Date: 06/24/2004

Evaluation of Air Content in Concrete Pavements

Nebraska Department of Roads

Research Project Title:

Evaluation of Air Content in Concrete Pavements

Research Project Number: R-04-01

Location:
Ramp3 Westbound Hwy 30
Blair, NE

Starting Date: 07/08/2004

Completion Date: 07/30/2009

Principle Investigators:

Robert C. Rea
NDOR
Assistant Materials & Research Engineer

Lieska Halsey
Research Engineer

Sample Coring:

Kate Dodson
Highway Materials & Tests Technician III

P.C.C Laboratory:

Scott Grossenbacher
Highway Quality Assurance Manager

Gary Mangen
Highway Quality Assurance Manager
District 2

Dave Gomez
Former NDOR
Highway Mat. & Test Technician III

Tom Gernert
Highway Mat. & Test Technician III

P.C.C Materials:

Tim Krason
Highway Quality Assurance Manager

Terry Master
Highway Mat. & Test Technician III

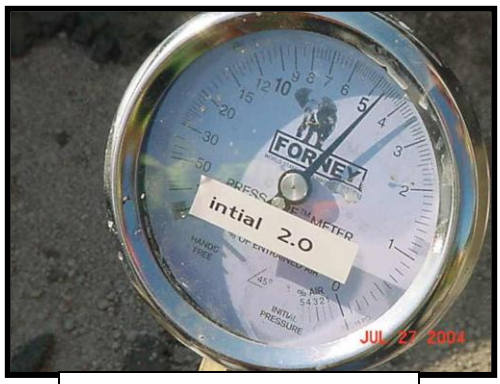
Jeremy Weigel
Highway Mat. & Test Technician II

Purpose of the Research Project:

This project was intended to predict how homogeneous and plastic the concrete must be when it reaches the pavers. The study focused on the tradeoffs between mixing time, air content and vibration frequency. NDOR, LUXA Construction Company and Gerhold Concrete Company, Inc worked together on this study.

Description of Project:

1. Established the frequency range for internal tube vibrator
2. Evaluated the effect of the vibrator frequencies within the different concrete sections
3. Evaluated the entrained air and the entrapped air in the vibrator path and in the vibrator gap
4. Evaluated the performance in varing mixing time (45sec and 60sec)
5. Established the range for air entrainment in concrete pavements



Air Meter

Plan of Actions in the field and Laboratory:

Tasks:

Conducted in the field:

Sections Evaluated:

Mix Design used: 47B with IPF cement

1. Control Section:
   Tested one section with mixing time (90 sec), standard air entrainment and vibration frequency (vpm) of 9000. The length was 65 ft.
2. Tested one section simulating a dump truck with normal mixing time (90 sec), standard air entrainment and vibration frequency of 9000 (vpm). The section length was 68 ft.
3. Tested two sections varying mixing times (45 sec and 60 sec) as the control section mix design. The sections lengths were 94 ft and 68 ft respectively.
4. Tested three sections with variable entrained air (8%, 10% and 12%) with a normal mixing time (90 sec) and vibration frequency of 9000 (vpm). The sections lengths were 137ft and 56 ft respectively.
5. Tested three sections varying vibration frequencies (4500, 6500 and 8000 vpm). The sections lengths were 81ft, 44 ft and 51 ft respectively. The mix design was the same as the control section.

Vibrators

Plan of Actions in the field and Laboratory by Tasks:

Conducted in the Field:

Sampling & Testing

Out of the Truck

1. Slump Test
2. Test for Density by the Test Nuclear Method ASTM C1040
3. Check Air:
   i. After the Truck
   ii. Behind the pavers in the vibrator path and vibrator gap (Testing for air content by the pressure method ASTM C 231
   iii. Specimens
   Cylinders (6x12in) for Mechanical Properties Test
   Beams (3x4x16in) for Freeze and Thaw Test

Field Testing (between Vibrators Gap)

In the Laboratory:

1. Standard test method for microscopic determination parameters of the air void system in hardened Concrete by the Linear Traverse Method ASTM C457-90
2. NDOR Wet and Dry
3. Mechanical Properties:
   i. Compressive Strength by the ASTM C39 method
   ii. Flexural Strength by the ASTM C293 method
   iii. Modulus of Elasticity by the ASTM C469 Method

Evaluation:

1. NDOR will continue to evaluate the test section the for the next five years

Paving Operation Finish

Field and Laboratory Investigation Test Results:

Plastic Stage Concrete Test Results (Field):

Varying Transport Type: Agitator, Dump Truck and Paver Speed:

The study found no significant difference in the unit weight and air content loss with either transport type or forward speed of the pavers.

Varying Mixing Time: Control Mix vs. Mixing Time 45-60 Sec

Tests indicated that longer mixing times led to significant slump variations and reduce the amount of entrapped air.

Varying the Air Content:

Three sections were used to reach a variable entrained air content of 8%, 10% and 12% each with a normal mixing time of 90 seconds and same vibration frequency of 9000 vpm. However, the maximum entrained air achieved in the field was 8% to 11%. The 12% air amount could not be reached in the field. The results showed an average air content loss of 2.6 % after the paver. In fact, it is important to note that the air sampled after the paver show no significant difference in the average air content loss between the vibrators path and vibrator gap. The investigation illustrated that increasing the air content provided less entrapped air in the mix. Increasing the air helped the workability of the mix. It was observed that the concrete produced with higher air was easier to place and finish.

Varying Vibrator Frequencies:

The average percentage of air loss indicated no significant difference as the vibrator frequency varied from 4500 to 6500 and 8000 to 9000 vpm. Note that data was not available for mixing time and forward speed during this analysis.

Hardened Concrete Test Results (Laboratory):

Varying Mixing Time: Control Mix vs. Mixing Time 45-60 Sec

The mix showed no significant difference in average air content for the various mixing times. Testing indicated that compressive strength is similar for all of the mixes. It was observed that with increased mixing time, the amount of entrapped air was reduced.

Varying the Air Content:

The results of the freeze thaw test of these sections confirmed adequate durability was obtained when the air content of the mortar fraction was in the range of 8 percent.
It was noted that the percentage of entrapped air declined noticeably as the relative density decreased. Compressive strength decreased as air content increased.

Varying Vibrator Frequencies:

The average percentage of air loss indicated no significant difference as the vibrator frequency varied from 4500 to 6500 and 8000 to 9000 vpm. However, increasing the frequency of vibration from 4500 to 6500 and 8000 to 9000 vpm did not reduce the entrapped air but helped to maintain the entrained air. The correlation was somewhat weak due to the fact that the results were based on a single sample.

Conclusion:

Variable data was obtained throughout this study. Therefore, more data needs to be collected to draw statistically valid conclusions. However, it was found throughout this study that increasing the air content in the mix will help workability and durability. Further investigation will be done in this area.