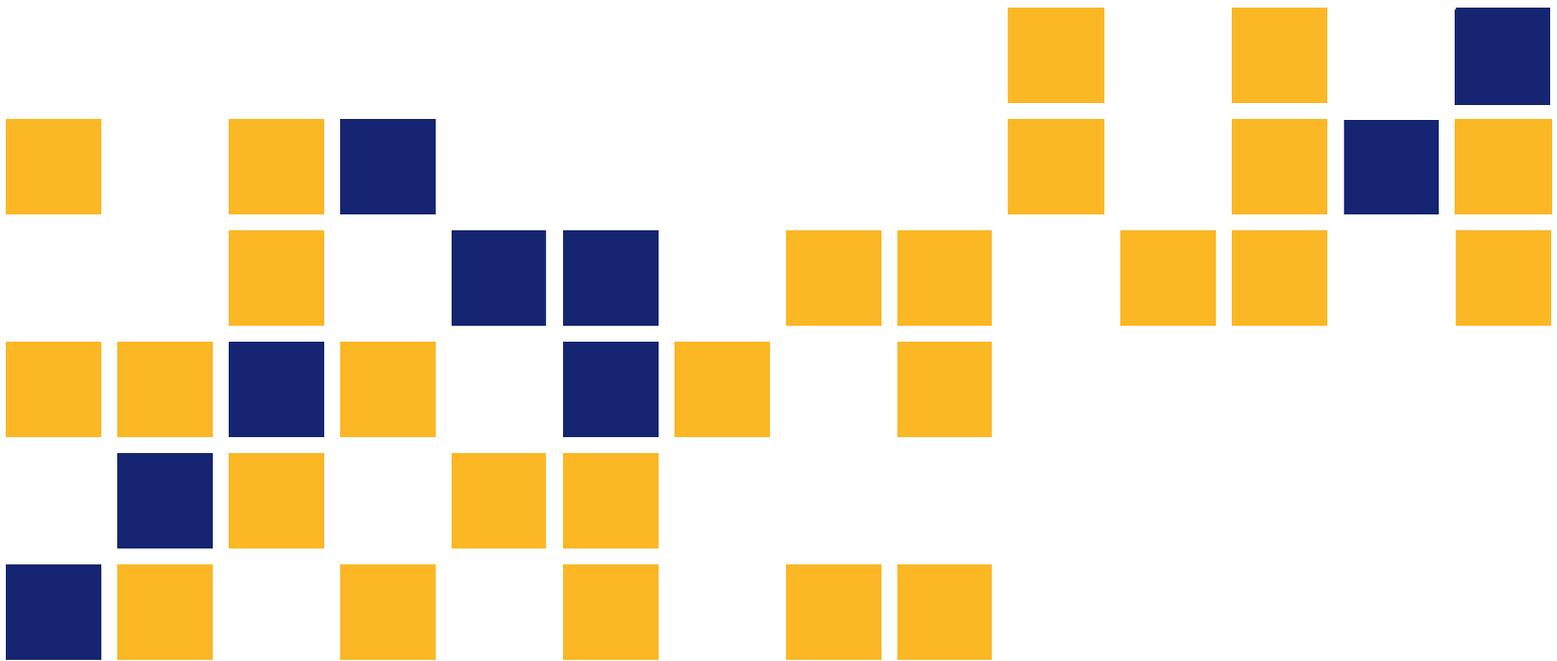


Report of Concrete Pavement Evaluation: Project 105 C-4181-01 Donahoo Road, Wyandotte County

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Kansas Department of Transportation



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16 Abstract <p>The physical properties of hardened concrete cores and fresh concrete test results were compared with aggregate gradation workability differences. The concrete cores were taken from a rural two-lane concrete road in northeastern Kansas constructed in 2011. The aggregates were crushed granite and local river sand. The aggregate workability was compared to a target workability for a given aggregate coarseness factor to determine the workability difference.</p> <p>The workability difference was compared to the total percent air, air void spacing factor, the rapid chloride permeability, the percent permeable voids and the strength of concrete cores obtained in January 2013. The results of concrete tests performed during construction, including compressive strength of cores, slump, total air content and unit weight were also compared to the workability difference.</p> <p>The only statistically significant difference in the hardened concrete properties between the lowest workability difference concrete and the highest workability difference concrete was in compressive strength. This effect was observed in samples cored and tested at the time of construction, but not in those cored and tested later. A correlation may exist between workability difference and total air content. The variability of both strength and air content may also increase with increasing workability difference.</p>			
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Final Report

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Chapter 1: Introduction

This report discusses findings from testing on concrete pavement cores from Donahoo Road, a two-lane road in rural northwestern Wyandotte County, Kansas. This pavement was constructed in 2011 under project number 105 C-4181-01. The project extended from 115th Street to 131st Street. J.M. Fahey was the paving contractor and the concrete was supplied by the Fordyce Ready Mix plant in Kansas City, Kansas. Eight inches of concrete pavement was placed on cement-treated base over fly-ash treated subgrade. See Figure 1.1 for project location.

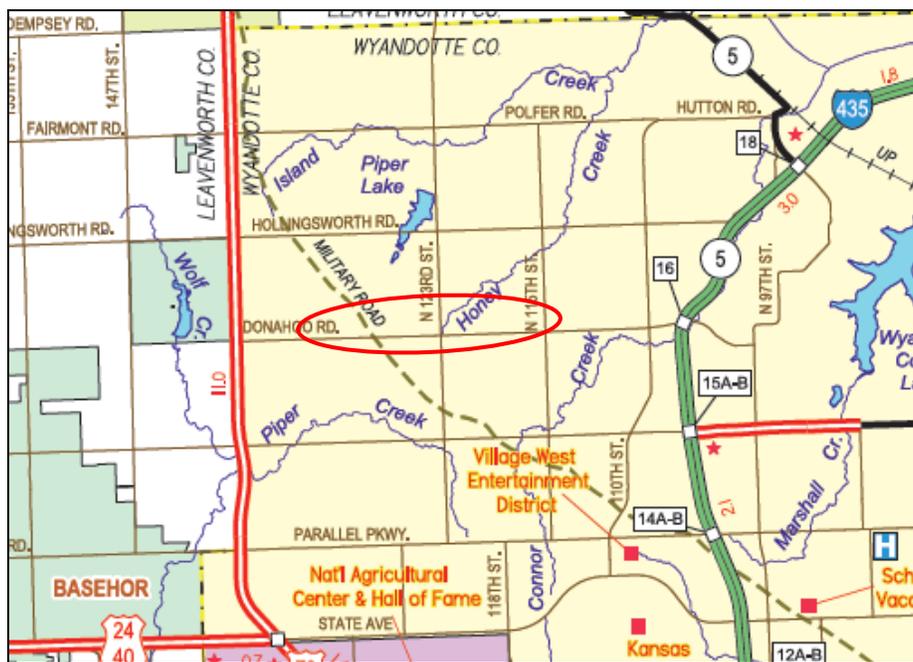


FIGURE 1.1
Location of Project 105 C-4181-01 on Donahoo Road in Wyandotte County

Mix design 1PMC070A was used throughout the project. The aggregates used in the concrete were granite from Martin Marietta's Oklahoma quarry (producer ID 808701) and sand from Holliday Sand in Missouri (producer ID 815404). The cement factor was 517 pounds per cubic yard. The cementitious materials were blended at a ratio of 75.2% cement to 24.8% fly ash. Ash Grove supplied the Type I/II cement and the Class F fly ash.

Coarse aggregate gradation testing was performed by Terracon consultant inspectors and Fordyce personnel at the ready-mix plant. Each of the individual gradation tests showed passing results in CMS and the combined aggregate gradation complied with the individual sieve gradation requirements for an MA-3 gradation. The QC/QA KDOT gradation specification used on this project determined the gradation percent within limits on the difference between the target workability and the actual workability. The percent within limits decreased from 100% for a workability difference less than or equal to 73.33% for the highest workability differences. Eleven of the twenty gradation sublots had a workability difference greater than five. Two sublots had a workability difference of one.

Chapter 2: Research Program

This study compares the physical properties of hardened concrete with varying workability differences. Construction testing data and the properties of pavement cores were analyzed. Concrete core samples were obtained from two areas where the actual and target workabilities differed by more than six points and one area where the workability difference was one point. Sublot locations and gradation details are given in Table 2.1.

TABLE 2.1
Sublot Locations and Gradation Parameters

Gradation Sublot	3A	4A	9A
Location	Eastbound Donahoo Road, 123 rd Street to 126 th Street	Westbound Donahoo Road, 123 rd Street to 126 th Street	Eastbound Donahoo Road, 0.4 miles west of 115 th Street
Date paved	May 26, 2011	June 3, 2011	August 24, 2011
% Coarse Aggregate	55	50	52
% Fine Aggregate	45	50	48
Coarseness Factor	59	71	69
Target Workability	36	34	35
Actual Workability	37	45	42
Workability Difference	1	11	7
Percent Within Limits	100%	73%	80%

Eleven core samples were obtained from each of the three pavement sublots. The cores were sampled and tested for strength, air void parameters, density and permeability according to the following test methods.

- ASTM C457 Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete (Air Voids in Hardened Concrete)
- KT-73 Density, Absorption and Voids in Hardened Concrete (Boil Test)
- AASHTO T 277 Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration (Rapid Chloride Permeability Test, RCP)

- KT-49 Method for Obtaining and Testing Drilled Cores From PCCP and Precast Girders

2.1 Core Test Results

The results of testing the concrete core are shown in Table 2.2.

**TABLE 2.2
Test Results**

	3A	4A	9A
Workability Difference	1	11	7
Total Air, %	10.5	9.3	8.3
Spacing Factor, mm	0.114	0.113	0.104
RCP, Coulombs	388	480	397
Boil, % Permeable Voids	10.4	10.5	11.4
Density, whole core, pcf	145.0	144.2	145.1
Strength, psi	6520	7140	5210

The total air contents of the three concretes vary more than the precision of the test. All three air contents are higher than the generally acceptable range of 5% to 8%. The values of the air void spacing factors and rapid chloride permeabilities for the three concretes agree within the precision of the respective tests, and all meet generally-accepted criteria for durable concrete. Precision statements are not available for the percent permeable voids and the whole-core density. The values of the percent permeable voids agree within 10% and are below the KDOT-specified maximum of 12.5%. The values of compressive strength vary by more than the precision of the test. Therefore, the result that the strength of subplot 4A is higher than the strength of subplot 3A and 9A may be statistically significant.

2.2 Field Concrete Test Results

The compressive strength of concrete cores, slump, total air content and unit weight were measured during construction. This data was compared with the workability difference as reported for that test date. No correlation was found between slump and workability difference. The daily average compressive strength of concrete cores was compared with the average workability difference from the same date. Compressive strength as measured by KT-49

decreased by approximately 150 psi for each one-point increase in workability difference, as seen in Figure 2.1.

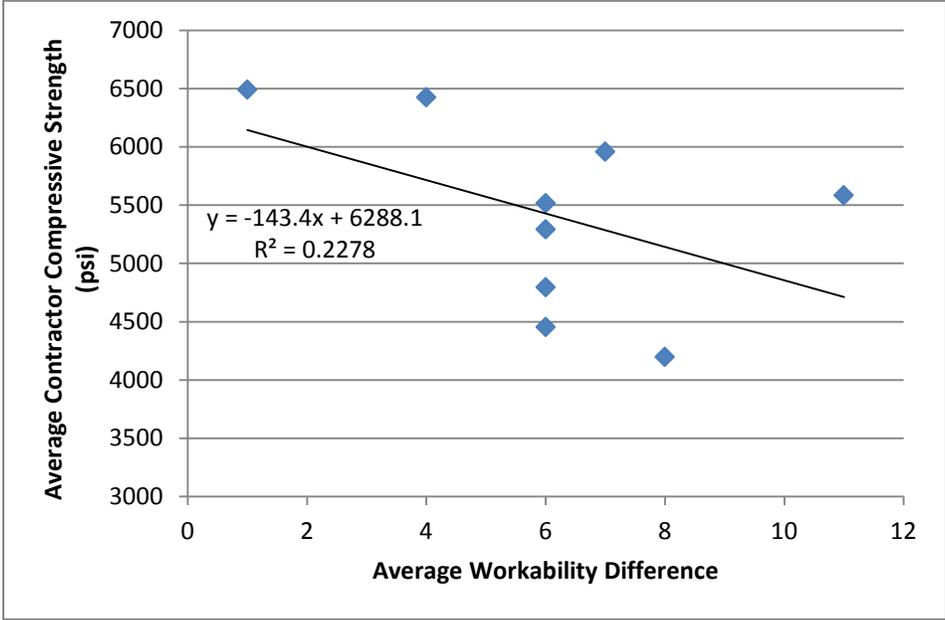


FIGURE 2.1
Variation of Daily Average 28-Day Core Strength with Daily Average Workability Difference

The total air content as measured by KT-18, Air Content of Freshly Mixed Concrete by the Pressure Method, may also vary with the workability difference. The daily average total air content was compared with the average workability difference from the same date. As seen in Figure 2.2, the air content tends to increase as the workability increases from 1 to 6, and to decrease as the workability difference decreases from 6 to 11.

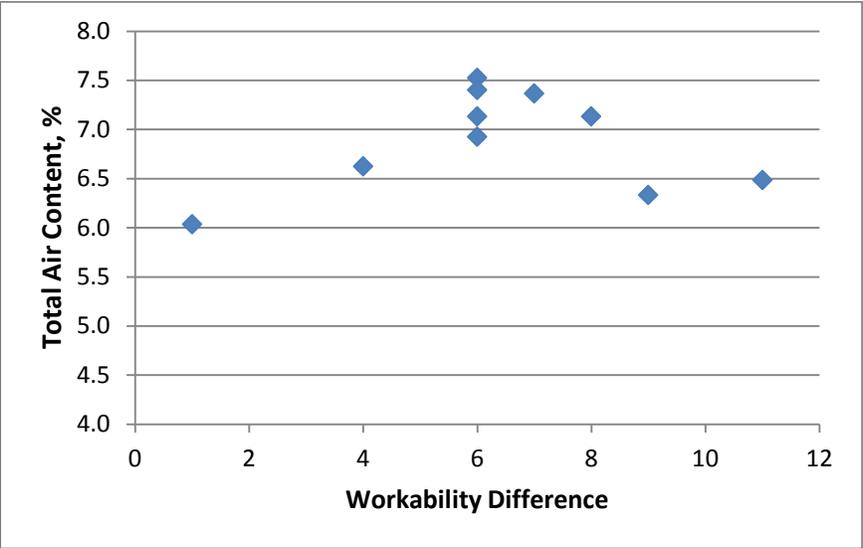


FIGURE 2.2
Variation of Daily Average Total Air Content with Daily Average Workability Difference

Chapter 3: Conclusion

The only statistically significant difference in the hardened concrete properties between the lowest workability difference concrete and the highest workability difference concretes was in strength. This effect was observed in samples cored and tested at the time of construction, but not in those cored and tested later. A correlation may exist between workability difference and total air content. The variability of both strength and air content may also increase with increasing workability difference.

