United States
Department of Transportation

SUMMARY REPORT

I-85 Widening

Charlotte, NC

May 2019

FHWA MCTC Project # NC1902

Federal Highway Administration
Office of Preconstruction,
Construction, and Pavements
1200 New Jersey Avenue, SE
Washington, DC 20590

BUCKLE UP AMERICA

MCTC Field Report – North Carolina

Summary of the Visit

The Federal Highway Administration (FHWA) Mobile Concrete Technology Center (MCTC) visited the I-85 widening project north of Charlotte (China Grove), NC from April 30 to May 16, 2019, at the request of Brian Hunter with North Carolina Department of Transportation (NCDOT). The objective of the MCTC visit was to demonstrate innovative technologies currently in the implementation phase; this is in conjunction with the work being done on this project using FHWA Performance Engineered Mixtures Implementation Incentive (PEMII) funding.

During this visit, the MCTC conducted a PEM Open House on May 15, 2019 in coordination with the Iowa State's Concrete Pavement Technology Center (CP Tech Center), and Greg Dean of the Carolinas Concrete Paving Association.

This report summarizes the test results, observations, and other activities conducted during this visit. Numerical values of the test results are presented in the Appendix.

Highlights or Impacts During the Field Visit

- ❑ The initial PEM efforts have been led by personnel at NCDOT's central office. The MCTC visit and Open House provided an opportunity for NCDOT's division and area personnel to learn more about the PEM initiative and testing technologies, as well as NCDOT's steps to move towards a more performance-based specification for concrete.

- ❑ Training and Open House presentations during the MCTC visit reinforced NCDOT's decisions to promote certain PEM technologies for use in their first shadow specifications. Industry learned why NCDOT is most interested in the Box Test, surface resistivity, and SAM for initial PEM implementation efforts.

- ❑ The demonstration / testing on site was a success. The contractor staff were very interested in the PEM and non-PEM tests that were showcased. On a few occasions, the SAM tests were conducted side by side by the MCTC and contractor staff. MCTC staff shared their experiences with the PEM tests with the Lane Construction staff.

- ❑ Lane Construction staff shared how they check dowel bar alignment as part of their Quality Control process on the first day of paving. They use this process to adjust the forks on their paver DBI for the best output (even if the existing set up yields results that are within compliance). **This is a best practice that is observed by the MCTC staff which will now be transferred to other agencies and contractors across the nation.**

- During demonstration of the MIT Scan T3 equipment to the NC DOT and Lane Construction staff, cores were cut to show the accuracy of the MIT Scan T3. Both the NC DOT and Lane construction staff were impressed with its accuracy, ease of use and rapid testing. Realizing its benefits (especially from safety aspects of not having to core after the newly paved lanes are open to traffic), the **NC DOT allowed the use of MIT Scan T3 in its specifications for this project**.



- One of big impacts of the visit are the relationships built with the contractor staff, where they realized the role of the MCTC in showcasing new technologies and demonstrating best practices. Staff from the **contractor reached out to the MCTC staff six months and a year after the MCTC left the project site for technical assistance** (questions on mixture designs, virtual training request on the MIT Scan T3).

- After our visit, Lane Construction commented that they are continuing to explore how they can incorporate A PEM approach and new testing technologies into their future projects.

- During the stay in NC, a contractor from South Carolina (Archer Western) visited the MCTC (since they missed the MCTC during its prior visit there). At their request, MCTC staff provided training on the MIT Scan 2 and MIT Scan T3. The contractor then took the technology back, building off our prior efforts in South Carolina.

Summary: Test Results

Box Test and Gradations: The Box Test indicated the mixture was workable. The pavement edge was straight and stood without slumping. The surface finished well. The mixture had well combined gradation and met the Tarantula Curve criteria. The paste content of the regular mixture (not the low cement content mixture) was slightly higher than the PEM recommendations.

Air System: The air void system, as tested in the plastic concrete, was adequate for the freeze-thaw conditions in North Carolina. The MCTC testing results of the SAM meter (total air and SAM number) compared well with results from the PEMII testing done by NC DOT and Lane Construction.

Permeability: The permeability test results (Surface Resistivity) met the 11kΩ-cm preliminary threshold established by the University of North Carolina at Charlotte for durable concrete performance in the state of North Carolina.

Surface Resistivity: The MCTC testing results for Surface Resistivity compared well with results from the PEMII testing done by NC DOT and Lane Construction.

Strengths: The 28-day compressive and flexural strengths were above the design requirements indicating strength was adequate.

Consistency: The unit weight and total air content tracked well. The data from the semi-adiabatic calorimetry data indicated consistent cementitious contents and sources. Overall, most of the fresh (air, slump, unit weight and calorimetry) and hardened concrete tests (strength and surface resistivity) showed low standard deviation which indicates consistent concrete.

Construction Aspects: Maturity was used to measure opening strength. Based on the MCTC data, opening strength was reached in two and a half days. The MIT Dowel Scan found dowels to be in the proper location and alignment in both the mainline and shoulder sections. Based on the MCTC MIT Scan T3 testing on the shoulder section, the average pavement thickness measurements were more than an inch above the design requirement of 12".

Summary - Observations

There were many positive observations made during the visit to this project both from agency specification and contractor quality control perspective. Some of them include the following:

NC DOT Concrete Paving Specification

- QC Plan Requirement
  - Process control
- Allowing Maturity
  - Opening to construction traffic
- MIT Scan Testing
  - Dowel bar alignment
- Other Construction related
  - Vibrator monitoring
  - Curing within 30 minutes

Contractor

- Quality conscious, examples include stockpile management, consistency in production, dowel basket protection during storage at the plant.
- Optimize mixture design - Lower cementitious content
- Using MIT Scan proactively to evaluate the DBI (even when the joint score meets the specification requirement)
- Willingness to try out new technologies to optimize operations, examples: PEM testing, MIT Scan T3.

Project Quality

Field test reports and the observation of the constructed product indicate a high-quality pavement that will meet and exceed the design parameters. Concrete consistency was maintained, a key to a quality product. Both North Carolina DOT and Lane Construction have embraced new technologies that have enhanced the quality of the project.

MCTC Recommendations

Consider how you can incorporate the following into your specifications/policies/procedures:

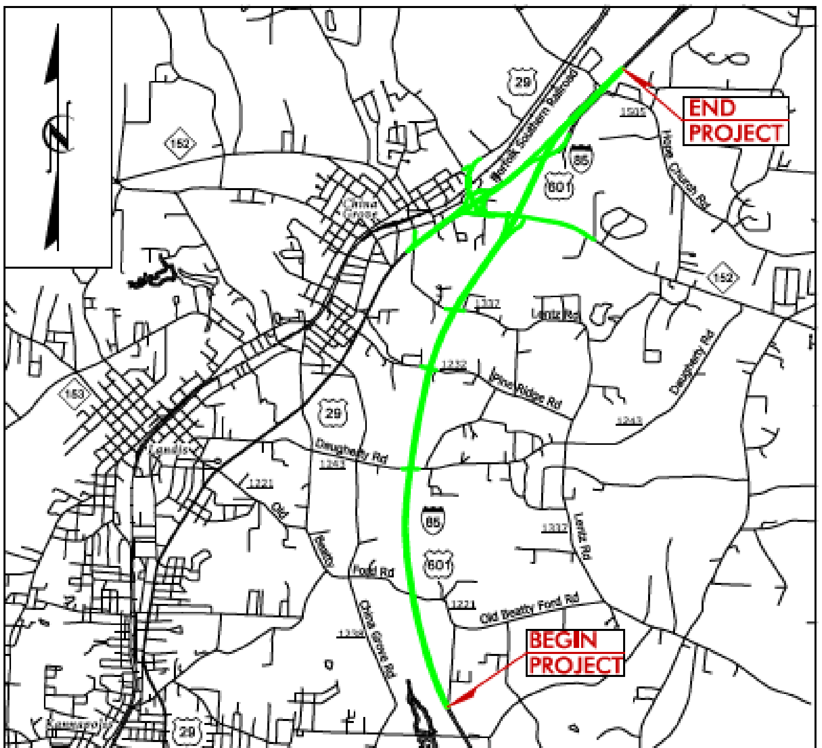
- North Carolina DOT
  - Lower cement content / paste content
  - Optimized aggregate gradation
  - Surface Resistivity
  - Super Air Meter
  - MIT Scan T3 for pavement thickness

- Contractor
  - Continue to use PEM tests (SAM, SR, Box)
  - Semi-adiabatic calorimeter

For questions pertaining to the report, please contact either Mike Praul (Michael.Praul@dot.gov), FHWA Senior Concrete Engineer or Jagan Gudimettla (Jagan.m.gudimettla.ctr@dot.gov), consultant, MCTC Project Manager. Details on the MCTC program and the technologies listed in the report can be found on the MCTC website at https://www.fhwa.dot.gov/pavement/concrete/trailer/.

Project Information

This project included the widening of 5.3 miles of I-85 in Rowan County, North Carolina. The existing four-lane interstate (two travel lanes in each direction) was widened to provide four additional travel lanes (two lanes in each direction) to support an eight-lane interstate from north of Lane Street (Exit 63) to north of the US 29/UW 601 Connector (Exit 68). In addition to the 500,000 square yards of concrete pavement construction, the scope work also included construction of 6 new bridges, 2 bridge replacements, construction of two roundabouts, and associated storm drainage and asphalt pavement. The total project cost was approximately $140 million. A map from the project drawings is shown below (*from reference 1*).



VICINITY MAP
(NOT TO SCALE)

Design Details

- The mainline concrete pavement design thickness is 12 inches.
- The interlayer is a combination of a nonwoven geotextile that met the physical properties of table 724-1 (NCDOT spec book) and a 1.25” asphalt concrete surface course (SF9.5A) placed over a stabilized subgrade.
- The travel lanes are each direction are 12 feet wide with a 22-foot median separating the four lanes in each direction.
- Additional details on the existing pavement and future traffic is presented in Appendix A.

Project Details (During the MCTC Visit)

- Paving subcontractor: Lane Construction
- Concrete batch plant and QC laboratory were located at the north end of the project site, just to the west of I-85 near Exit 68.

MCTC Visit Timeline

- MCTC at the project site from April 30-May 16
- MCTC sampling at the plant
- Shoulder paving
- Day paving

Project Specifications for Paving Concrete on I-85

- 28 Day minimum compressive strength: 4500 psi
- 28 Day minimum flexural strength: 650 psi
- Target air content: 5% (range 4.5% to 5.5%)
- Target w/cm: 0.44
- Minimum cement content: 526 pounds per cubic yard
- Fly ash can be substituted for up to 30% of cement at a replacement rate of 1.0 pounds of fly ash for 1.0 pounds of cement)
- Maximum slump: 1.5 inches

Concrete Plant, Aggregates, and Stockpiles

- Plant capacity: 12cy, batch loads: 10cy, production speed: 400cy/hr
- Three aggregates were used.
- Aggregates were stockpiled on site and were well managed. No contamination was observed between stockpiles.
- A cement stabilized base was used as a separation layer for aggregate stockpiles to minimize contamination.
- The longest haul distance of concrete was approximately 5 miles to the southernmost end of the project. Paving operations were performed from both north to south, and from south to north, so hauling times varied over the duration of the work.

Concrete Plant

Coarse (#57)

Coarse (#78)

Fine (sand)

Aggregate Stockpile Management

Mixture Designs

Concrete Mixture (regular mixture)

- Cement: 77%, Fly Ash: 23%
- Total Cementitious Content: 598 lbs
- Strength requirement: 4500 psi compressive and 650 psi flexural at 28 days
- NC DOT approved mixture design in shown in Appendix B.

Material	Source	Weight, lbs
Cement, I/II	Roanoke Cement, Company	460
Fly Ash, Class F	Ash Venture - Belews Creek	138
Coarse Aggregate #57	Martin Marietta - WoodLeaf	1434
Intermediate Aggregate #78M	Martin Marietta - WoodLeaf	506
Fine Aggregate	G.S. Materials - Emery Pit	1046
Water	Municipal	260
Water c/m		0.44
Target Air		5.00%

Low Cement Concrete Mixture

- Cement: 77%, Fly Ash: 23%
- Total Cementitious Content: 549 lbs
- Strength requirement: 4500 psi at 28 days
- Same combined gradation for the regular and low cement mixtures

Material	Source	Weight, lbs
Cement, I/II	Roanoke Cement, Company	422
Fly Ash, Class F	Ash Venture - Belews Creek	127
Coarse Aggregate #57	Martin Marietta - WoodLeaf	1486
Coarse Aggregate #78M	Martin Marietta - WoodLeaf	525
Fine Aggregate	G.S. Materials - Emery Pit	1083
Water	Municipal	236
Water c/m		0.43
Target Air		5.00%

Paste Content Calculations

Concrete Mixture

	Batch Weights wt.cu/yd	Specific Gravity	Absolute Volume cu,yd	Percent of Total Volume
Cement	460	3.15	2.3	8.7
Fly Ash	138	2.22	1.0	3.7
Fine Agg	1046	2.63	6.4	23.6
57 Stone	1434	2.64	8.7	32.2
78 Stone	506	2.64	3.1	11.4
Water	261	1.00	4.2	15.5
w/c ratio	0.44			
% Air	5.0	0.00	1.4	5.0
Total volume of known ingredients			27	100

PERCENT MORTAR AND PASTE

1 cu.yd.

% Paste = 27.8

Low Cement Concrete Mixture

	Batch Weights wt.cu/yd	Specific Gravity	Absolute Volume cu,yd	Percent of Total Volume
Cement	422	3.15	2.1	8.0
Fly Ash	127	2.22	0.9	3.4
Fine Agg	1083	2.63	6.6	24.4
57 Stone	1486	2.64	9.0	33.4
78 Stone	525	2.64	3.2	11.8
Water	236	1.00	3.8	14.0
w/c ratio	0.43			
% Air	5.0	0.00	1.4	5.0
Total volume of known ingredients			27.0	100.0

PERCENT MORTAR AND PASTE

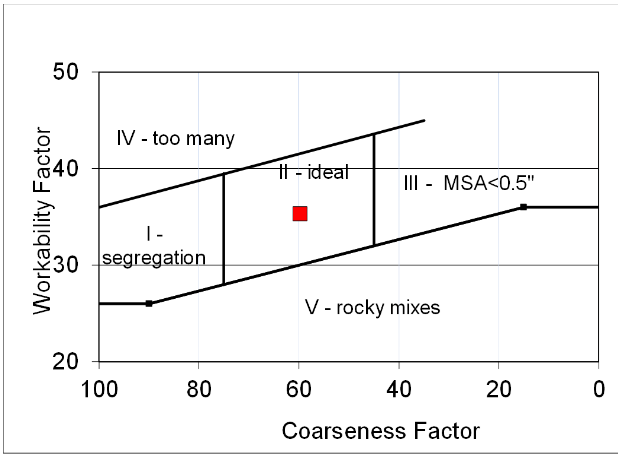
1 cu.yd.

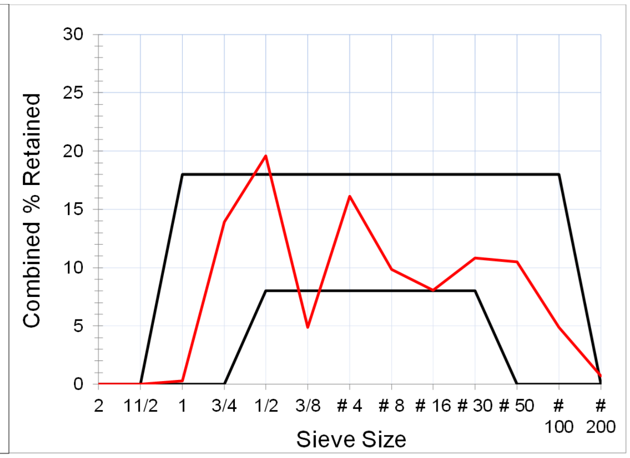
% Paste = $\boxed{25.4}$

- % Paste should be less than 25% for lowering the crack tendency of concrete (PEM requirement per AASHTO PP 84)

Mixture Design Gradations

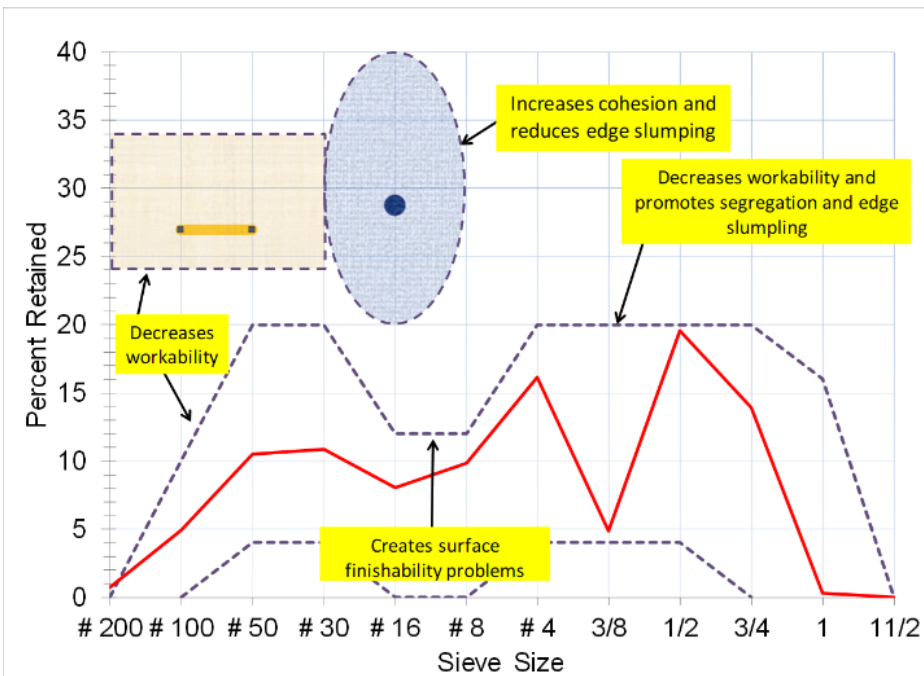
- In the ideal category on the Shilstone criteria
- Barely did not meet the 8-18 gradation
- Met all the three criteria for the Tarantula Curve





Coarseness Factor Chart

Percent of Aggregate Retained



Tarantula Curve

Paving Operations

Mainline (prior to the MCTC visit) (info from reference 1)

- Mainline paving was performed using a Guntert & Zimmerman (G&Z) GZ 850S paver capable of paving 24 feet (2 lanes) in width. This G&Z paver had dowel-bar inserter (DBI) technology, Trimble GPS guidance system, and a GOMACO GSI real-time smoothness indicator.
- Vibrators had a spacing of 1 foot spacings on center. Vibrators operated at 3,500 to 8,500 vibrations per minute in both the pavers.
- Finishing of the pavement behind the paver began with a wet burlap drag.
- The pavement was hand-floated and transverse tining was applied, with edging done using hand trowels.
- A membrane curing compound was applied using a GOMACO application machine at a rate of 0.0067 gallons per square foot.
- Early opening strength was determined using the maturity method.
- Transverse joints were sawcut to a depth of T/3 (4 inches). Joints were later widened, cleaned, and sealed using a Dow Corning 890 SL (self-leveling) silicone joint sealant applied over a backer rod. Minimal raveling and no cracking was observed indicating saw timing was well planned and carried out.
- The project required diamond grinding of the pavement to produce longitudinal tining. Since diamond grinding wouldn't take place until all of the paving was complete and the new pavement would be used for construction and temporary traffic, the pavement was transverse tinned for traction control initially.

Concrete placed onto asphalt interlayer prior to entering paver (source: *reference 1)*

G&Z paver with DBI technology and real-time smoothness measurement used for mainline pavement (source: *reference 1)*


Curing Operations (source: *reference 1)*

Shoulder Paving (during the MCTC visit)

- A smaller paver, a GOMACO Commander III, was used to pave shoulders and ramp areas. This was the paver that was used during the MCTC visit.
- Vibrators had a spacing of 1 foot on center. Vibrators operated at 3,500 to 8,500 vibrations per minute.
- Stringless paving, daytime paving
- Dowel baskets
- Geotextile interlayer
- Transversely tined for texture
- Diamond Grinding

Paving Operations during the Shoulder Construction

Sampling and Testing Locations

QC and agency on the grade

MCTC Sampling at the plant

MCTC Fresh Concrete Testing Matrix

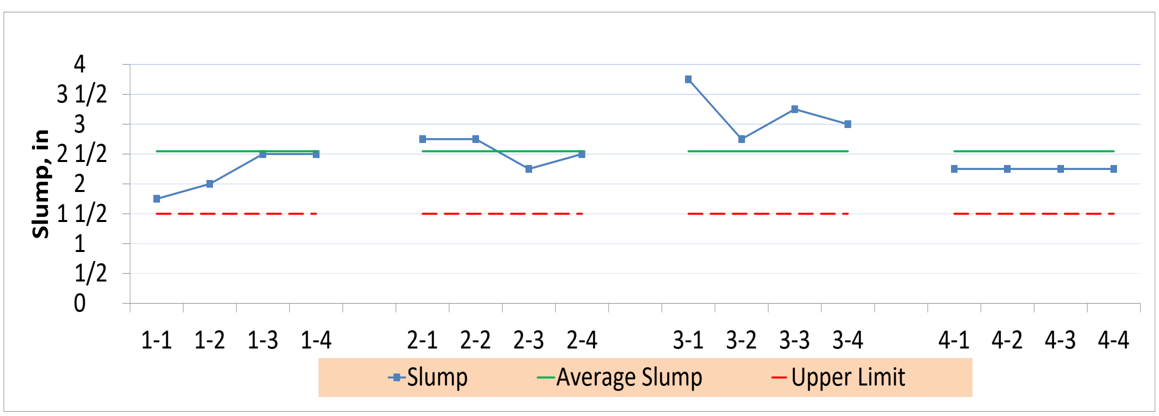
Section	Mixture Type	Date	Sample ID
Shoulder	Regular	4/30/2019	1-1, 1-2, 1-3, 1-4
Shoulder	Regular	5/1/2019	2-1, 2-2, 2-3, 2-4
Shoulder	Regular	5/2/2019	3-1, 3-2, 3-3, 3-4
Shoulder	Regular	5/6/2019	4-1, 4-2, 4-3, 4-4

TEST RESULTS

- ❑ Numerical values of all test results are presented in Appendix C.

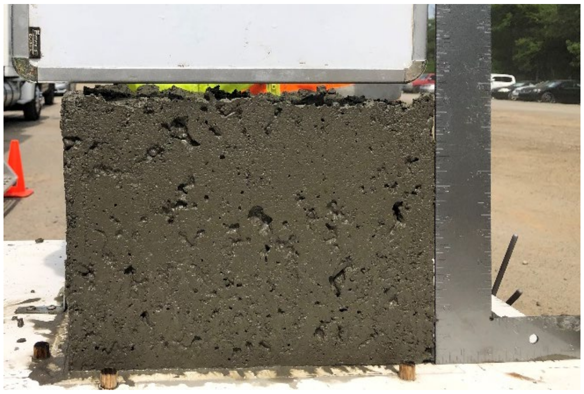
Slump

- ❑ Sixteen tests were taken at the plant
- ❑ Average Slump: 2.75”, Standard deviation: 0.5”



Box Test

- Four box tests were performed
- No edge slump or consolidation issues noticed
- Finish in the field resembles the box test



Sample 1-3 (rating:2)

Sample 2-2 (rating:2)

Sample 3-2 (rating:2)

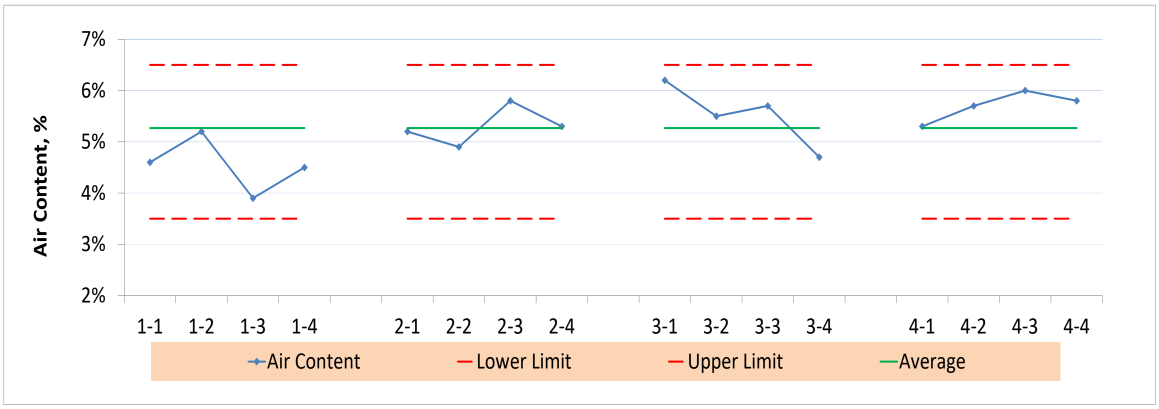
Sample 4-3 (rating:1)

Finish in the Field

Air Content and Air Void System

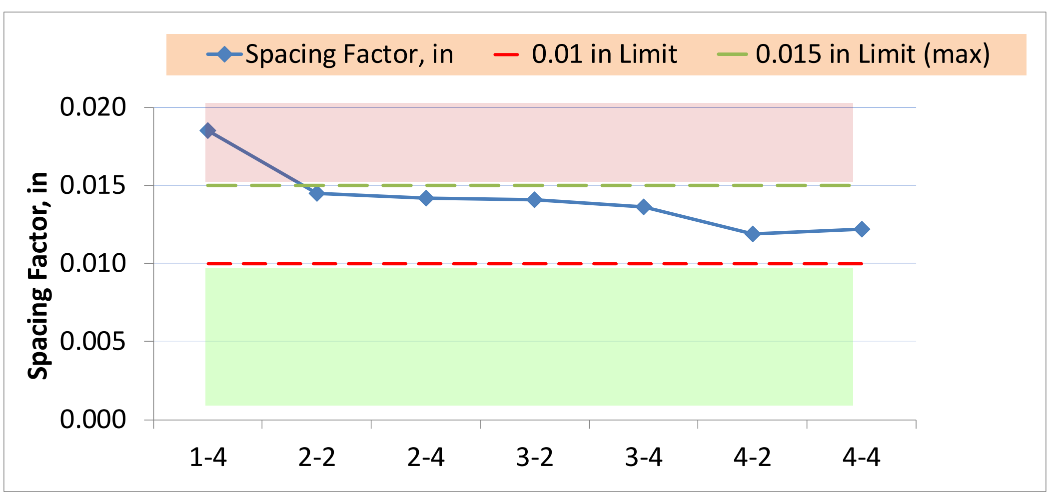
Total Air Content

- Total Air is different than Air Void System.
- Sixteen air tests performed, all of them at the plant.
- Average air content: 5.3%, Standard Deviation: 0.6%
- Average air content close to the average air content from the NC DOT PEMII report (5.42%) (*Reference 1*)
- Limited variability observed.



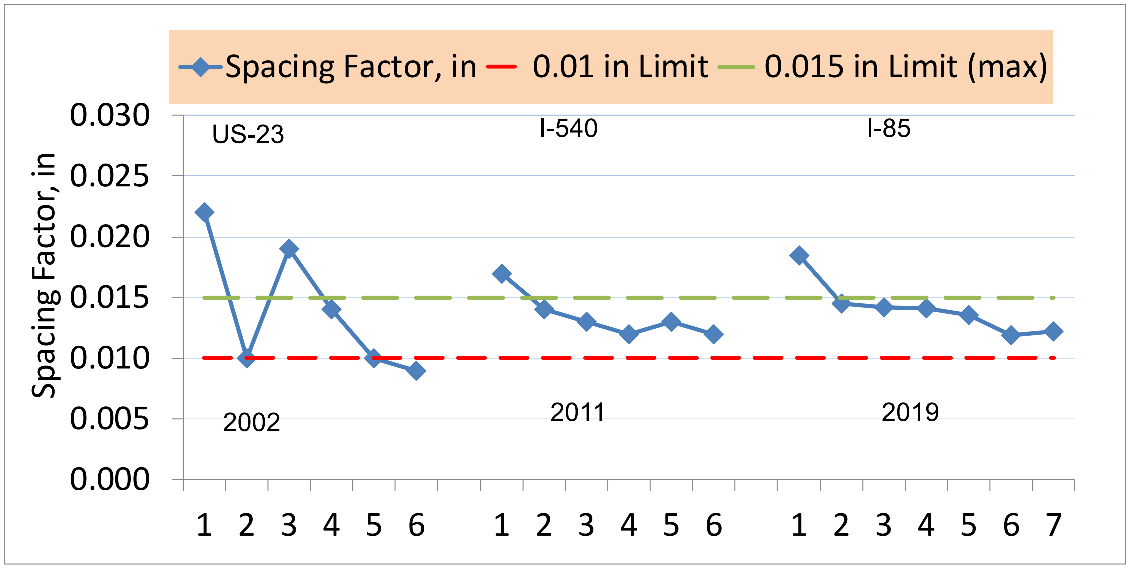
Air Void System Measured by the Air Void Analyzer (AVA)

- Seven tests performed from samples taken at the plant.
- Standard Deviation of 0.002.
- For QC, not for a specification compliance.
- Majority of the results in the acceptable category (less than 0.015 in).



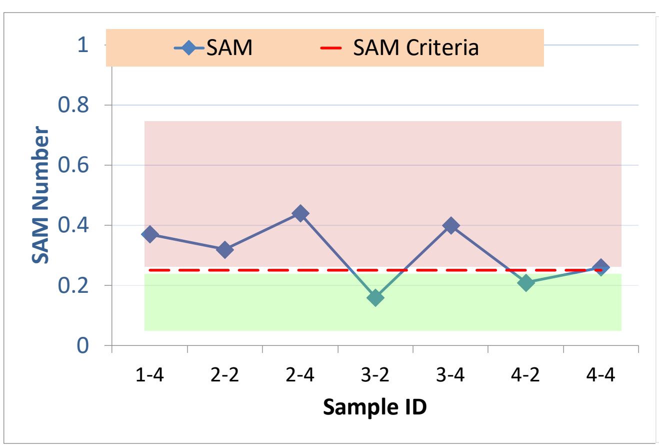
AVA from Past MCTC Visits to North Carolina (different projects)

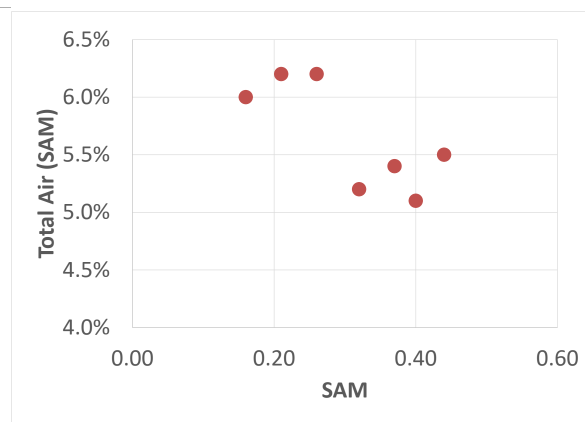
- 2002 visit: Average 0.014, Standard Deviation 0.005
- 2011 visit: Average 0.014, Standard Deviation 0.002
- 2019 visit: Average 0.014, Standard Deviation 0.002



Air Void System Measured by the Super Air Meter (SAM)

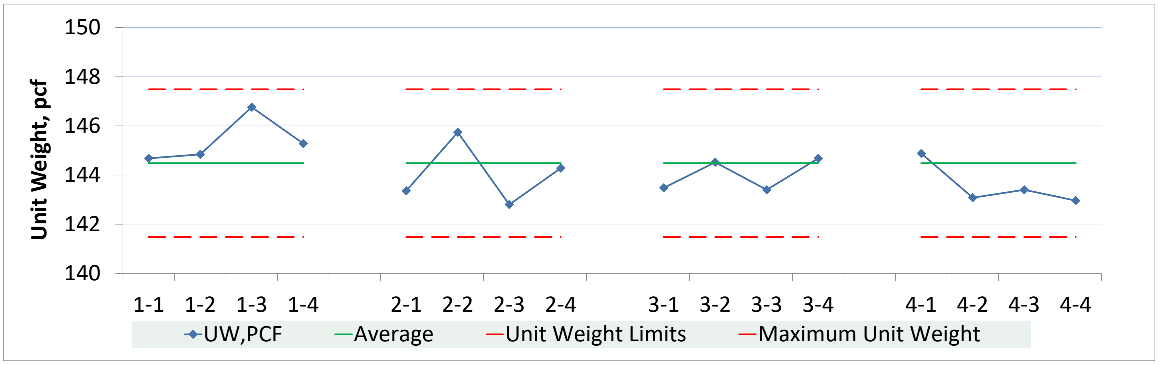
- Seven tests performed from samples taken at the plant
- SAM results: Average 0.31, Standard Deviation of 0.10
- Correlation between SAM and Total Air content (higher air content, lower SAM numbers)
- <u>MCTC Average SAM results are close to the average SAM results from the NC DOT PEMII report (Average SAM: 0.30)</u>





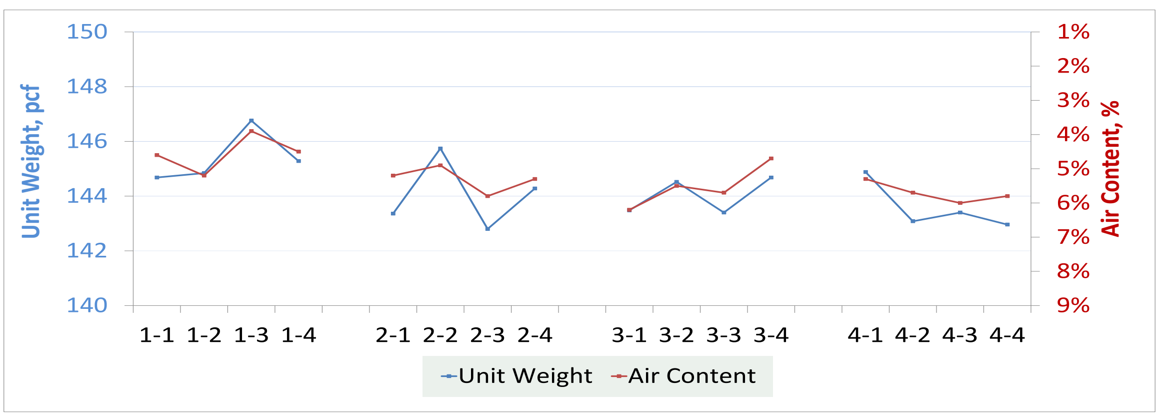
Unit Weight

- Simple test to check uniformity: weight and volumetric proportions.
- Sixteen tests were performed at the plant
- Average unit weight: 144.5 pcf, Standard Deviation: 1.1 pcf.



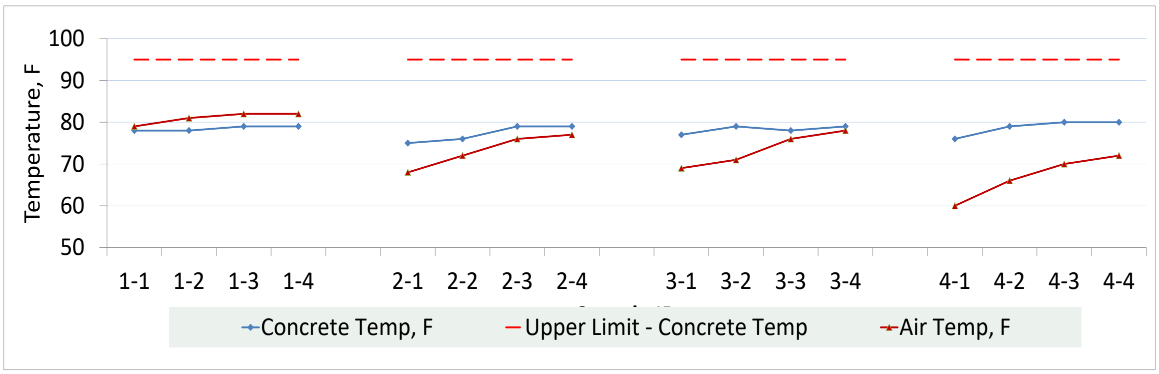
Air Content with Unit Weight

- Normally they will run parallel
- Unit weight will change if either air content or slump changes
- If they diverge, it means there has been a change in materials or proportions
- Good correlation between air content and unit weight from the sixteen samples



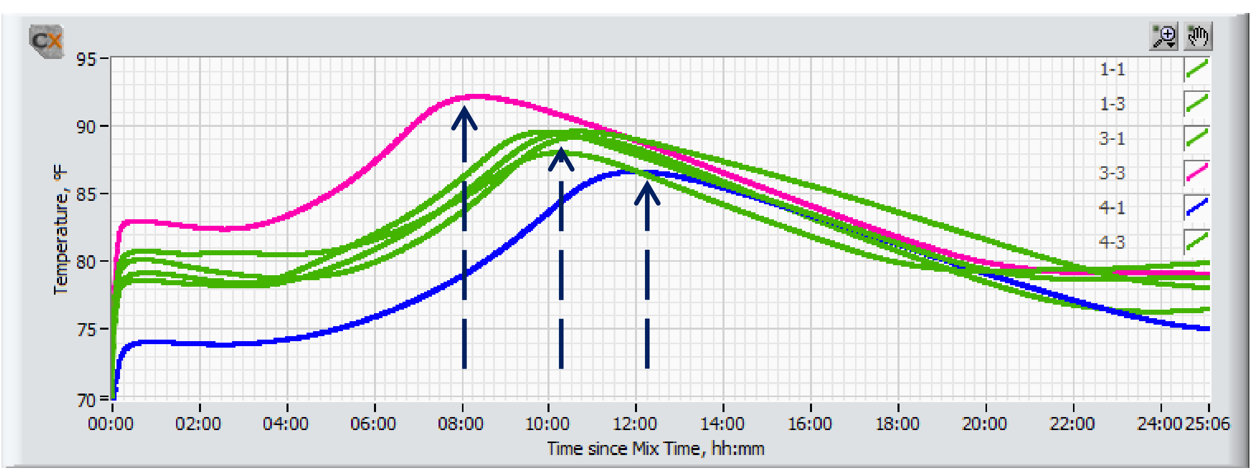
Concrete Temperature

- Concrete temperature affects the hydration rate, which can impact workability and compatibility.
- Sixteen tests were performed at the plant.
- Air temperature stayed between 60 and 82°F.
- Concrete temperature was stable, consistently between 75 and 80°F.
- All tests showed that concrete temperatures were within acceptable limits.



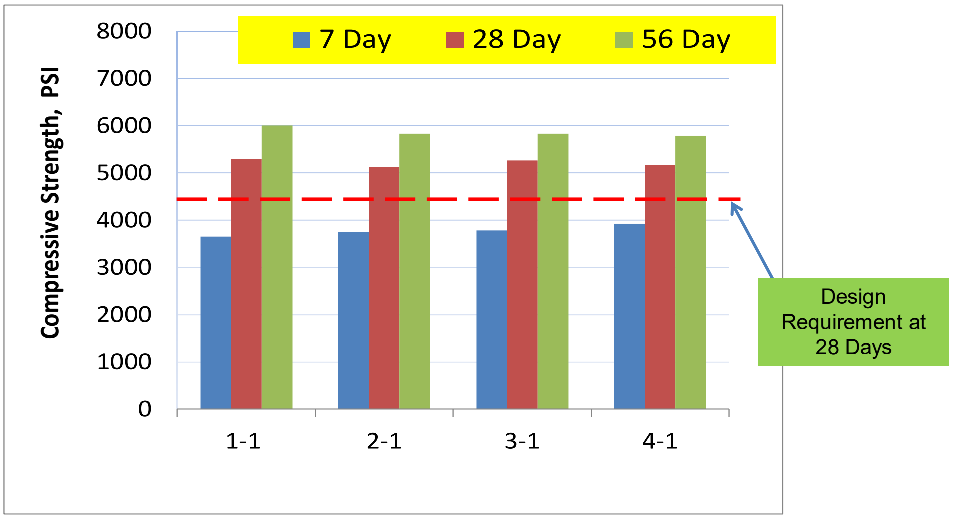
Heat Signature / Semi-Adiabatic Calorimetry

- Identifies changes in cementitious hydration due to cement, SCM's and admixtures.
- Six tests were performed.
- Peak heat of hydration of the heat signature curves correlated with the initial temperature of concrete at the beginning of the test.
- Samples with similar initial temperatures showed consistent heat signature curves.
- Overall, cementitious contents and sources were consistent.



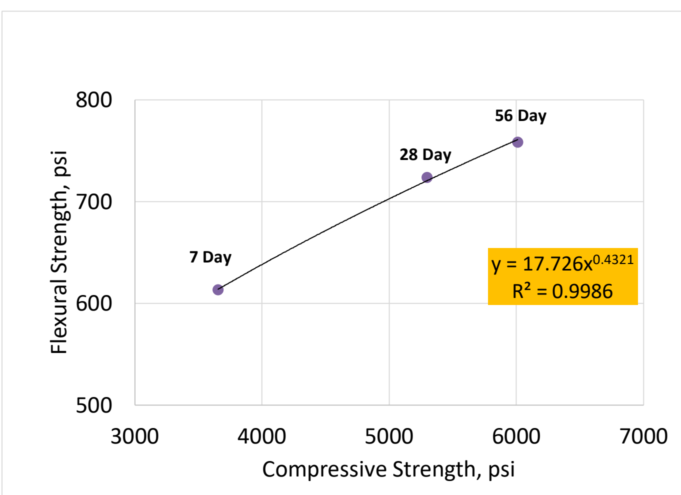
Compressive Strength

- Samples from four different days of production were tested for compressive strength at 7, 28 and 56 days.
- At seven days, all four tests had reached over 75% of the 28-day required strength of 4500 psi. At 56 days, strengths were 34 % over the design requirement.
- Compressive strength test results were very consistent. Average strength: 5213 psi, Standard Deviation: 80 psi



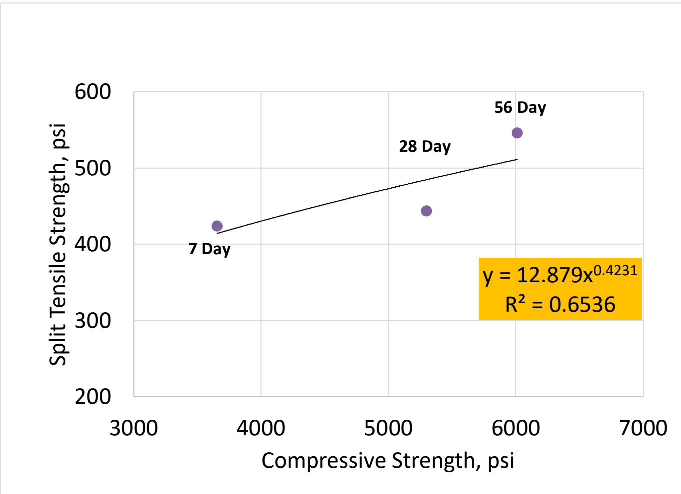
Flexural Strength

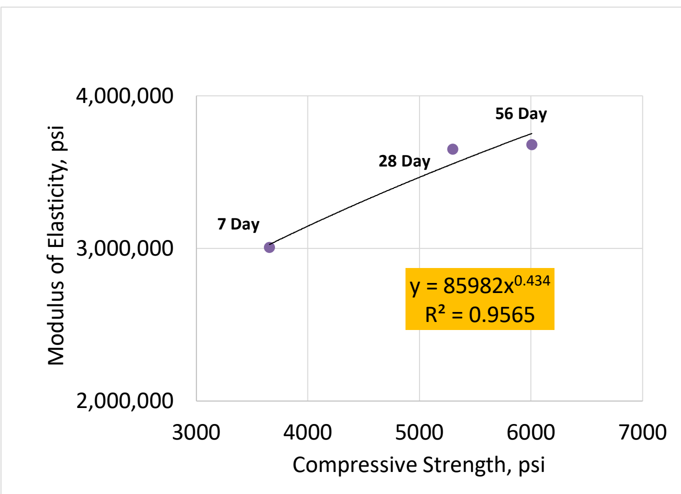
- Flexural strengths were measured at 7, 28 and 56 days on sample 1-1
- Excellent correlation between compressive and flexural strengths.
- 28 days flexural strength was 724 psi (design requirement 650 psi at 28 days).



Other Strength Tests

- Split Tensile strength tests, modulus of elasticity and Poisson's ratio were measured on sample 1-1 at 7, 28 and 56 days.
- MOE and Poisson's ratio are inputs in the AASHTO Pavement ME software for Jointed Plain Concrete Pavements and Split Tensile strength for Continuously Reinforced Concrete Pavements.





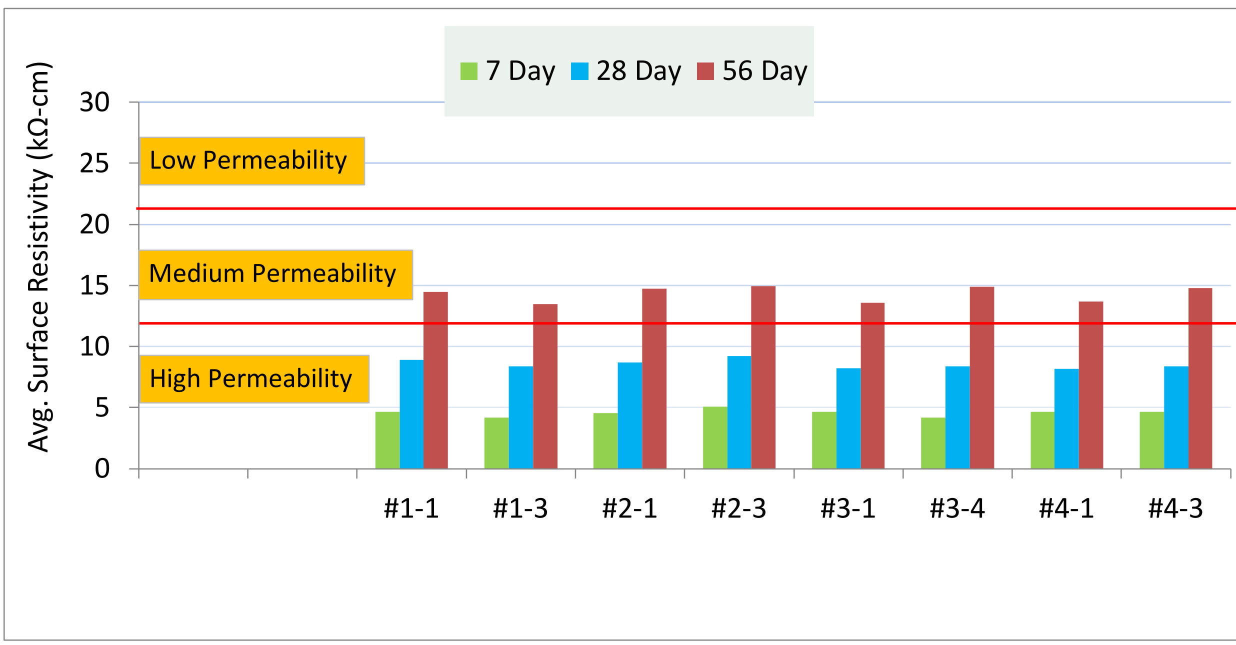
Coefficient of Thermal Expansion

- Coefficient of Thermal Expansion (CTE) is an input for pavement design in the AASHTO Pavement ME software.

Sample ID	Age, Days	CTE, Microstrain/ºF
3-4	301	5.0
4-1	297	4.7

Permeability / Surface Resistivity

- This test is more efficient in both time and effort compared to the Rapid Chloride Permeability Test.
- Eight Surface Resistivity Tests were performed.
- The results showed that the concrete samples had high permeability at seven days, although the concrete will develop lower permeability as it approaches 56 days.
- 7 Day Average: 4.6 kΩ-cm, Standard Deviation: 0.3 kΩ-cm,
- 28 Day Average: 8.5 kΩ-cm, Standard Deviation: 0.4 kΩ-cm,
- 56 Day Average: 14.3 kΩ-cm, Standard Deviation: 0.6 kΩ-cm
- These results are consistent with those reported from the NC DOT PEMII report from the same project.
- Based on research performed at the University of North Carolina-Charlotte a preliminary threshold of 11 kΩ-cm was established for durable concrete performance in the State of North Carolina.
- Based on the MCTC data, this threshold is reached between 28 and 56 days.

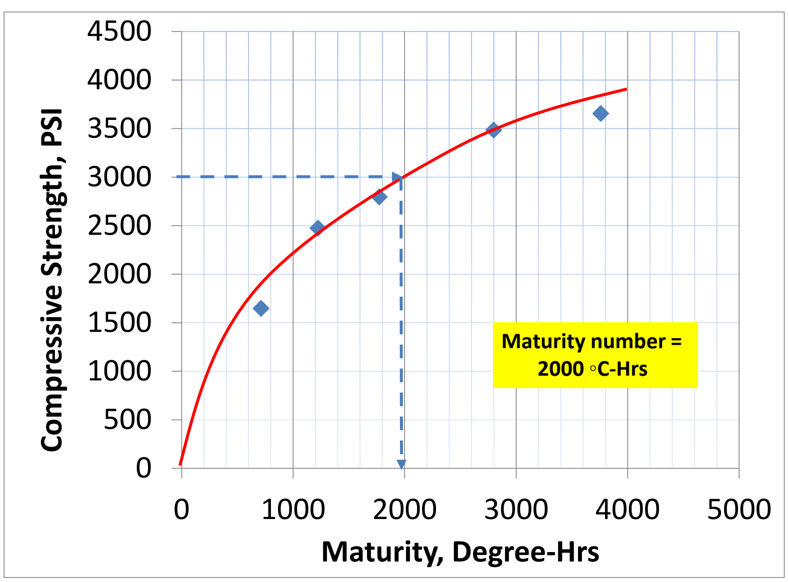


Maturity Tests

- ❑ Technique used to determine in-place pavement strength of concrete.
- ❑ This test is for measuring opening strength only, not 28-day acceptance strength.
- ❑ Two-step process:
    - ○ Build a Maturity Curve in the laboratory or in the field (uses temperature and time factors).
    - ○ Measure maturity in the field to determine in-place strength using the maturity curve.
- ❑ Opening strength for construction traffic = 3000 psi Compression

Step 1:

- ❑ Curve built on specimens cast at the plant from concrete produced on 4/30/19
- ❑ Maturity number = 2000 ◦C-Hrs

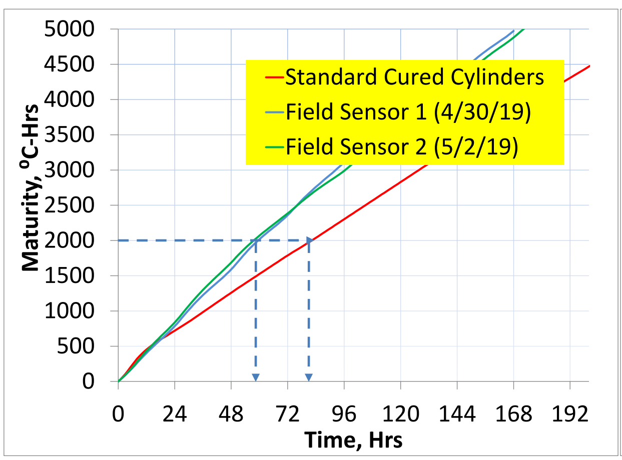


Maturity – Compressive Strength Relationship

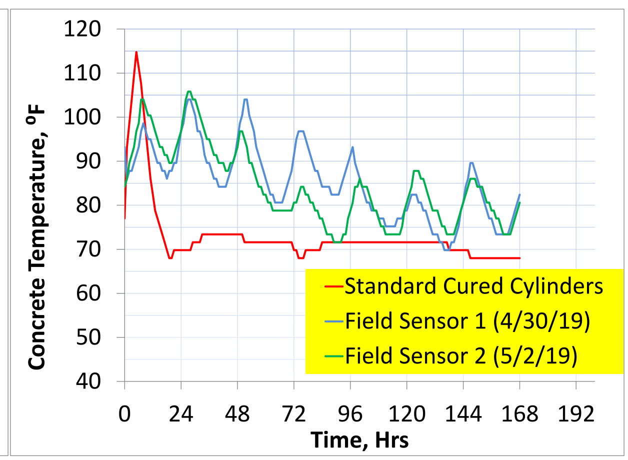
Step 2:

- Maturity sensors were instrumented in the pavement on 4/30 and 5/2/19.

- Based on the maturity data in the field, the pavement reached the required 3000 psi compressive strength in two and a half days.
- Due to the similar temperature profiles on 4/30/19 and 5/2/19 data loggers in the field, their opening strength times are also similar.



Maturity Readings from Data loggers

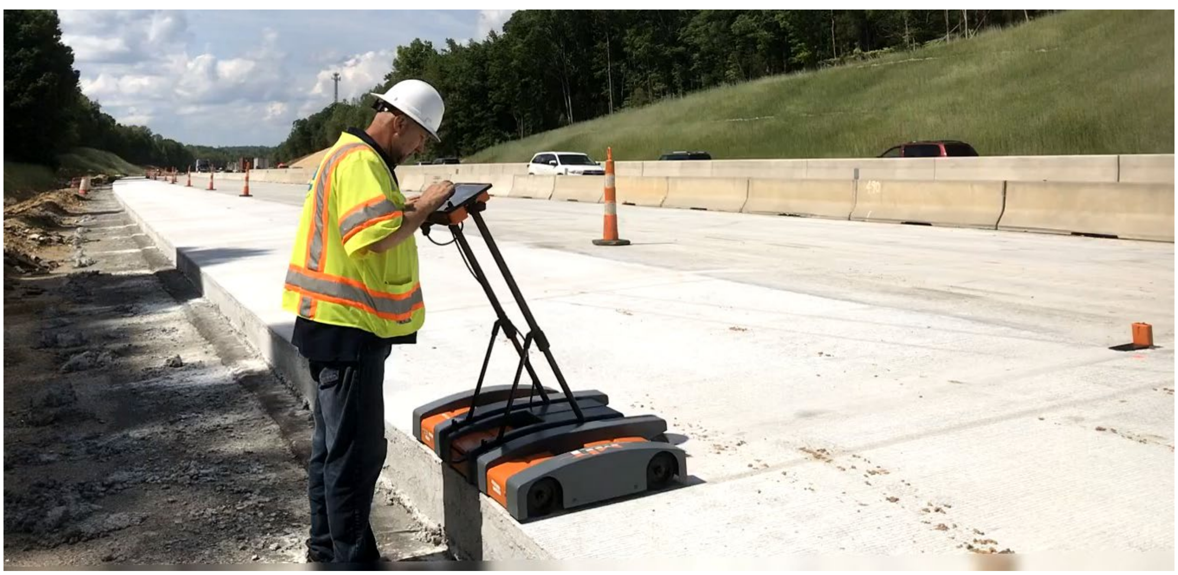


Concrete Temperature Readings

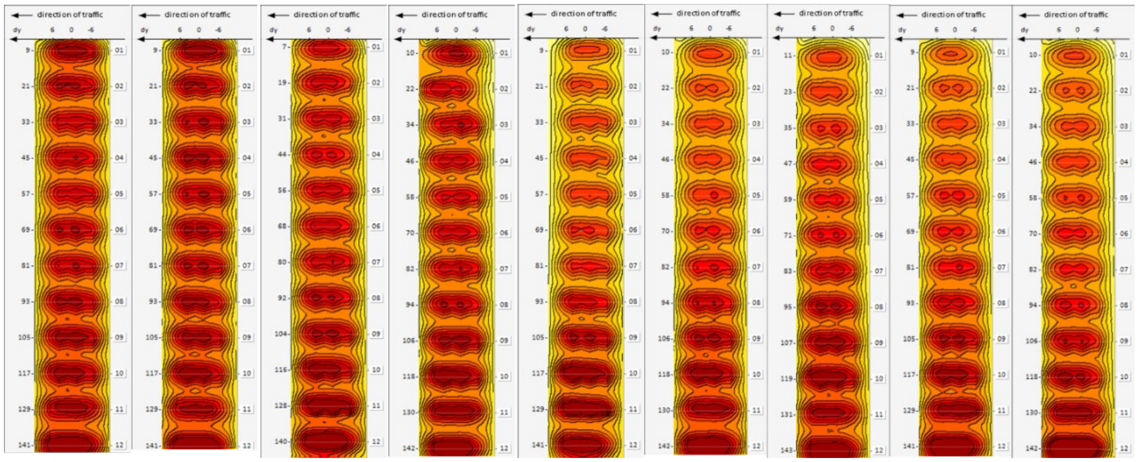
Dowel Bar Alignment

- Fifteen consecutive mainline joints were scanned using the MIT Dowel Scanner (only nine shown here). Dowels placed using DBI.
- Twelve consecutive shoulder joints were scanned using the MIT Dowel Scanner (only nine shown here). Dowels placed using Baskets.
- Nondestructive approach (pulse induction technology).
- All scans showed that the dowel bars were correctly placed and well aligned.

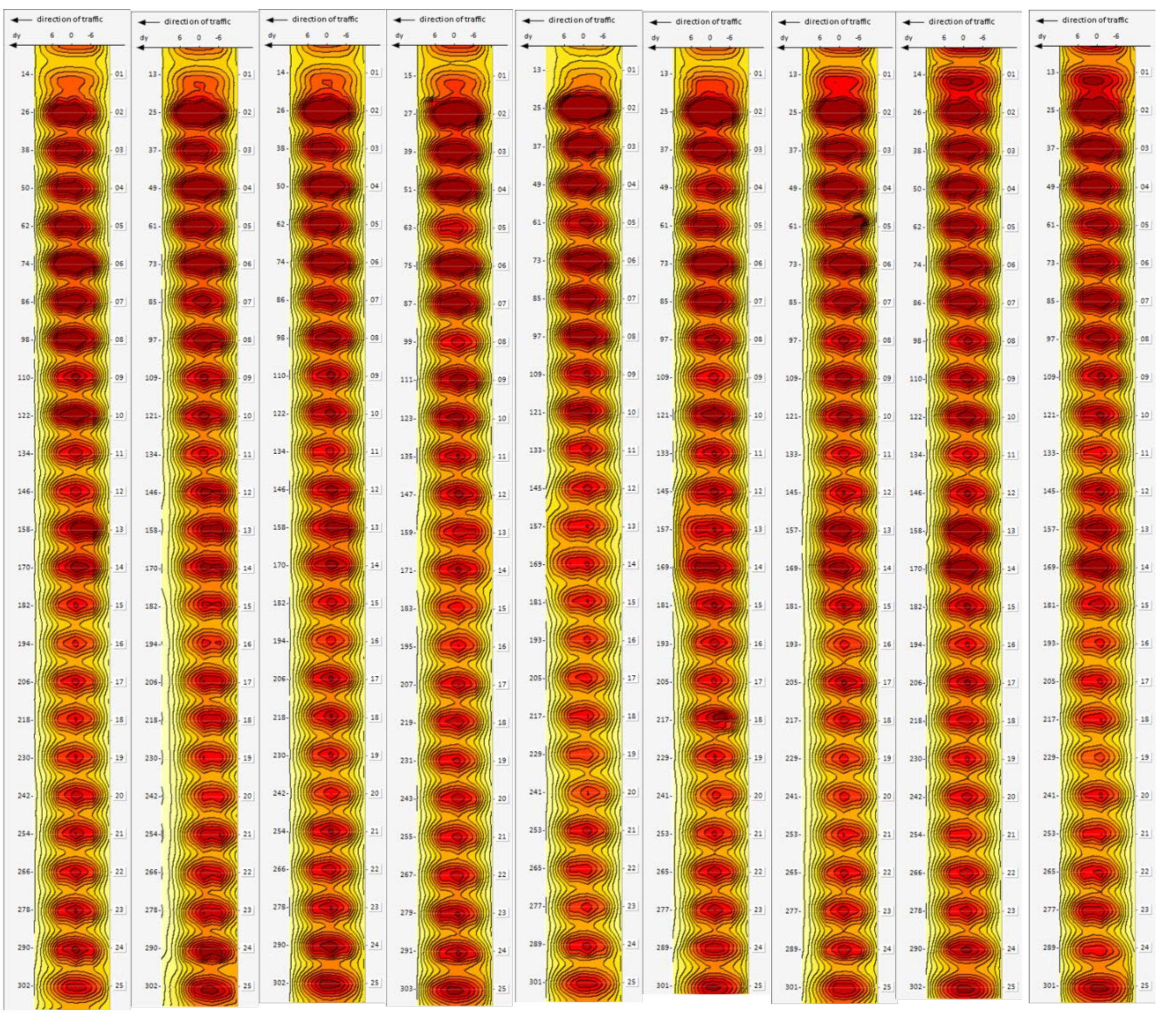
MCTC Personnel using the MIT Dowel Bar Scanner on Mainline Section



MCTC Personnel using the MIT Dowel Scanner on Shoulder Section



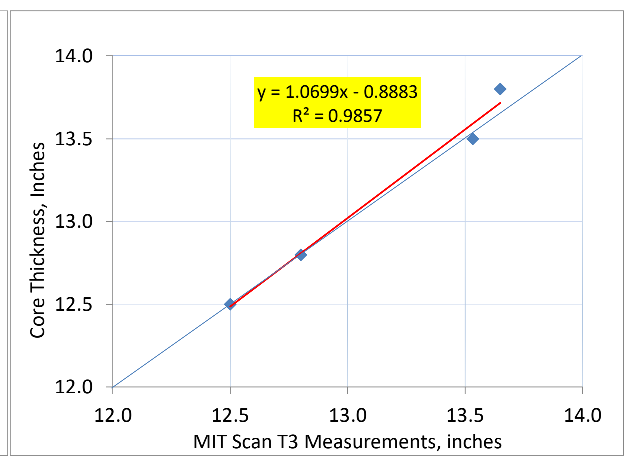
Dowel bar alignment along the shoulder (in dowel baskets)



Dowel bar alignment along the mainline (DBI)

Pavement Thickness

- Concrete pavement thickness was measured in ten different locations.
- The measurements were carried out utilizing the MIT Scan T3. (Nondestructive)
- The accuracy of the MIT Scan T3 was verified through core drilling.
- The design thickness of the pavement was 12”.
- Average thickness: 13.2”, with no measurement falling below 12”.



MCTC Activities

- Kick-Off meeting at the MCTC on April 30.
- MCTC/PEM Open House on May 15.
- Close-Out meeting at the MCTC on May 15.

MCTC / PEM Open House

- A PEM open house event was held during the MCTC visit on May 15. This visit was locally coordinated by Greg Dean of the Carolinas Concrete Paving Association. A number of industry and NCDOT attendees were present, and presentations were made by personnel from Iowa State's Concrete Pavement Technology Center (CP Tech Center), FHWA MCTC, NCDOT, UNC-Charlotte, Lane Construction, and others. During the open house, several PEM and non-PEM technologies were showcased by the MCTC staff.

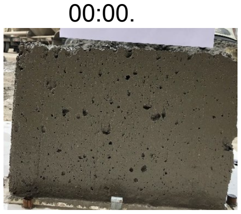
Other Activities

- MCTC staff also worked with the contractor in performing Box Tests on a low cement content (422lbs) mixture that was being designed. The intent of this testing was to observe the change in workability characteristics of the low cement mixture with changes in time (how long the mixture would be workable) and water content.

Low Cement Mixture (422lbs) as Designed

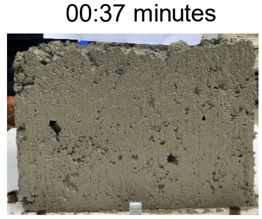
Low Cement Mixture (422lbs) with a higher water cement ratio

00:00.

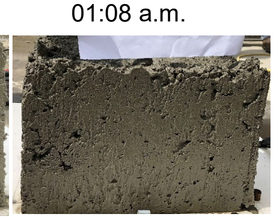


00:24 minutes

00:37 minutes



01:08 a.m.



01:25 a.m.

Low Cement Mixture (422lbs) at various intervals of time.

- This Box Testing showed the 422lb mixture is viable and the contractor mentioned that they will continue to develop it for use on future projects.

Acknowledgements

- Brian Hunter (NC DOT)
- Phillip Kelly Seitz (NC DOT)
- Jim Phillips (FHWA NC Division)
- Tara Cavalline (UNC Charlotte)
- Greg Dean (CCPA)
- Fred White (Lane Construction)
- Chip Fuquay (Kisinger Campo)
- Tommy Rushing (Lane Construction)
- Chris Ange (Lane Construction)
- Richard Burley (formerly NC DOT)

Reference 1

- Post Construction Report for North Carolina DOT Demonstration Project, Implementation of Performance Engineered Concrete Mixtures (PEM)/AASHTO PP 84, April 30, 2020, Tara Cavalline, Brett Tempest, Brian J. Hunter, P.E., Fredrick D. White, Christopher M. Ange.

Appendix

Appendix A – Design Features of the project

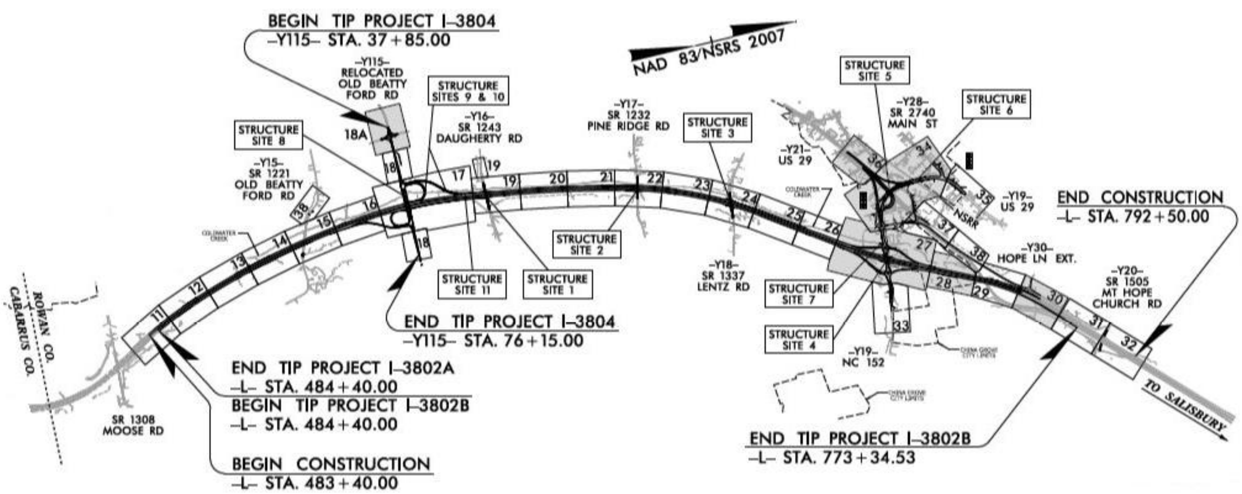


Figure A1: Overview of the project site from project drawings

Existing Pavement and Traffic Information

The existing 10-inch thick continuously reinforced concrete pavement was constructed in approximately 1978, was placed on an aggregate base course. The 2015 ADT for this segment of I-85 was 97,100, with a design year (2040) ADT of 179,500. Truck traffic in 2015 was estimated to be 19% (14% TTST and 5% duals). The design speed for this section of I-85 is 70 mph, with a posted speed of 65 mph.

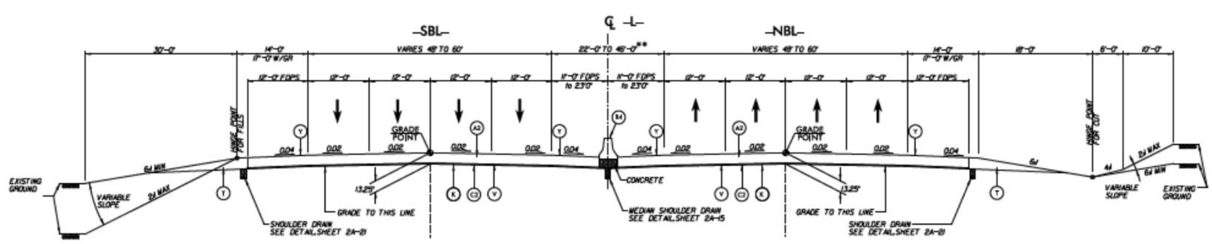


Figure A2: Cross section showing widening of northbound and southbound lanes of I-85 (from project drawings)

Appendix B – Concrete Mixture Design

Form 312U
3-96

North Carolina Department of Transportation, Division of Highways, Materials and Tests Unit
Statement of Concrete Mix Design and Source of Materials

Project	Date Expires 12/31/2075
Mix Design Status Active	Concrete Producer LANE CONSTRUCTION CORPORATION
County	Plant Location & DOT No. HAMPTONVILLE, NC - 474
Resident Engr.	Contractor
Class of Concrete PAVEMENT	Date Assigned
Mix Design No. 474TVFSLNS598E	Contractor's Signature
Note Mix Design Units (English or Metric) ENGLISH	

Mix Design Proportions Based on SSD Mass of Aggregates

Material	Producer	Source	Qty. per Cu. Yard
Cement	ROANOKE CEMENT COMPANY	ROANOKE - TROUTVILLE, VA	460 lbs.
Pozzolan	ASH VENTURE	ASH VENTURE - BELEWS CREEK STEAM STATI	138 lbs.
Fine Aggregate	G.S. MATERIALS	EMERY PIT	1046 lbs.
Coarse Aggregate	MARTIN MARIETTA	WOODLEAF QUARRY - SALISBURY	1940 lbs.
Total Water		CITY	31.2 gals.
Air. Entr. Agent	EUCLID CHEMICAL CO.	EUCON AEA 92	As recommended
Retarder	EUCLID CHEMICAL CO.	EUCON LR	As recommended
Water Reducer	EUCLID CHEMICAL CO.	EUCON WR	As recommended
Superplasticizer			
Corrosion Inhibitor			

Mix Properties and Specifications

Slump	1.50 in.	Mortar Content	15.22 cu. ft.
Max Water	38.6 gals.	Air Content	5.0 %

Material	Specific Gravity	% Absorption	Unit Mass	Fineness Modulus
Fine Aggregate	2.63	0.8	NA	2.81
Coarse Aggregate, #57	2.64	0.5	97.5	NA

Comment Coarse Aggregate is a blend of 1434 lbs. # 57 and 506 lbs. # 78M.

Cast-in-place concrete shall conform to Section 1000, precast concrete to Section 1077, and prestressed concrete to Section 1078 of the applicable edition of the Standard Specifications for Roads and Structures plus all applicable Special Provisions.

Appendix C – MCTC Test Results

Aggregate Gradations (From Lane Construction)

Sieve Size, in	FA 1	#78M	#57	Combined % Passing
2"	100	100	100	**100**
1.5"	100	100	100	**100**
1"	100	100	99	**100**
3/4"	100	100	70	**86**
1/2"	100	100	30	**66**
3/8"	100	96	21	**61**
No. 4	98	39	9	**45**
No.8	93	6	4	**35**
No.16	78	0	0	**27**
No.30	47	0	0	**16**
No.50	17	0	0	**6**
No.100	3	0	0	**1**
No.200	1	0	0	**0**
Proportions	35%	17%	48%	**100%**

Fresh Concrete Properties

S. No	Sample ID	Date	Time, Local	Slump, Inches	Conc Temp, °F	Air Temp, °F	Unit Weight, pcf	Air Content, %	**Box Test**	
									Ranking	**Edge Slump**
1	1-1	30-Apr	12:20	1.75	78	79	144.7	4.60%		
2	1-2	30-Apr	1:42	2	78	81	144.8	5.20%		
3	1-3	30-Apr	2:49	2.5	79	82	146.8	3.90%	**2**	**None**
4	1-4	30-Apr	3:43	2.5	79	82	145.3	4.50%		
5	2-1	1-May	9:44	2.75	75	68	143.4	5.20%		
6	2-2	1-May	10:45	2.75	76	72	145.7	4.90%	**2**	**None**
7	2-3	1-May	12:20	2.25	79	76	142.8	5.80%		
8	2-4	1-May	1:12	2.5	79	77	144.3	5.30%		
9	3-1	2-May	9:28	3.75	77	69	143.5	6.20%		
10	3-2	2-May	10:30	2.75	79	71	144.5	5.50%	**2**	**None**
11	3-3	2-May	11:42	3.25	78	76	143.4	5.70%		
12	3-4	2-May	12:25	3	79	78	144.7	4.70%		
13	4-1	6-May	8:00	2.25	76	60	144.9	5.30%		
14	4-2	6-May	9:17	2.25	79	66	143.1	5.70%		
15	4-3	6-May	10:50	2.25	80	70	143.4	6.00%	**1**	**None**
16	4-4	6-May	11:53	2.25	80	72	143	5.80%		
Specification Requirement								**3.5-6.5%**		

Air Void Characteristics (Air Void Analyzer and Super Air Meter (SAM))

		AVA				SAM		
Sample ID	Date	Spacing Factor, in	Max Rec	Specific Surface. 1/in	Min Rec	SAM Number	Max Rec	SAM Air
1-4	4/30/2019	0.0185	**0.0100**	359	**600**	0.37	0.25	5.4%
2-2	5/1/2019	0.0145	**0.0100**	404	**600**	0.32	0.25	5.2%
2-4	5/1/2019	0.0142	**0.0100**	414	**600**	0.44	0.25	5.5%
3-2	5/2/2019	0.0141	**0.0100**	421	**600**	0.16	0.25	6.0%
3-4	5/2/2019	0.0136	**0.0100**	471	**600**	0.40	0.25	5.1%
4-2	5/6/2019	0.0119	**0.0100**	511	**600**	0.21	0.25	6.2%
4-4	5/6/2019	0.0122	**0.0100**	465	**600**	0.26	0.25	6.2%

Average Compressive Strength

Average Compressive Strength, psi				
	1-1	2-1	3-1	4-1
1 Day	1648			
2 Day	2474			
3 Day	2797			
5 Day	3485			
7 Day	3656	3753	3783	3929
28 Day	5298	5127	5263	5166
56 Day	6009	5834	5827	5786

Average Flexural and Split Tensile Strength

Sample 1-1	Compressive Strength, psi	Flexural Strength, psi	Split Tensile Strength, psi	MOE, psi	Poisons Ratio
Day 1	1648				
Day 2	2474				
Day 3	2797				
Day 5	3485				
Day 7	3656	613	424	3,005,788	0.18
Day 28	5298	724	444	3,650,468	0.22
Day 56	6009	758	546	3,680,815	0.22

Surface Resistivity

ID	Cast Date	Days	0	90	180	270	0	90	180	270	AVG	AVG * 1.1
#1-1	4/30/2019	7	4.3	4.1	4.1	4.4	4.3	4.1	4.2	4.4	4.2	4.7
#1-3		7	3.8	3.7	3.9	3.8	3.8	3.7	3.9	3.8	3.8	4.2
#2-1	5/1/2019	7	4.2	4.1	4.2	4.0	4.2	4.1	4.2	4.0	4.1	4.5
#2-3		7	4.6	4.5	4.8	4.7	4.5	4.5	4.8	4.6	4.6	5.1
#3-1	5/2/2019	7	4.3	4.1	4.1	4.4	4.3	4.1	4.2	4.4	4.2	4.7
#3-4		7	3.8	3.7	3.9	3.8	3.8	3.7	3.9	3.8	3.8	4.2
#4-1	5/6/2019	7	4.5	4.3	4.0	4.1	4.5	4.2	4.0	4.2	4.2	4.6
#4-3		7	3.9	4.3	4.5	4.3	3.9	4.3	4.5	4.3	4.3	4.7
#1-1	4/30/2019	29	9.0	7.8	7.7	8.0	9.0	7.8	7.6	7.8	8.1	8.9
#1-3		29	7.2	7.8	7.8	7.9	7.0	7.8	7.7	7.9	7.6	8.4
#2-1	5/1/2019	28	8.0	7.9	8.0	7.5	8.0	8.1	8.1	7.7	7.9	8.7
#2-3		28	8.3	8.2	8.8	8.3	8.3	8.2	8.7	8.4	8.4	9.2
#3-1	5/2/2019	28	7.5	7.2	7.4	7.8	7.5	7.2	7.3	7.7	7.5	8.2
#3-4		28	7.7	7.3	8	7.4	7.6	7.4	7.9	7.5	7.6	8.4
#4-1	5/6/2019	28	7.6	7	7.3	8	7.6	7	7.2	7.8	7.4	8.2
#4-3		28	7.1	7.8	8	7.6	7	7.7	8	7.6	7.6	8.4
#1-1	4/30/2019	56	12.3	13	13.1	14.3	12.6	12.9	12.8	14.2	13.2	14.5
#1-3		56	12.5	11.2	12.6	12.5	12.7	11.5	12.5	12.5	12.3	13.5
#2-1	5/1/2019	56	13.5	13.3	13.8	13	13.3	13.5	13.8	13	13.4	14.7
#2-3		56	13.9	13.1	13.1	13.7	14.3	13.5	13.3	13.7	13.6	14.9
#3-1	5/2/2019	56	12.4	12	12.1	13	12.5	12	12.1	12.7	12.4	13.6
#3-4		56	13.4	13.7	13.5	13	13.9	13.8	13.6	13.2	13.5	14.9
#4-1	5/6/2019	56	12.6	12.2	12	12.9	12.5	12.3	12.1	12.9	12.4	13.7

Pavement Thickness Measurements

S. No	MIT Scan T3 Measurements, inches	Cores Thickness, inches	Design Thickness, inches
1	12.5	12.5	12.0
2	13.4		
3	13.1		
4	13.2		
5	12.8	12.8	
6	13.4		
7	13.5	13.5	
8	13.1		
9	13.4		
10	13.7	13.8	
Average	13.2		