Plastic Air Content versus Hardened Air Content by High Pressure Air Meter

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for
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Plastic Air Content versus Hardened Air Content by High Pressure Air Meter

Final Report
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MLR-99-3

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8. ABSTRACT

Plastic air content is typically tested by the pressure method, ASTM C138. Loss of air content through the paver has been shown to exceed 2 percent at times. Research[1] has shown that early deterioration of pavements in Iowa may be directly or indirectly related to low or inadequate air content.

Hardened air content is typically checked using the linear traverse method, ASTM C457. The linear traverse method is very time consuming and could not be used on a production scale. A quick and effective method of testing in place air content is needed.

Research has shown a high degree of correlation with the high-pressure method of determining air content of hardened concrete versus plastic air content in laboratory conditions. This research indicated that air contents are more variable when comparing core results to plastic air content, although the overall average for the air content was comparable. Perhaps, the location of the plastic air content test, obtained from construction records, versus location of the cores was not as accurate as needed.

9. KEY WORDS	10. NO. OF PAGES
Air Content High Pressure Air Test	14

TABLE OF CONTENTS

DISCLAIMER

INTRODUCTION

It is well known that entrained air in Portland cement concrete pavements is critical to provide protection from freezing and thawing. Research[1] has shown that early deterioration of pavements in Iowa may be directly or indirectly related to low or inadequate air content. Plastic air content is tested by the pressure method, ASTM C138. Samples are typically taken ahead of the paver before consolidation and loss of air through the paver has been shown to exceed 2 percent at times. (Figure 2) Hardened air content is typically checked using the linear traverse method, ASTM C457. The linear traverse method is very time consuming and could not be used on a production scale. A quick and effective method of testing in place air content is needed.

Research[2] has shown that the high-pressure method of determining air content of hardened concrete gives highly reliable results compared to plastic air content in laboratory conditions. This research investigates the possibility of using the high-pressure method to determine in place air content of concrete pavements. A few cores were also examined for air content using the scanning electron microscope (SEM) and image analysis for comparison purposes.

TEST METHODS

High-Pressure Air Content Test Procedure

The Illinois DOT developed the high-pressure air test method in the late 1940's. Iowa has been using the high-pressure air test on cores obtained for thickness since 1969 for project information. The test utilizes the principles of Boyles Law with pressure and volume. Basically, the volume of a core is obtained from dry weight and weight in water and is subjected to a pressure of 5000 psi. The volume of liquid forced into the core is equivalent to the amount of entrained air minus a correction factor for the coarse aggregate. The cores obtained in this research were tested in accordance with Iowa Test Method 407-B. A picture of the equipment is shown in Figure 1 of the Appendix.

Air Content SEM Image Analysis

Air contents were determined on slices obtained from the top, middle, and bottom of the additional cores obtained on each project. Air content and air void parameters were determined by the method proposed by Scott Schlorholtz in research project HR-396[2]. The method is similar to that in ASTM C 457. Forty images were taken with the SEM on one face of each slice. Each image was analyzed with an image analysis software program and the results were averaged. The final air content was determined by averaging the test results from the top, middle, and bottom faces to obtain an overall average for the core.

PROCEDURE

Cores were obtained from locations on three 1999 paving projects at the point where plastic air tests were taken before and after consolidation. The locations were noted by construction personnel and cores were taken at that station. The projects were located on I-35 Story County, US 30 Benton County, and US 18 Cerro Gordo County. The before and after consolidation air contents were noted at each location (Figure 2). The plastic air content after consolidation was compared to the high-pressure air content of cores obtained from those areas. The high-pressure air content was corrected for the void content of the coarse aggregate. At three locations on each project, an additional core was obtained to compare air analysis using SEM micrographs and image analysis.

TEST RESULTS

Results of air contents are plotted in Figures 4 and 5.

Plastic air after consolidation versus high-pressure air content

For each project, the plastic air content after consolidation was plotted against the high-pressure air content and linear regression was performed. Results indicated a fair correlation on the Benton US 30 and Story I-35 projects with an

r^2=0.511 and 0.556 respectively. No correlation whatsoever was established on the Cerro Gordo US 18 project. The results for each project are plotted on Figures 5-7.

Plastic air content was plotted against the high-pressure air content for all projects and an r^2=0.347 was established. Results are plotted on Figure 8. The correlation, which was poor at best, included the Cerro Gordo US 18 data. With the data from this project removed an r^2 of 0.490 was established. Results are plotted on Figure 9.

High-pressure air content versus image analysis air content

The high-pressure air content was plotted against the content determined by image analysis for all projects. Regression indicated an r^2 of 0.387. Removing the data from the Cerro Gordo project gave an r^2 of 0. 600.

DISCUSSION

The results did not indicate as good of a correlation between plastic air content and high-pressure air content, as previous research had indicated. Perhaps the precise location of the concrete was not given as accurately as needed for this research. The overall average plastic air content, before consolidation, was fairly close to the overall average for the high-pressure air content at 7.7 % and 7.2% respectively. Also, the overall average air content for the plastic air content, after consolidation, was fairly close to the overall average for the air content checked by image analysis at 5.9 % and 6.3% respectively.

Although the average air contents for each were close, there was poor correlation between the data. The data was in the normal range for air content.

CONCLUSIONS

The research indicated the following conclusions:

1. Although a 0.99 correlation between plastic and high pressure hardened air content was determined in laboratory testing, a 0.490 correlation was determined from field testing, when the Cerro Gordo results are removed. These results may have been based on inaccurate placement of coring where actual plastic air tests were taken.

2. A 0.600 correlation between hardened air and image air contents was determined, when the Cerro Gordo results are removed.

3. Since the high pressure air test usually gives good results, the best approach to determine correlation with plastic air may be to correlate plastic air results versus hardened air results for the entire project.

ACKNOWLEDGEMENTS

The writers would like to thank Ken Kennedy of the Cement and Concrete Section for performing the high-pressure air testing and Jerry Amenson and Warren Straszheim of Iowa State University MARL laboratory for performing the image analysis testing of air content.

REFERENCES

1. Schlorholtz, S., Determine Initial Cause for Current Premature Portland Cement Concrete Pavement Deterioration, TR-406, 2000

2. Schlorholtz, S., Image Analysis for Evaluating Air Void Parameters of Concrete, HR-396, 1998

APPENDIX

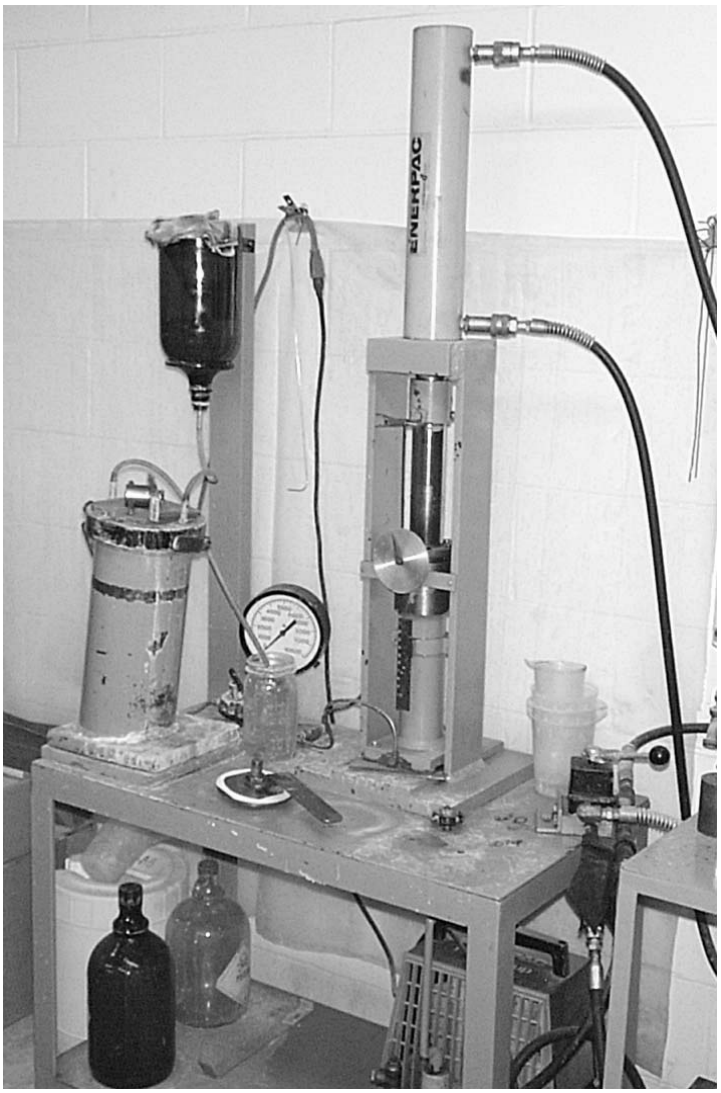


Figure 1. High Pressure Air Test Equipment

Figure 2. Air Test Results

County	Route	Station	Plastic Air Before %	Plastic Air After %	HP Air Air Content %	Image Analysis Air %
Benton	US 30	966+25	8.4	6.8	8.51	8.36
Benton	US 30	939+50	8.0	6.4	7.55	
Benton	US 30	917+00	7.9	7.1	9.34	
Benton	US 30	887+00	7.6	6.4	7.04	7.33
Benton	US 30	846+40	7.4	6.3	10.00	
Benton	US 30	831+50	7.9	6.7	9.13	
Benton	US 30	824+00	8.0	6.9	9.24	
Benton	US 30	797+80	6.9	5.2	7.55	
Benton	US 30	777+00	7.6	5.3	7.38	
Benton	US 30	733+50	7.8	5.3	5.99	
Benton	US 30	720+25	9.6	5.3	7.12	6.45
Floyd	US 18	271+50 EB	6.5	5.4	7.31	5.56
Floyd	US 18	298+20 EB	7.4	5.0	7.74	
Floyd	US 18	334+60 EB	7.0	6.2	7.15	
Cerro Gordo	US 18	427+20 WB	7.0	5.0	6.83	
Cerro Gordo	US 18	378+55 WB	7.2	5.5	7.16	5.47
Cerro Gordo	US 18	322+60 WB	7.6	5.4	6.39	7.13
Cerro Gordo	US 18	299+70 WB	7.2	5.6	6.51	
Cerro Gordo	US 18	276+90 WB	7.6	6.6	7.17	
Hamilton	I-35	243+30	8.2	6.2	7.39	
Hamilton	I-35	209+90	8.5	7.1	7.63	
Hamilton	I-35	171+75	9.0	5.5	5.07	
Hamilton	I-35	147+25	8.1	5.9	6.70	
Hamilton	I-35	58+25	8.2	5.8	5.35	4.81
Hamilton	I-35	21+50	7.1	5.5	6.06	
Story	I-35	5562+75	7.7	5.8	5.71	
Story	I-35	5483+50	7.2	5.3	6.13	
Story	I-35	1074+35	8.0	6.5	8.36	7.33
Story	I-35	1010+00	7.5	5.6	6.83	4.13
Story	I-35	984+00	6.6	5.4	5.87	
		Average	7.7	5.9	7.2	6.3
		Std. Dev	0.7	0.6	1.2	1.4

Figure 3. Plastic Air Contents

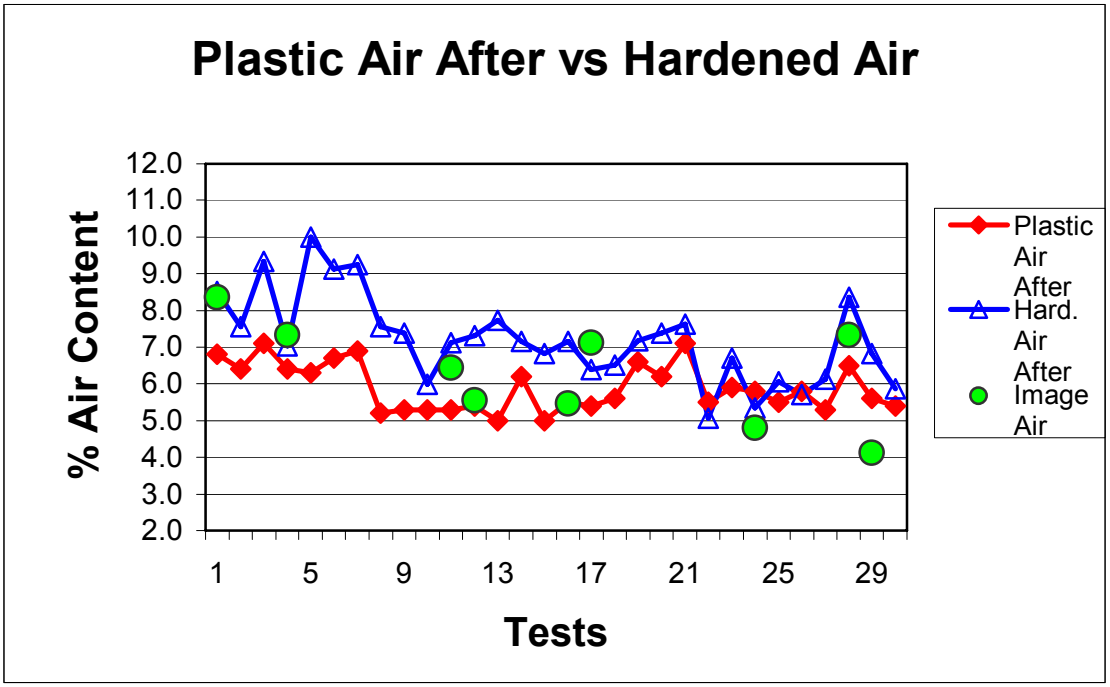


Figure 4. Hardened Air Contents

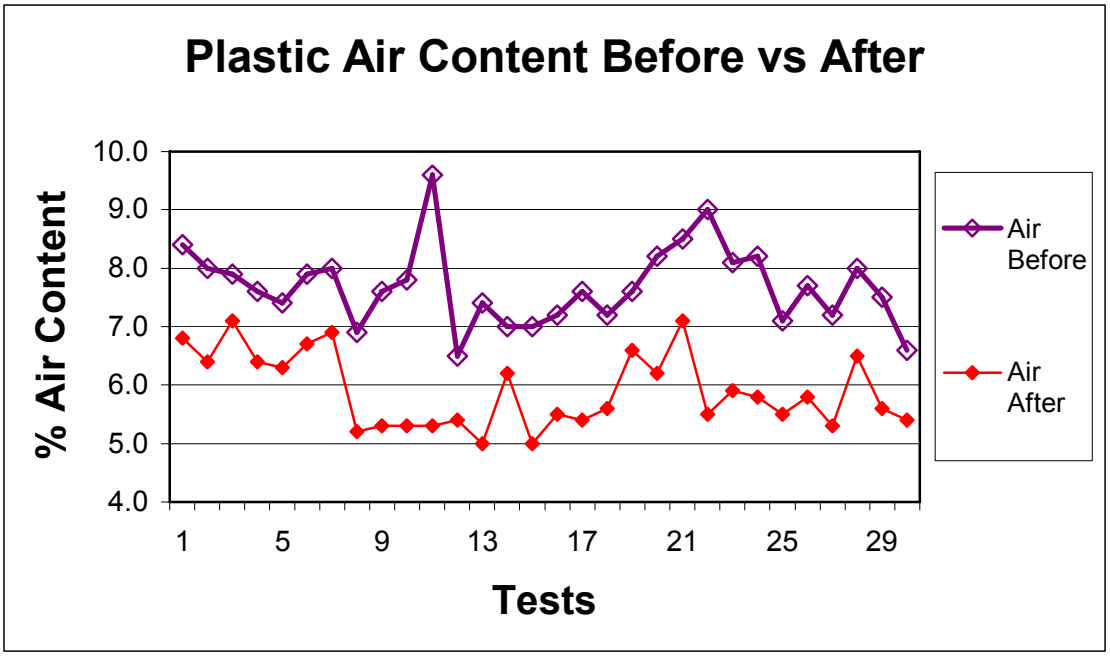


Figure 5. Hardened vs. Plastic Air Story County I-35

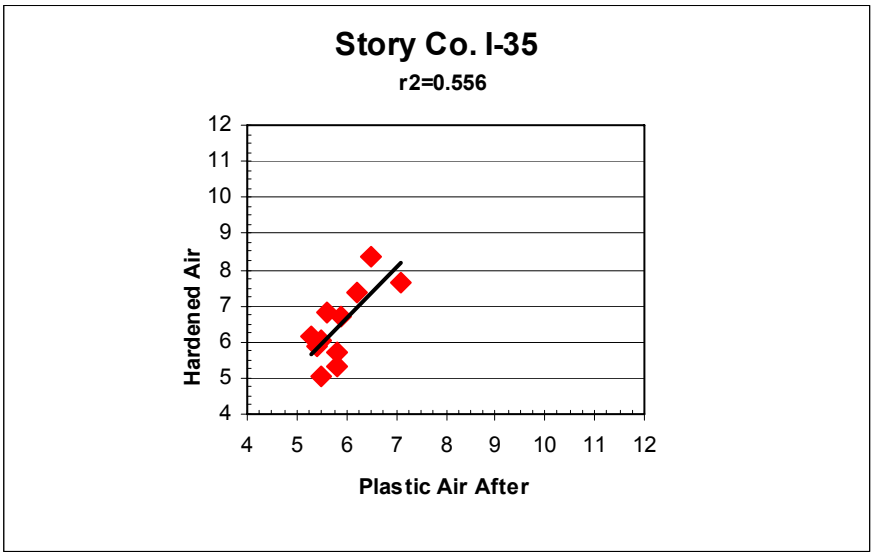


Figure 6. Hardened vs. Plastic Air Benton County US 30

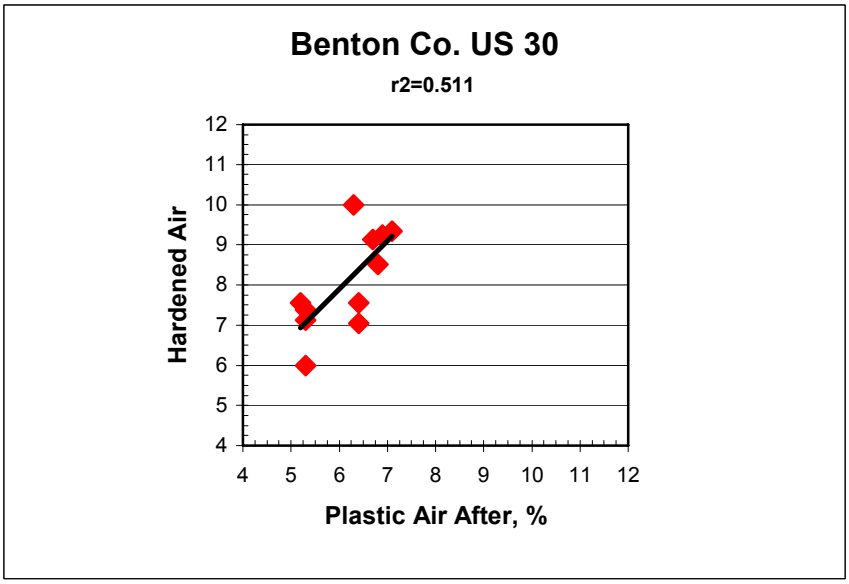


Figure 7. Hardened vs. Plastic Air Cerro Gordo County US 18

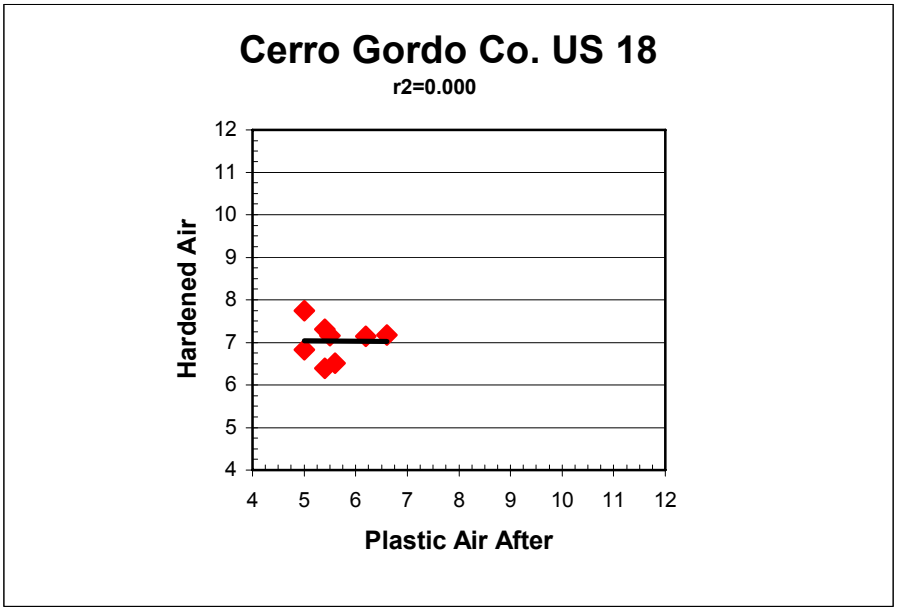


Figure 8. Plastic vs. Hardened Air All Projects

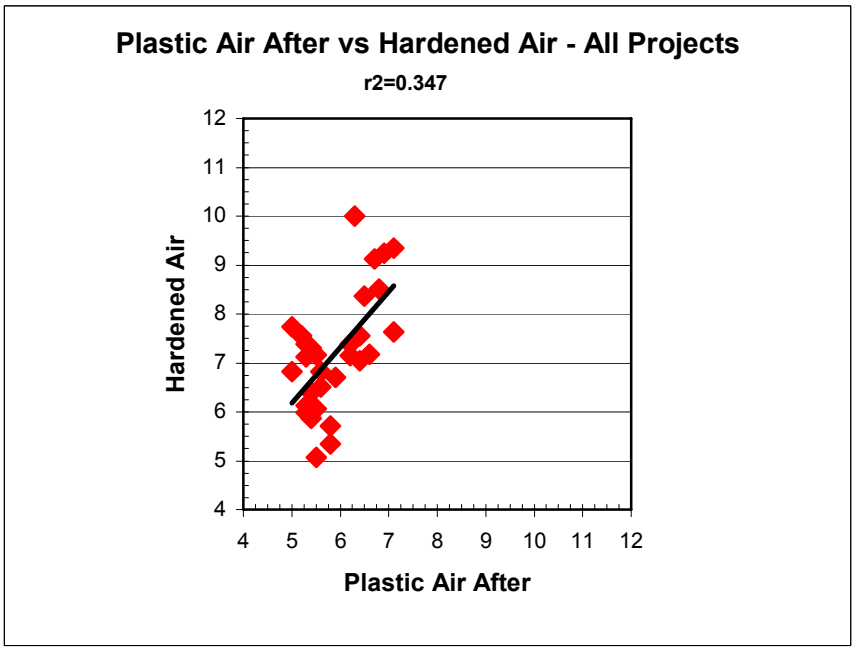
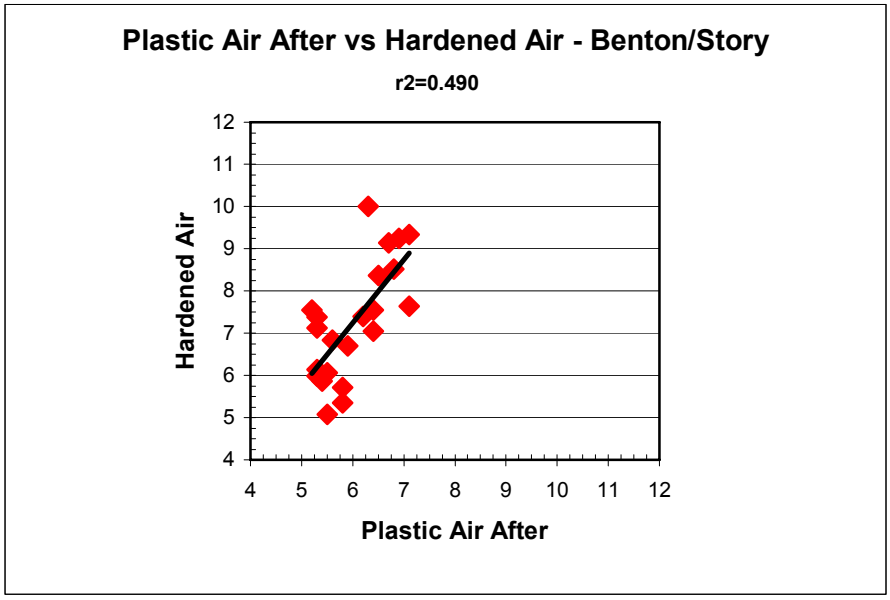
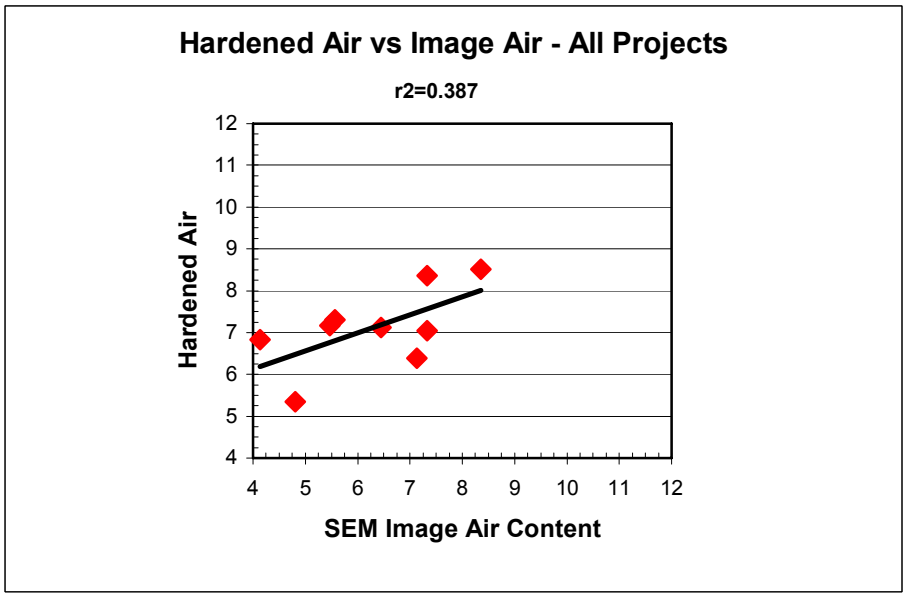
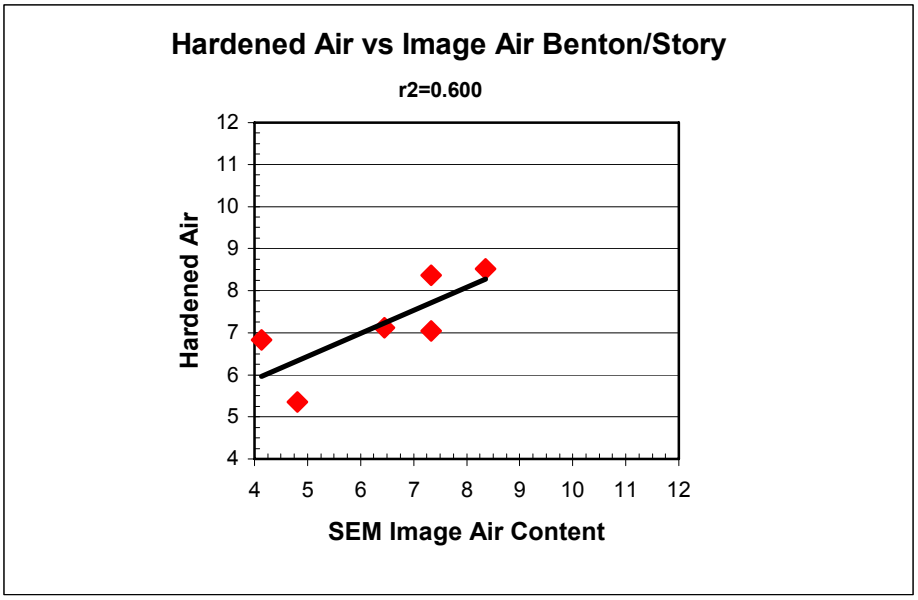


Figure 9. Plastic vs. Hardened Air – Benton/Story County Projects






Hardened Air vs Image Air Benton/Story
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Hardened Air
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10
11
12