010	11/25/2010	10/29/2010	11/26/2010	10/30/2010	11/27/2010	11/11/2010	12/9/2010	11/19/2010	12/17/2010	11/15/2010	12/13/2010	11/22/2010
Age at Test	28	56	28	56	28	56	28	56	28	56	28	56	28
Cylinder #1	34.6	100.5	84.4	136.3	72.6	160.5	115.9	163.4	74.8	110.1	73.5	161.0	50.0
Cylinder #2	67.4	105.0	82.3	127.5	68.5	157.0	111.5	153.8	65.4	104.8	82.0	168.9	53.4
Cylinder #3	42.1	70.4	80.3	134.6	66.5	158.6	120.6	171.4	74.9	106.0	81.8	161.4	54.4
Cylinder #4	49.5	80.3	79.5	136.3	52.0	152.3	132.5	165.0	72.6	105.1	79.8	160.6	56.8
Average	**48.4**	**89.1**	**81.6**	**133.7**	**64.9**	**157.1**	**120.1**	**163.4**	**71.9**	**106.5**	**79.3**	**163.0**	**53.7**
Surface Resistivity - Permeabili	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**14.05**	**16.43**	**2.19**	**4.19**	**8.97**	**3.51**	**9.05**	**7.27**	**4.48**	**2.45**	**3.98**	**3.96**	**2.82**
Coefficient of Variance	***29.03***	***18.45***	***2.69***	***3.14***	***13.82***	***2.23***	***7.53***	***4.45***	***6.23***	***2.30***	***5.02***	***2.43***	***5.26***

LTRC Lab. No.	C-3634	C-3635	C-3635	C-3636	C-3636	C-3644	C-3645	C-3645	C-3646	C-3646	C-3647	C-3647	C-3653	C-3653
State Project Number	450-17-0025	450-17-0025	450-17-0025	450-17-0025	450-17-0025	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040
Submitter ID	C 089	S 348	S 348	S 353	S 353	P-10-A	P-11-B	P-11-B	P-12-C	P-12-C	P-13-A	P-13-A	BT3-C	BT3-C
Date Made	9/30/2010	10/26/2010	10/26/2010	10/29/2010	10/29/2010	10/7/2010	10/15/2010	10/15/2010	10/19/2010	10/19/2010	10/25/2010	10/25/2010	10/28/2010	10/28/2010
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or 1075877)														
Coulombs														
Date Tested	11/25/2010	11/23/2010	12/21/2010	11/26/2010	12/24/2010	12/2/2010	11/12/2010	12/10/2010	11/16/2010	12/14/2010	11/22/2010	12/20/2010	11/25/2010	12/23/2010
Age at Test	56	28	56	28	56	56	28	56	28	56	28	56	28	56
Sample #1	401	376	323	552	418	376	509	357	1040	624	889	537	748	516
Sample #2	435	345	265	586	389	376	887	337	1094	630	847	462	723	467
Sample #3	406	374	272	538	432	408	772	372	1145	625	879	528	613	461
Sample #4	357	321	311	509	387	402	846	362	944	613	946	514	698	475
Average	**400**	**354**	**293**	**546**	**407**	**391**	**754**	**357**	**1056**	**623**	**890**	**510**	**696**	**480**
Chloride Ion Penetrability	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**32.20**	**26.17**	**28.57**	**31.98**	**22.13**	**16.92**	**169.80**	**14.72**	**85.95**	**7.16**	**41.26**	**33.53**	**58.67**	**24.84**
Coefficient of Variance	***8.06***	***7.39***	***9.76***	***5.86***	***5.44***	***4.33***	***22.54***	***4.12***	***8.14***	***1.15***	***4.63***	***6.57***	***8.44***	***5.18***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864														
Resistivity (kΩ-cm)														
Date Tested	11/25/2010	11/23/2010	12/21/2010	11/26/2010	12/24/2010	12/2/2010	11/12/2010	12/10/2010	11/16/2010	12/14/2010	11/22/2010	12/20/2010	11/25/2010	12/23/2010
Age at Test	56	28	56	28	56	56	28	56	28	56	28	56	28	56
Cylinder #1	140.9	82.5	159.6	58.8	101.0	87.3	54.6	135.6	35.1	71.5	44.9	86.6	40.4	85.9
Cylinder #2	145.4	88.6	186.0	59.0	113.8	92.1	56.5	131.9	34.8	72.6	41.8	93.0	40.6	89.9
Cylinder #3	146.0	92.1	189.5	60.9	108.4	94.3	57.6	130.6	34.4	70.3	41.5	89.5	38.1	82.3
Cylinder #4	147.9	90.5	167.5	62.1	91.6	94.5	55.8	124.1	34.6	72.3	43.8	89.8	42.1	87.8
Average	**145.1**	**88.4**	**175.7**	**60.2**	**103.7**	**92.1**	**56.1**	**130.6**	**34.7**	**71.7**	**43.0**	**89.7**	**40.3**	**86.5**
Surface Resistivity - Permeabili	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**2.96**	**4.20**	**14.41**	**1.58**	**9.62**	**3.35**	**1.26**	**4.79**	**0.30**	**1.03**	**1.63**	**2.62**	**1.65**	**3.23**
Coefficient of Variance	***2.04***	***4.75***	***8.20***	***2.63***	***9.28***	***3.64***	***2.24***	***3.67***	***0.86***	***1.43***	***3.78***	***2.92***	***4.10***	***3.73***

LTRC Lab. No.	C-3654	C-3654	C-3655	C-3655	C-3661	C-3661	C-3662	C-3662	C-3663	C-3663	C-3664	C-3664	C-3665	C-3665
State Project Number	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	064-01-0040	450-17-0025	450-17-0025	450-17-0025	450-17-0025	450-17-0025	450-17-0025	450-17-0025	450-17-0025
Submitter ID	P-75-C	P-75-C	Lot 021	Lot 021	Lot 022	Lot 022	C095-C442	C095-C442	C097-C447	C097-C447	C452	C452	C454	C454
Date Made	10/29/2010	10/29/2010	11/10/2010	11/10/2010	11/12/2010	11/12/2010	11/4/2010	11/4/2010	11/10/2010	11/10/2010	11/16/2010	11/16/2010	11/18/2010	11/18/2010
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or 1075877)														
Coulombs														
Date Tested	11/26/2010	12/24/2010	12/8/2010	1/5/2011	12/10/2010	1/7/2011	12/2/2010	12/30/2010	12/8/2010	1/5/2011	12/14/2010	1/11/2011	12/16/2010	1/13/2011
Age at Test	28	56	28	56	28	56	28	56	28	56	28	56	28	56
Sample #1	661	496	430	370	589	283	560	504	570	515	507	309	655	326
Sample #2	639	485	437	369	575	304	570	524	484	1021	501	328	704	303
Sample #3	587	475	674	378	586	337	566	433	474	456	396	306	637	334
Sample #4	724	520	431	274	575	264	501	559	656	466	520	337	656	306
Average	**653**	**494**	**493**	**348**	**581**	**297**	**549**	**505**	**546**	**615**	**481**	**320**	**663**	**317**
Chloride Ion Penetrability	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**56.74**	**19.34**	**120.71**	**49.33**	**7.32**	**31.27**	**32.43**	**53.11**	**85.06**	**272.22**	**57.22**	**14.94**	**28.69**	**15.13**
Coefficient of Variance	***8.69***	***3.91***	***24.48***	***14.19***	***1.26***	***10.53***	***5.90***	***10.52***	***15.58***	***44.30***	***11.90***	***4.67***	***4.33***	***4.77***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864														
Resistivity (kΩ-cm)														
Date Tested	11/26/2010	12/24/2010	12/8/2010	1/5/2011	12/10/2010	1/7/2011	12/2/2010	12/30/2010	12/8/2010	1/5/2011	12/14/2010	1/11/2011	12/16/2010	1/13/2011
Age at Test	28	56	28	56	28	56	28	56	28	56	28	56	28	56
Cylinder #1	46.5	83.0	88.9	129.8	80.8	115.4	56.4	97.0	67.6	90.4	65.0	132.3	58.0	116.8
Cylinder #2	54.4	90.0	96.0	138.0	80.9	114.9	63.3	91.9	64.3	81.4	65.1	137.4	62.3	121.5
Cylinder #3	54.1	90.3	116.5	156.8	76.3	119.6	69.8	111.3	71.5	100.4	68.1	130.3	61.5	123.6
Cylinder #4	47.9	86.0	110.0	132.5	85.1	117.0	67.6	104.0	68.1	94.3	65.3	126.6	63.0	122.5
Average	**50.7**	**87.3**	**102.9**	**139.3**	**80.8**	**116.7**	**64.3**	**101.1**	**67.9**	**91.6**	**65.9**	**131.7**	**61.2**	**121.1**
Surface Resistivity - Permeabili	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**4.11**	**3.49**	**12.64**	**12.17**	**3.59**	**2.12**	**5.90**	**8.44**	**2.95**	**7.96**	**1.49**	**4.50**	**2.22**	**2.99**
Coefficient of Variance	***8.11***	***3.99***	***12.29***	***8.74***	***4.45***	***1.81***	***9.18***	***8.36***	***4.34***	***8.69***	***2.26***	***3.42***	***3.63***	***2.47***

LTRC Lab. No.	C-3666	C-3666	C-3667	C-3667
State Project Number	064-01-0040	064-01-0040	064-01-0040	064-01-0040
Submitter ID	Lot 022	Lot 022	Lot 023	Lot 023
Date Made	11/23/2010	11/23/2010	11/23/2010	11/23/2010
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOV				
Coulombs				
Date Tested	12/21/2010	1/18/2011	12/21/2010	1/18/2011
Age at Test	28	56	28	56
Sample #1	740	609	539	366
Sample #2	888	575	526	370
Sample #3	915	521	502	381
Sample #4	895	569	497	382
Average	**860**	**569**	**516**	**375**
Chloride Ion Penetrability	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**80.48**	**36.24**	**19.88**	**7.97**
Coefficient of Variance	***9.36***	***6.37***	***3.85***	***2.13***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864				
Resistivity (kΩ-cm)				
Date Tested	12/21/2010	1/18/2011	12/21/2010	1/18/2011
Age at Test	28	56	28	56
Cylinder #1	42.8	68.1	86.5	113.4
Cylinder #2	43.5	74.0	79.0	120.5
Cylinder #3	50.4	70.4	77.1	127.6
Cylinder #4	43.8	64.8	79.6	128.6
Average	**45.1**	**69.3**	**80.6**	**122.5**
Surface Resistivity - Permeabili	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**3.54**	**3.87**	**4.11**	**7.07**
Coefficient of Variance	***7.85***	***5.59***	***5.10***	***5.77***

Raw Data – 09-4C Test Matrix

LTRC Lab. No.	C-3442	C-3445	C-3451	C-3456	C-3474	C-3479	C-3485	C-3534	C-3534	C-3543	C-3543
Type Design	50TI-30G100S-20C-5SF	30TI-30G100S-40C	30TI-50G100S-20C	20TI-50G100S-30C	10TI-50G100S-40C	50TI-30G100S-20F	40TI-30G100S-30F	30TI-50G100S-20F	30TI-50G100S-20F	20TI-50G100S-30F	20TI-50G100S-30F
Cementitious Content (lbs/yd³)	500	500	500	500	500	500	500	500	500	500	500
W/C Ratio	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c
LTRC Project Number	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C
Date Made	1/12/2010	1/27/2010	2/4/2010	2/11/2010	3/16/2010	3/25/2010	4/7/2010	7/8/2010	7/8/2010	7/13/2010	7/13/2010
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or 1075877)											
Coulombs											
Date Tested	3/12/2010	4/15/2010	4/16/2010	4/9/2010	5/12/2010	5/20/2010	6/2/2010	8/5/2010	9/2/2010	8/10/2010	9/7/2010
Age at Test	59	78	71	57	57	56	56	28	56	28	56
Cylinder #1 (Top)	414	912	320	412	573	573	389	387	350	427	147
Cylinder #1 (Middle)	453	821	221	392	572	572	310	340	338	396	233
Cylinder #2 (Top)	410	867	317	470	575	575	357	387	416	306	234
Cylinder #2 (Middle)	297	901	311	449	485	485	336	387	289	353	205
Average	**394**	**875**	**292**	**431**	**551**	**551**	**348**	**375**	**348**	**371**	**205**
Chloride Ion Penetrability	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**67.19**	**40.93**	**47.65**	**35.25**	**44.18**	**44.18**	**33.42**	**23.50**	**52.31**	**52.63**	**40.78**
Coefficient of Variance	***17.08***	***4.68***	***16.30***	***8.18***	***8.02***	***8.02***	***9.60***	***6.26***	***15.02***	***14.20***	***19.92***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864											
Resistivity (kΩ-cm)											
Date Tested	3/10/2010	4/14/2010	4/14/2010	4/8/2010	5/10/2010	5/19/2010	6/1/2010	8/5/2010	9/2/2010	8/10/2010	9/7/2010
Age at Test	57	77	69	56	55	55	55	28	56	28	56
Cylinder #1	73.3	42.6	105.5	73.5	89.4	89.4	106.3	91.5	110.4	128.0	147.3
Cylinder #2	76.6	47.5	108.3	75.9	85.0	85.0	113.0	103.5	112.8	127.5	140.1
Average	**75.0**	**45.1**	**106.9**	**74.7**	**87.2**	**87.2**	**109.7**	**97.5**	**111.6**	**127.8**	**143.7**
Surface Resistivity - Permeabili	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**2.33**	**3.46**	**1.98**	**1.70**	**3.11**	**3.11**	**4.74**	**8.49**	**1.70**	**0.35**	**5.09**
Coefficient of Variance	***3.11***	***7.69***	***1.85***	***2.27***	***3.57***	***3.57***	***4.32***	***8.70***	***1.52***	***0.28***	***3.54***

LTRC Lab. No.	C-3547	C-3547	C-3555	C-3555	C-3565	C-3565	C-3578	C-3578	C-3580	C-3580
Type Design	10TI-50G100S-40F	10TI-50G100S-40F	50TI-30G120S-20F	50TI-30G120S-20F	40TI-30G120S-30C	40TI-30G120S-30C	30TI-30G120S-40C	30TI-30G120S-40C	30TI-50G120S-20C	30TI-50G120S-20C
Cementitious Content (lbs/yd³)	500	500	500	500	500	500	500	500	500	500
W/C Ratio	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c
LTRC Project Number	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C
Date Made	7/15/2010	7/15/2010	7/27/2010	7/27/2010	8/4/2010	8/4/2010	8/18/2010	8/18/2010	8/25/2010	8/25/2010
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or 1075877)										
Coulombs										
Date Tested	8/12/2010	9/9/2010	8/24/2010	9/21/2010	9/1/2010	9/29/2010	9/15/2010	10/13/2010	9/22/2010	10/20/2010
Age at Test	28	56	28	56	28	56	28	56	28	56
Cylinder #1 (Top)	109	141	1089	738	611	479	637	371	628	329
Cylinder #1 (Middle)	95	128	1349	684	735	552	815	428	545	340
Cylinder #2 (Top)	173	141	1230	851	858	427	734	388	602	381
Cylinder #2 (Middle)	1713	154	1210	788	734	345	940	418	522	373
Average	**523**	**141**	**1220**	**765**	**735**	**451**	**782**	**401**	**574**	**356**
Chloride Ion Penetrability	**Very Low**	**Very Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**794.39**	**10.61**	**106.46**	**71.22**	**100.84**	**87.17**	**128.30**	**26.37**	**49.14**	**25.16**
Coefficient of Variance	***152.04***	***7.53***	***8.73***	***9.31***	***13.73***	***19.34***	***16.42***	***6.57***	***8.56***	***7.07***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864										
Resistivity (kΩ-cm)										
Date Tested	8/12/2010	9/9/2010	8/24/2010	9/21/2010	9/1/2010	9/29/2010	9/15/2010	10/13/2010		10/20/2010
Age at Test	28	56	28	56	28	56	28	56		56
Cylinder #1	225.1	309.1	30.9	52.0	45.6	79.4	44.3	76.9	62.6	75.9
Cylinder #2	183.3	307.0	29.0	53.0	45.8	74.4	44.3	79.0	64.9	90.1
Average	**204.2**	**308.1**	**30.0**	**52.5**	**45.7**	**76.9**	**44.3**	**78.0**	**63.8**	**83.0**
Surface Resistivity - Permeabili	**Very Low**	**Negligible**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**29.56**	**1.48**	**1.34**	**0.71**	**0.14**	**3.54**	**0.00**	**1.48**	**1.63**	**10.04**
Coefficient of Variance	***14.47***	***0.48***	***4.49***	***1.35***	***0.31***	***4.60***	***0.00***	***1.90***	***2.55***	***12.10***

LTRC Lab. No.	C-3614	C-3614	C-3619	C-3619	C-3627	C-3627	C-3668	C-3668	C-3671	C-3671
Type Design	20TI-50G120S-30C	20TI-50G120S-30C	10TI-50G120S-40C	10TI-50G120S-40C	50TI-30G120S-20F	50TI-30G120S-20F	40TI-30G120S-30F	40TI-30G120S-30F	30TI-30G120S-40F	30TI-30G120S-40F
Cementitious Content (lbs/yd³)	500	500	500	500	500	500	500	500	500	500
W/C Ratio	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c	0.45 w/c
LTRC Project Number	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C	09-4C
Date Made	9/30/2010	9/30/2010	10/6/2010	10/6/2010	10/26/2010	10/26/2010	11/30/2010	11/30/2010	12/9/2011	12/9/2011
ASTM C 1202, Rapid Chloride Permeability, Testing conducted with Germann Instruments PROOVE it© ASTM C 1202-97 (DOTD No. 1073572 and/or 1075877)										
Coulombs										
Date Tested	10/28/2010	11/25/2010	11/3/2010	12/1/2010	11/23/2010	12/21/2010	12/28/2010	1/25/2011	1/6/2012	2/3/2012
Age at Test	28	56	28	56	28	56	28	56	28	56
Cylinder #1 (Top)	547	384	1170	736	518	620	767	502	674	328
Cylinder #1 (Middle)	575	336	1142	709	712	602	726	533	703	448
Cylinder #2 (Top)	442	396	1207	723	718	548	897	490	501	477
Cylinder #2 (Middle)	393	378	1184	737	681	666	708	605	646	559
Average	**489**	**374**	**1176**	**726**	**657**	**609**	**775**	**533**	**631**	**453**
Chloride Ion Penetrability	**Very Low**	**Very Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**85.99**	**26.10**	**27.18**	**13.15**	**94.24**	**48.79**	**85.32**	**51.62**	**89.74**	**95.68**
Coefficient of Variance	***17.58***	***6.99***	***2.31***	***1.81***	***14.34***	***8.01***	***11.02***	***9.69***	***14.22***	***21.12***
Wenner Probe CNSFARNELL® Resistivity Meter no. 002867 Probe no. 002864										
Resistivity (kΩ-cm)										
Date Tested	10/28/2010	11/25/2010	11/3/2010	12/1/2010	11/23/2010	12/21/2010	12/28/2010	1/25/2011	1/6/2012	2/3/2012
Age at Test	28	56	28	56	28	56	28	56	28	56
Cylinder #1	50.5	68.4	28.0	52.4	38.1	61.6	58.5	72.3	54.3	88.1
Cylinder #2	45.8	82.4	28.0	58.3	41.9	58.8	51.8	74.3	55.9	93.1
Average	**48.2**	**75.4**	**28.0**	**55.4**	**40.0**	**60.2**	**55.2**	**73.3**	**55.1**	**90.6**
Surface Resistivity - Permeabili	**Very Low**	**Very Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
Standard Deviation	**3.32**	**9.90**	**0.00**	**4.17**	**2.69**	**1.98**	**4.74**	**1.41**	**1.13**	**3.54**
Coefficient of Variance	***6.90***	***13.13***	***0.00***	***7.54***	***6.72***	***3.29***	***8.59***	***1.93***	***2.05***	***3.90***