Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
TX-95-2918-1F		

4. Title and Subtitle	5. Report Date
PRODUCTION VARIABILITY ANALYSIS OF HOT-MIXED ASPHALT CONCRETE CONTAINING RECLAIMED ASPHALT PAVEMENT	February 1995
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Mansour Salaimanian and Thomas W. Kennedy	Research Report 2918-1F

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Center for Transportation Research The University of Texas at Austin 3208 Red River, Suite 200 Austin, Texas 78705-2650	11. Contract or Grant No. Research Study 7-2918
	13. Type of Report and Period Covered Final
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Transfer Office P. O. Box 5051 Austin, Texas 78763-5051	14. Sponsoring Agency Code

15. Supplementary Notes

Study conducted in cooperation with the Texas Department of Transportation
Research study title: "Production Variability Analysis of HMAC Containing RAP"

16. Abstract

A research project was undertaken to evaluate the production and construction variability of HMAC containing high quantities of RAP material. Four construction projects were selected for this purpose. Two of the projects used 35 percent RAP material (both type-C mixes), while the other two used 40 percent (a type-B mix) and 50 percent (a type-D mix) of the RAP material, respectively. The projects differed in sizes, with total construction tonnage ranging from 10.9 million kg to 27.2 million kg (12,000 to 30,000 tons). In all cases, dedicated stockpiles of RAP material were used. A series of tests according to TxDOT Special Specification Item 3007 (Quality Control/Quality Assurance of Hot Mix Asphalt) were performed both in the hot-mix plant laboratory and in The University of Texas (UT) asphalt laboratory. The tests in the plant included extraction, gradation determination, and determination of asphalt content using a nuclear gauge. A series of specimens were also compacted and shipped to the TxDOT Materials and Tests Division for Hveem stability testing. The tests conducted in the UT laboratory were the same as those conducted in the plant; in addition, the researchers undertook asphalt recovery, penetration, and viscosity tests for both the HMAC and RAP. Attempts made to obtain samples four times a day for four sublots (in accordance with TxDOT Special Specification Item 3007) were not successful on all days, owing to low tonnage or other problems. Analysis was performed on the results obtained from the tests. The gradation and asphalt content deviations, air voids, penetration and viscosities, and stabilities were included in the analysis. Pay adjustment factors were determined for gradation and asphalt content deviation, as well as for air voids (based on TxDOT Specification 3007). In general, these high-percent RAP projects indicated a variability higher than that of a typical HMAC without RAP. The pay adjustment factors for gradation and asphalt content deviation were lower than typical values. The construction gradations were finer than the job-mix formula target gradations, possibly a result of aggregate crushing during the milling operation.

17. Key Words	18. Distribution Statement
Hot-mix asphalt concrete (HMAC), reclaimed asphalt pavement (RAP), production variability, construction variability, total construction tonnage, stockpiles, pay adjustment factors (PAF), asphalt content	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	136	

PRODUCTION VARIABILITY ANALYSIS OF HOT-MIXED ASPHALT CONCRETE CONTAINING RECLAIMED ASPHALT PAVEMENT

by

Mansour Solaimanian
Thomas W. Kennedy

Research Report Number 2918-1F

Research Project 7-2918
Production Variability Analysis of HMAC Containing RAP

Conducted for the

TEXAS DEPARTMENT OF TRANSPORTATION

by the

CENTER FOR TRANSPORTATION RESEARCH
Bureau of Engineering Research
THE UNIVERSITY OF TEXAS AT AUSTIN

February 1995

IMPLEMENTATION STATEMENT

The results of this study impact the way reclaimed asphalt pavement (RAP) is utilized in hot-mixed asphalt concrete (HMAC). The information on RAP variability and its effect on HMAC variability can be very beneficial in determining the acceptable range of RAP quantity that can be used without adverse effects on the quality and performance of HMAC. Based on the findings of this study, the currently available specifications regarding utilization of RAP in HMAC may be modified by the Texas Department of Transportation (TxDOT).

Prepared in cooperation with the Texas Department of Transportation

PREFACE

This is the first and final report for project 7-2918, "Production Variability Analysis of HMAC Containing RAP." The report focuses on the variation in the quality of hot-mixed asphalt concrete as a result of utilizing different amounts of RAP material. The report presents the information and findings based upon a series of tests performed both in the plant during construction and in the laboratory for four projects.

The authors would like to express their appreciation to the personnel of the Texas Department of Transportation (TxDOT), especially those directly involved with the projects in the districts, and the personnel of the Materials and Tests Division in performing the stability tests. Special thanks are extended to Mr. Maghsoud Tahmoressi and Ms. Caroline Herrera of TxDOT for their great help and guidance throughout the project. Thanks are also extended to Mr. Eugene Betts for conducting a large number of tests required for the project. The assistance of the Center for Transportation Research staff in providing this report is also greatly appreciated.

DISCLAIMERS

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation.

There was no invention or discovery conceived or first actually reduced to practice in the course of or under this contract, including any art, method, process, machine, manufacture, design or composition of matter, or any new useful improvement thereof, or any variety of plant, which is or may be patentable under the patent laws of the United States of America or any foreign country.

NOT INTENDED FOR CONSTRUCTION, BIDDING,
OR PERMIT PURPOSES

Thomas W. Kennedy, P.E. (Texas No. 29596)
Research Supervisor

TABLE OF CONTENTS

SUMMARY

A research project was undertaken to evaluate the production and construction variability of HMAC containing high quantities of RAP material. Four construction projects were selected for this purpose. Two of the projects used 35 percent RAP material (both type-C mixes), while the other two used 40 percent (a type-B mix) and 50 percent (a type-D mix) of the RAP material, respectively. The projects differed in sizes, with total construction tonnage ranging from 10.9 million kg to 27.2 million kg (12,000 to 30,000 tons). In all cases, dedicated stockpiles of RAP material were used. A series of tests according to TxDOT Special Specification Item 3007 (Quality Control/Quality Assurance of Hot Mix Asphalt) were performed both in the hot-mix plant laboratory and in The University of Texas (UT) asphalt laboratory. The tests in the plant included extraction, gradation determination, and determination of asphalt content using a nuclear gauge. A series of specimens were also compacted and shipped to the TxDOT Materials and Tests Division for Hveem stability testing. The tests conducted in the UT laboratory were the same as those conducted in the plant; in addition, the researchers undertook asphalt recovery, penetration, and viscosity tests for both the HMAC and RAP. Attempts made to obtain samples four times a day for four sublots (in accordance with TxDOT Special Specification Item 3007) were not successful on all days, owing to low tonnage or other problems. Analysis was performed on the results obtained from the tests. The gradation and asphalt content deviations, air voids, penetration and viscosities, and stabilities were included in the analysis. Pay adjustment factors were determined for gradation and asphalt content deviation, as well as for air voids (based on TxDOT Specification 3007). In general, these high-percent RAP projects indicated a variability higher than that of a typical HMAC without RAP. The pay adjustment factors for gradation and asphalt content deviation were lower than typical values. The construction gradations were finer than the job-mix formula target gradations, possibly a result of aggregate crushing during the milling operation.

CHAPTER 1. INTRODUCTION

1.1. BACKGROUND AND SIGNIFICANCE OF WORK

Considerable research has been undertaken regarding not only the use of salvaged recycled asphalt pavement, but also the processes used to both remove and reuse the product (Refs 1, 2 and 3). This recycled asphalt, more commonly referred to as reclaimed asphalt pavement (RAP), is defined as salvaged, milled, pulverized, broken, or crushed asphalt pavement (Ref 4). RAP represents a significant asset, and the tendency until recently has been to remove the material completely, with the ownership transferring to the contractor. On occasions the contractor has elected to stockpile this material and utilize all new material in the project. At present in Texas, the RAP is owned by the state and, thus, must be utilized by the state in future projects. Under the current Texas Department of Transportation (TxDOT) QC/QA specifications, a maximum of 20 percent of the RAP is allowed in surface mixtures. It is important to obtain information on the anticipated variability and its impact on production of a satisfactory product meeting the established needs of the particular project.

This short-term study investigates the variability of available RAP produced under previously existing TxDOT specifications; it also attempts to determine the impact of utilizing varying percentages of RAP in the production and control of HMAC as produced under current QC/QA specifications. Combined with this need is the need to convey the information provided by this study in such a manner as to be compatible with or supportive of the QC/QA HMAC standard specifications currently being used by TxDOT. Although many individual studies have been conducted both nationally and in this state, there exists a need to bring this information together through a formalized literature search.

This study will utilize actual values developed from field production of HMAC materials using varying percentages of RAP in TxDOT paving projects. These data, combined with the results of the literature search, will provide the basis for responding to the needs expressed by TxDOT.

1.2. OBJECTIVE OF THE STUDY

The objectives of this study are to (1) determine the variability that exists in stockpiles of RAP material; (2) determine the variability in the plant-produced HMAC containing between 20 and 50 percent RAP; and (3) provide statistical information on RAP variability and its influence on HMAC through data analysis. These data will be used to determine the allowable maximum amount of RAP and its effect on the mixture quality. The data will be useful in improving TxDOT QC/QA HMAC specifications and test procedures.

1.3. RESEARCH APPROACH

Originally, it was anticipated that five projects utilizing RAP material would be included in this study. However, during the course of the study only four projects were available for

performing tests and collecting data; that is, only those projects using at least 20 percent RAP material were considered. A certified technician from The University of Texas at Austin (UT) was assigned to attend the projects and perform a series of quality control and quality assurance tests according to TxDOT specifications. In all cases, close cooperation and coordination were maintained between the UT and TxDOT personnel in carrying out the tests in the plant. Samples from both the plant mix and the RAP material were also shipped to the UT laboratory for further testing and evaluation. Data analysis began as soon as the first set of field and laboratory test results became available. The results are presented in this report.

1.4. ORGANIZATION OF THE REPORT

Chapter 2 discusses the experimental program and data collection procedure. Chapter 3 presents the data and discusses the results, while Chapter 4 provides conclusions and recommendations.

CHAPTER 2. EXPERIMENTAL PROGRAM

2.1. GENERAL

To achieve the objectives of this research project, the following tasks were identified in cooperation with TxDOT (as necessary):

- Selection of appropriate projects using RAP
- Determination of variability in RAP materials
- Determination of variability of asphalt mixtures containing RAP
- Investigation of relationship between RAP variability and HMAC variability

2.2. PROJECT SELECTION

Selection of HMAC projects utilizing high percentages of RAP was an essential part of this project. The intent was to select five projects having at least 10 days of operation and which utilized at least 20 percent of the RAP material. This task was achieved mainly through cooperation with TxDOT. During the course of this research project, however, no more than four projects were found that satisfied the required criteria with respect to the percentage of RAP. Moreover, one of these projects did not have more than five days of operation; but because of the limited number of projects available, it was included in the study. Table 2.1 indicates the RAP projects selected for this study. Figure 2.1 indicates the districts in which these projects are located.

Table 2.1. RAP projects investigated during the research project

Project	District	County	Highway	Aggregate Source	Asphalt Source	Mixture Type	% RAP
IM20-2(174)295	Abilene	Callahan	IH 20	Vulcan Material	Coastal AC-10	C Surface	35
IM20-6(71) 580	Tyler	Gregg	IH 20	G-H Perch & CXI	Lion AC-10	C Base	35
CPM 5-5-81	Abilene	Howard	IH 20	Transit Material	Fina AC-10	D Surface	50
NH94(21)M	Pharr	Cameron	SH 100	Parker La Farge and Fordyce	Coastal AC-5	B Base	40

It should be noted that three different percentages of RAP are included in this study.

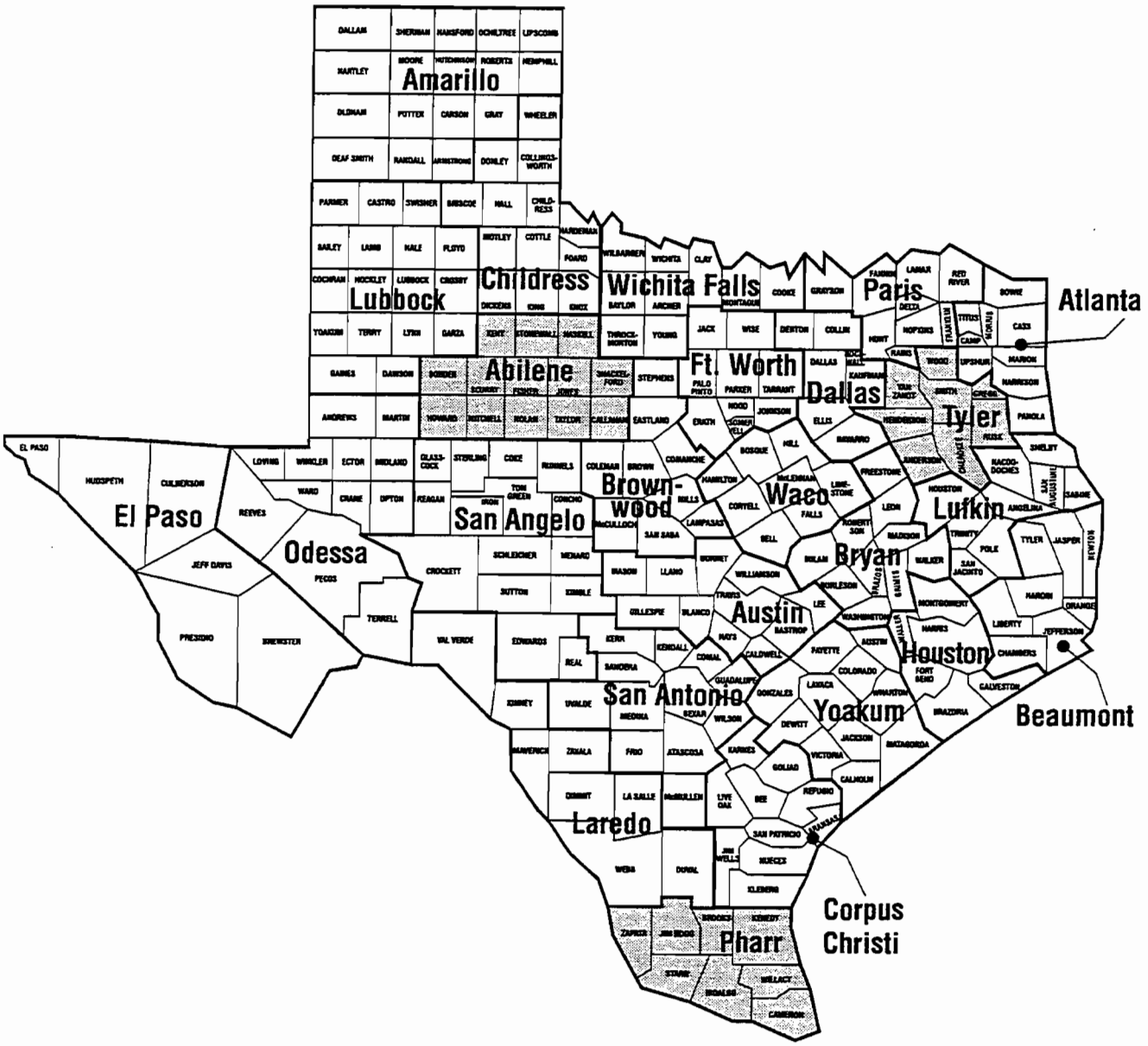


Figure 2.1. Shaded areas indicate districts where HMAC projects with RAP were constructed

Callahan County (IH-20)

The type-C surface course for this project, which was laid down in July of 1994, used a total of approximately 10.8 million kg (12,000 tons) of HMAC. The total construction period did not last for more than five days. However, samples were taken during all five days. The original design indicated an asphalt content of about 6.8 percent (of total weight of mixture) for the RAP material. Thirty-five percent RAP in the mix provided 2.3 percent of the total 5.8 percent job mix formula AC content required in the mix. During the last day of construction, the design was changed to use a slightly finer gradation, as well as a 0.2 percent reduction in total asphalt content. Asphalt content was determined based on the results from extraction tests. Nuclear measurements for asphalt content were not carried out for this project.

Gregg County (IH-20)

A type-C mix was used as a base course for this project. The construction took place during the months of May and early June of 1994. A total of approximately 13.6 million kg (15,000 tons) of HMAC was laid down within a 9-day period. However, since the plant was used to give service to three different projects at the same time, the construction of the HMAC with RAP was not continuous, and these nine days are distributed over approximately a one-month period. On the average, about two days per week the plant was used for the RAP project. Original design had indicated that the RAP material had an asphalt content of 4.5 percent. Thirty-five percent of the RAP material provided 1.6 percent of the job-mix formula design asphalt content of 3.8 percent. The only problem noticed in the very beginning of the project was that the resulting asphalt binder did not meet the TxDOT specifications for penetration. Necessary modifications were made until this problem was resolved. During all nine days, samples from the mix were obtained. On two of the days, only two samples of the mix were obtained because of the limited production (low tonnage) on those days. Unfortunately, samples of the RAP were taken during only three days of construction. Nuclear measurements for asphalt conduct were not carried out for this project.

Howard County (IH-20)

The type-D surface course used in this project was laid down during the second half of May and early in June of 1994. Approximately 18.1 million kg (20,000 tons) of HMAC were used for this project. The construction lasted a total of twelve days. Samples were taken during all days of construction. Based on the original design, the RAP material had an asphalt content of about 5.6 percent. Fifty percent of RAP, used in this project, accounted for 2.8 percent of the job mix formula asphalt content of 5.6 percent. During the first four days of construction, the mix gradation was considerably finer than the design gradation, possibly because the RAP gradation for the original design was obtained from road cores. This gradation could be significantly coarser than the resulting RAP because of the aggregate crushing during milling operation. A redesign was conducted based on the finer gradation of the roadway RAP. In this way, the combined gradation of the virgin aggregate, which accounts for 50 percent of the total gradation, was

adjusted. As a result, the final gradation (RAP combined with virgin aggregate) was slightly different from the original gradation. The job-mix formula target asphalt content was also re-designed considerably, changing from 5.6 percent to 4.8 percent. The daily construction asphalt content was determined using both extraction results and nuclear measurements.

Cameron County (SH 100)

The construction for this project took place during the month of August 1994. Approximately 27.2 million kg (30,000 tons) of a type-B mix were used on State Highway 100 for the base course during eleven construction days. The aggregates were limestone and crushed gravel, and the virgin asphalt was Coastal AC-5. Forty percent RAP material, milled from Loop 374, was used in this project. The RAP and mix design asphalt contents were 6.1 and 4.7 percent, respectively. Two extraction tests were conducted in the plant laboratory, while four samples per day of construction were shipped to The University of Texas asphalt laboratory for additional testing (extraction, abson recovery, etc.). The daily construction asphalt content was determined using both extraction results and nuclear measurements.

2.3 SAMPLE PROCUREMENT

To obtain the required samples for quality control/quality assurance, we followed TxDOT Special Specification Item 3007 (Ref 4). We organized the following schedule for sample procurement.

1. Samples of the RAP material were taken for each of the selected ten days of production (one sample per day). It was expected that a total of 40 RAP samples would be obtained through the life of this research study (10 samples per construction project for four projects). However, as mentioned before, a limited number of RAP samples were obtained because of the limited number of construction days (average of about seven RAP samples per project). These samples were shipped to the UT laboratory for testing.
2. Samples of the asphalt mixtures were taken four times per production day according to the TxDOT recommended procedures (one sample per sublot assuming a total of four sublots).
3. Up to four sets of specimens per day were molded and shipped to TxDOT Materials and Tests Division.
4. One sample of the mixture per day was taken and shipped back to the UT laboratory.

This schedule was followed as closely as possible. However, on occasions, it was not quite possible to obtain all four samples from all four sublots, due to low daily tonnage or other problems. As a result, fewer samples were obtained in a few cases.

2.4. TESTING

Testing was carried out on both the RAP material and the plant mix. The following series of tests were performed in the plant laboratory:

1. Determination of asphalt content according to Tex-210-F
2. Determination of gradation according to Tex-200-F
3. Determination of asphalt content using nuclear gauge (Tex 228-F)
4. Determination of density of field cores (Tex-207-F)
5. Determination of maximum theoretical specific gravity (Tex-226-F)
6. Determination of the asphalt material viscosity according to ASTM D 2171
7. Determination of the asphalt material penetration according to ASTM D 5
8. Compaction of a series of three specimens per sublot to be tested at the TxDOT Materials and Tests Division (Tex-206-F)

In cases in which time was not sufficient to perform all the tests in the plant laboratory, the specimens were taken to The University of Texas asphalt laboratory, where testing was completed.

The preceding tests, as well as recovery of asphalt from bituminous mixtures by the abson process (Tex-211-F), were performed on specimens in the UT laboratory. The recovered asphalts were tested both for penetration at 25° C (77° F) and viscosity at 60° C (140° F). The UT tests were performed on the RAP material as well as the plant mix.

2.5. DATA COLLECTION AND ANALYSIS

Data from QC/QA tests at the site, as well as laboratory tests on the RAP material, were collected and organized in a database. The collected data were analyzed to determine the mean and standard deviation for quality control parameters of HMAC containing different amounts of RAP. The RAP stockpile variability was also determined through analysis. The analyzed data and calculated statistical parameters were related to the variability of the RAP and HMAC containing RAP.

CHAPTER 3. ANALYSIS AND DISCUSSION

3.1. GENERAL

This chapter presents and discusses the results from both the plant and the laboratory tests. Discussion is provided on variations in both RAP and mix gradation, variation in asphalt content, air voids, and stabilities. TxDOT Special Specification Item 3007 (Ref 4) was used as a guideline in evaluating the quality of the mix. According to this specification, certain requirements must be satisfied to ensure a paved road of high quality. The variations in asphalt material content, aggregate gradation, and air void levels must be within certain ranges to ensure better quality. Observed variations with respect to the job mix formula are compared with the operational tolerances outlined in the Special Specification (Table 3.1).

Table 3.1. Operational tolerances

ITEM	TOLERANCE (WEIGHT OR VOLUME)
Passing Each Sieve 3.81 cm (1-1/2 in.) through No. 10	Plus or Minus 5 %
Passing Each Sieve No. 40 through No. 200	Plus or Minus 3 %
Moisture Content, Percent	0-1
Laboratory Molded Bulk Density, Percent of Theoretical Maximum Specific Gravity	95.0 to 97.0
Stability	Minimum 35 - No Maximum

In addition, pay adjustment factors are determined for each project based on the values listed in TxDOT Special Specification Item 3007. According to this specification, pay adjustment factors (PAF) are determined for aggregate gradation (No. 10 and No. 200 sieves), asphalt material content, and in-place air voids (Tables 3.2 and 3.3). The PAF for gradation and asphalt content is called the pay adjustment factor for production, and PAF for air void is called the pay adjustment factor for placement. The total pay factor (TPA) is based on the applicable pay factors for production and placement.

Table 3.2. Pay adjustment factors for gradation

Pay Adjust. Factor	Mean Absolute Deviation from Job-Mix Formula Target (Percent)	
	Pass No. 10	Pass No. 200
1.05	0.00 - 0.99	0.00 - 0.50
1.02	1.00 - 1.90	0.51 - 0.90
1.00	1.91 - 3.00	0.91 - 1.50
0.95	3.01 - 4.00	1.51 - 2.00
0.90	4.01 - 5.00	2.01 - 2.50
0.85	5.01 - 6.00	2.51 - 3.00
0.80	6.01 - 7.00	3.01 - 3.50
0.75	7.01 - 8.00	3.51 - 4.00
0.70	8.01 - 9.00	4.01 - 4.50
Remove	> 9.00	> 4.50

Table 3.3. Pay adjustment factors for air voids and asphalt material content

Pay Adjustment Factor	Measured Air Voids (Average of Two Cores per Sublot) (Percent)	Mean Absolute Deviation From Job-Mix Formula Target For Asphalt Content Material (Percent)
1.05	4.0 - 5.9	0.00 - 0.19
1.02	6.0 - 6.9	0.20 - 0.24
1.00	7.0 - 9.0	0.25 - 0.30
0.95	3.5 - 3.9 OR 9.1 - 9.5	0.31 - 0.35
0.90	3.0 - 3.4 OR 9.6 - 10.0	0.36 - 0.40
0.85	2.6 - 2.9 OR 10.1 - 12.0	0.41 - 0.45
0.80	12.1 - 13.0	0.46 - 0.50
0.75	13.1 - 14.0	0.51 - 0.60
0.70	14.1 - 15.0	0.61 - 0.65
Remove	> 15.0 OR < 2.6	> 0.65

The above pay adjustment factors are based on the mean absolute deviation from the job-mix formula target values. The mean absolute deviation is calculated as the sum of the absolute values of deviations from the job-mix formula targets for each of the four sublots divided by four (Ref 4). It is important to note that the TxDOT Special Specification 3007 is currently applicable to HMAC with a maximum allowable level of 20 percent RAP material. All the HMAC projects presented in this report have been using at least 35 percent RAP. Analysis and discussion of data obtained from various plant and laboratory tests are provided in this chapter.

3.2. AGGREGATE GRADATION

3.2.1. RAP Gradation

Tables A.1 through A.4 and Figures A.1 through A.4 (Appendix A) present the gradations of the RAP material for different projects. These gradations were obtained from extraction tests on samples taken daily from the RAP stockpile. In most cases, the RAP material has a higher variation in gradation than that of the HMAC. The mean absolute deviation from the average RAP gradation for sieves No. 10 and No. 200 is provided in Table 3.4. Some other statistical parameters are also provided in the table. The deviations for gradations reported in Table 3.4 were determined according to the following procedure for each project:

1. All gradations from extraction were considered.
2. The mean gradation from all gradations was determined
3. Deviation of each gradation from the mean gradation was determined.
4. The absolute values of deviations from step 3 were determined.
5. The mean and standard deviations for the absolute deviations obtained in step 4 were determined. The values calculated in this step were reported in Table 3.4.
6. The above steps were repeated for each project.

Table 3.4 Deviation from the mean value for various parameters

Project	Parameter	Deviation #10 Sieve		Deviation #200 Sieve		Deviation AC	
		RAP	MIX	RAP	MIX	RAP	MIX
Howard	Mean	3.33	4.48	0.95	2.22	0.49	0.29
Des#1	Std Dev	1.73	2.68	0.64	1.15	0.41	0.29
	COV, %	52	60	67	52	84	100
	Min	0.84	0.10	0.07	0.00	0.01	0.05
	Max	5.84	10.90	1.97	4.00	1.21	0.73
	Range	5.00	10.80	1.90	4.00	1.20	0.68
Howard	Mean	3.33	2.99	0.95	1.04	0.49	0.39
Des#2	Std Dev	1.73	2.09	0.64	0.76	0.41	0.21
	COV, %	52	70	67	73	84	54
	Min	0.84	0.10	0.07	0.00	0.01	0.15
	Max	5.84	6.20	1.97	2.40	1.21	0.55
	Range	5.00	6.10	1.90	2.40	1.20	0.41
	Mean	3.54	2.20	0.71	0.68	0.54	0.19
Callahan	Std Dev	2.88	1.47	0.41	0.61	0.44	0.12
	COV, %	81	67	58	90	81	63
	Min	0.90	0.10	0.10	0.00	0.03	0.07
	Max	7.00	5.20	1.10	1.90	1.08	0.30
	Range	6.10	5.10	1.00	1.90	1.05	0.23
	Mean	2.54	2.30	1.83	0.62	0.18	0.26
Cameron	Std Dev	1.30	2.74	1.24	0.75	0.17	0.26
	COV, %	51	119	68	121	94	100
	Min	1.30	0.13	0.44	0.04	0.00	0.02
	Max	5.70	13.67	4.24	3.36	0.31	1.12
	Range	4.40	13.54	0.00	3.33	0.31	1.10

Figures 3.1 and 3.2 exhibit the correspondence between standard deviations for the RAP gradation deviation and mix gradation deviation. It is important to note that the mix deviations reported in Table 3.4 and Figures 3.1 and 3.2 are obtained according to the steps above, and that they are not deviations from target values. Of course, the mix deviations from job-mix formula target values, for calculation of pay factors, are also analyzed and presented in a different set of plots and tables, as will be discussed later. One obvious conclusion from Figures 3.1 and 3.2 is the fact that variations for sieve No. 200 are smaller than those for sieve No. 10. However, no trend is observed to suggest that higher deviations in RAP correspond to higher deviations to the mix gradation. Nor can it be concluded that the higher percent of RAP results in higher deviations for the mix gradation. A possible explanation for this observation is the fact that a number of other parameters influence the variation of the mix gradation.

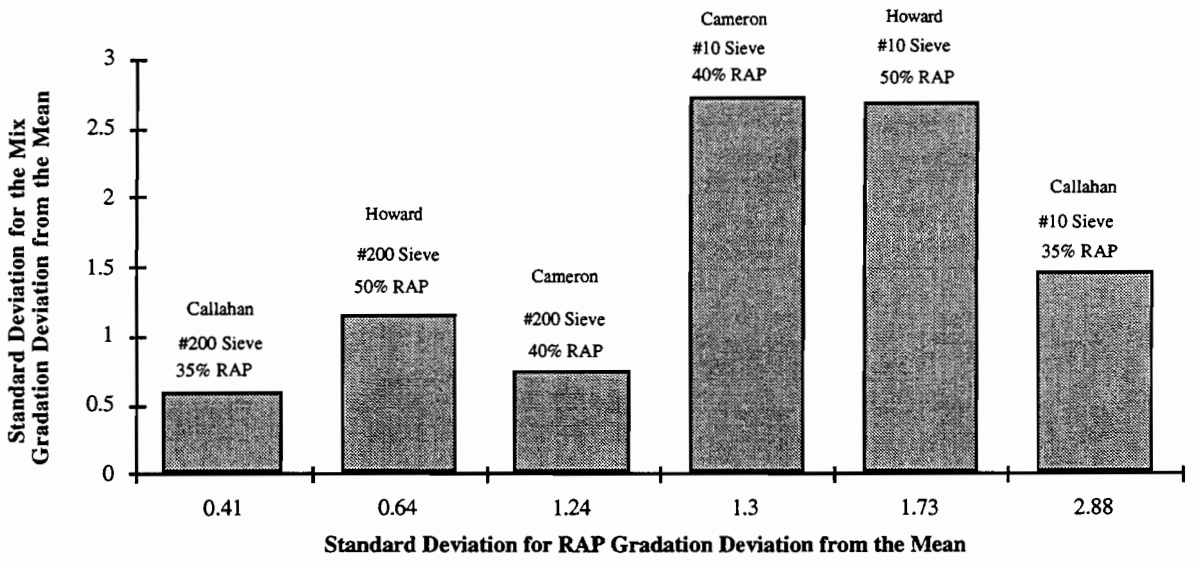


Figure 3.1. Relationship between standard deviation or RAP gradation variation with that of the mix

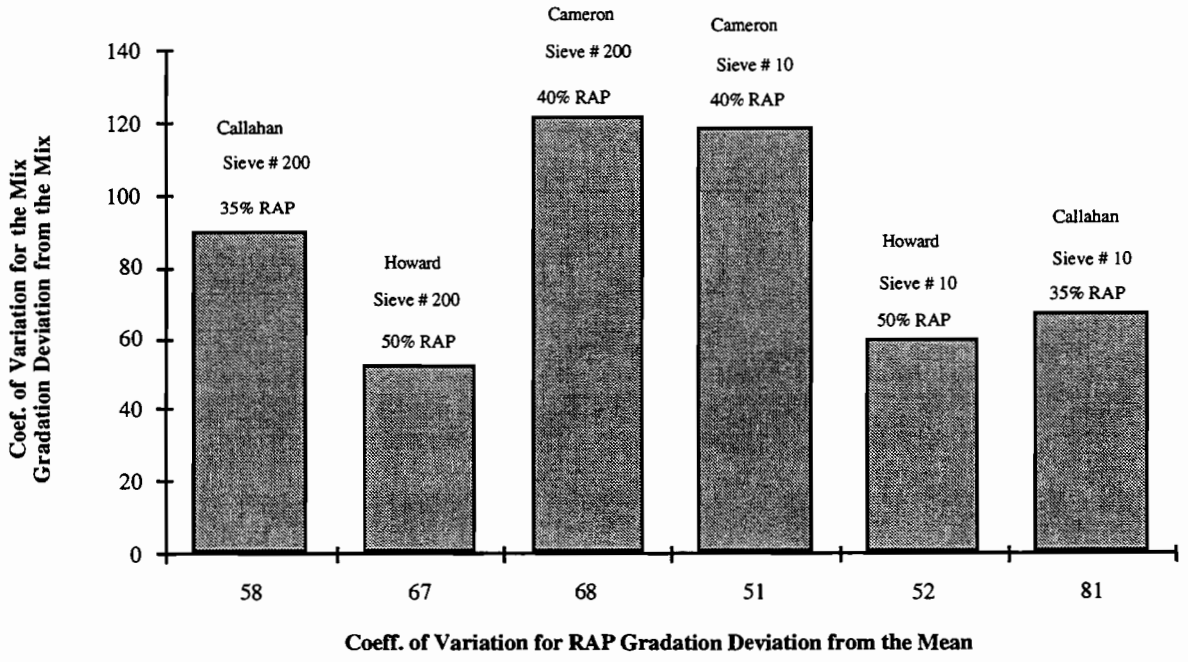


Figure 3.2. Relationship between coefficient of RAP gradation variation with that of the mix

3.2.2. Plant Mix Gradation

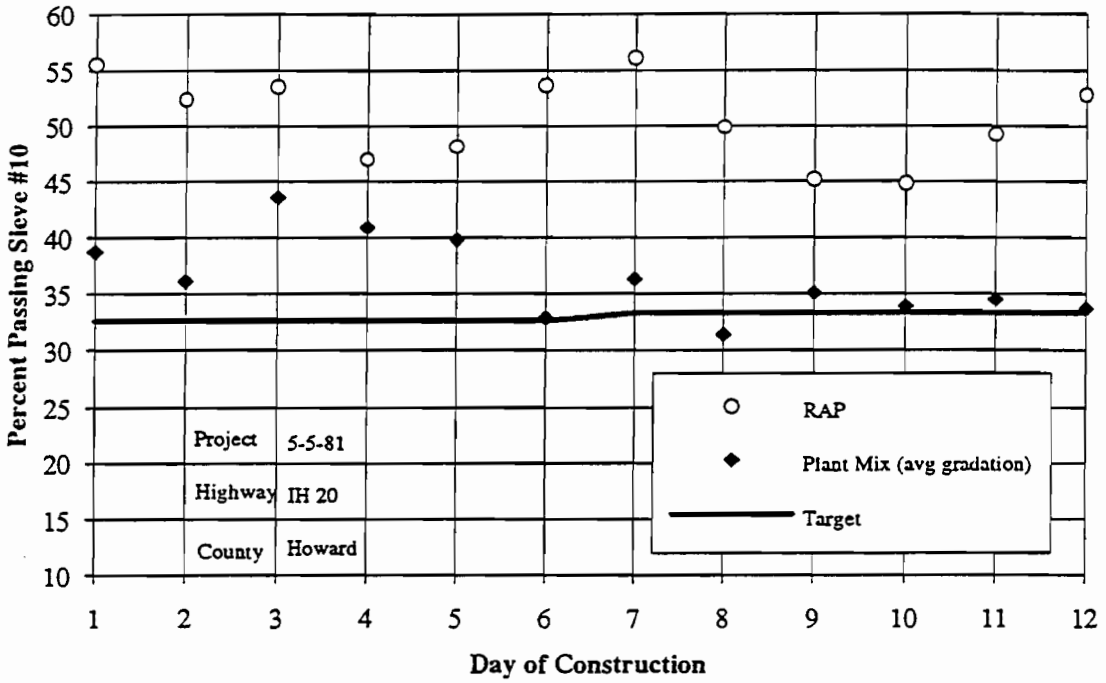
Tables B.1 through B.20 and Figures B.1 through B.32 (Appendix B) present the gradations for the plant mix obtained from extraction for different projects. For the project in Howard County, during the first four days of construction, the mix gradation was considerably finer than the design gradation, possibly because the RAP gradation for the original design was obtained from road cores. This gradation could be significantly coarser than the resulting RAP because of the aggregate crushing during milling operation.

A redesign was conducted based on the finer gradation of the roadway RAP. In this way, the combined gradation of the virgin aggregate, which accounts for 50 percent of the total gradation, was adjusted. As a result, the final gradation (RAP combined with virgin aggregate) differed slightly from the original gradation. Figures B.1 through B.32 indicate that for almost all projects the resulting daily gradations during construction are finer than the design gradation. Again, a possible explanation is that the RAP gradation has been determined from the cores from the old pavement, whereas the real RAP gradation during construction comes from milling, which tends to create a finer gradation than that obtained from the core.

Figures 3.3 through 3.5 indicate how the average daily gradation varies as construction progresses and how this gradation compares with the job-mix formula target gradation. Only the percent passing sieves No. 10 and No. 200 is presented. In these plots are also presented the daily RAP gradations. No particular trend is observed between the daily RAP gradation and average daily mixture gradation in any of the projects. This could be the case because the RAP specimen used for extraction may have not been representative of the RAP material used in the mix for a particular segment of construction.

Figures 3.6 through 3.9 present the control charts for sieves No. 10 and No. 200. In these figures, the solid lines indicate the percent passing sieves No. 10 and No. 200 for the job-mix-formula target values. Mean deviations from job-mix formula target gradations for sieves No. 10 are shown in Figure 3.10. From this figure it can be noted that, in general, higher deviations are observed as the amount of RAP is increased.

In addition, all four projects indicate higher deviation than a typical mix with no RAP material. The mean deviation for the no-RAP mix is presented as the average for 58 typical mixes constructed throughout the state during 1987. It can be seen that for the percent passing sieve No. 10, the average deviation from the job-mix-formula target values varies between 2 and 5 percent, compared with about 1 percent, which is a typical deviation for mixes without RAP. From Figure 3.11 it can be seen that, again, all RAP projects indicate higher mean deviation for sieve No. 200 than the mixes with no RAP material. However, among the projects considered in this study, the mix with 50 percent RAP does not exhibit larger deviation for sieve No. 200 than the other RAP mixes. The deviation for the percent passing sieve No. 200 is, on the average, about 1 to 3 percent, compared with a typical deviation of 1 percent for non-RAP mixes.



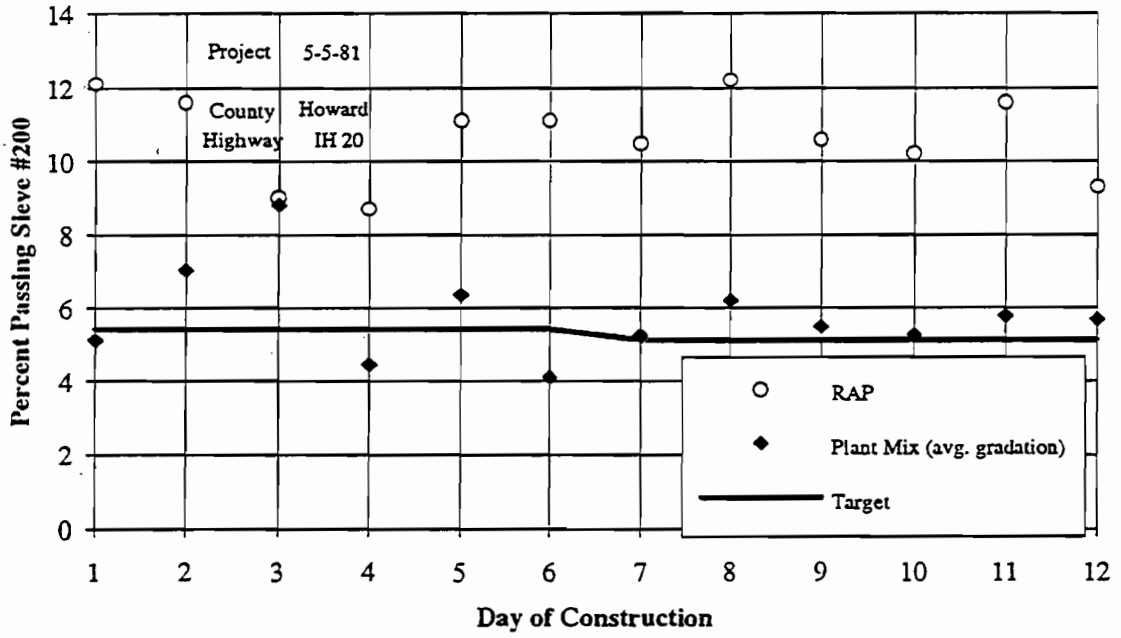
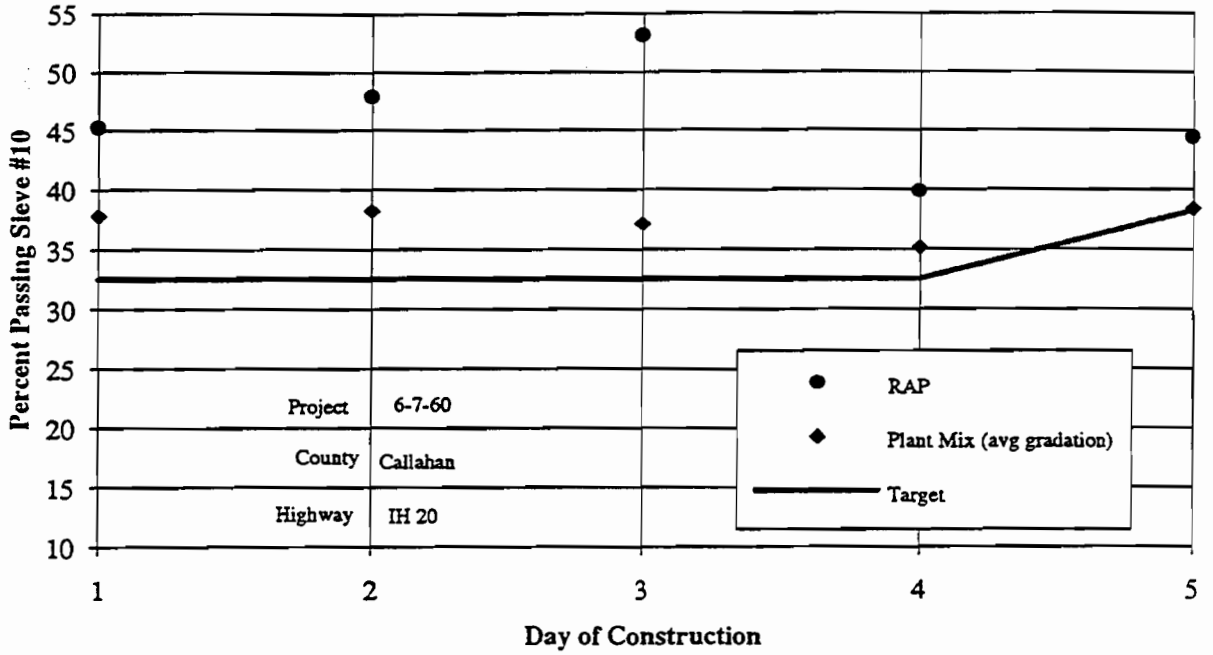


Figure 3.3. Control charts for percent passing sieves No. 10 and No. 200 for the mix average daily gradation and the RAP (Howard County)



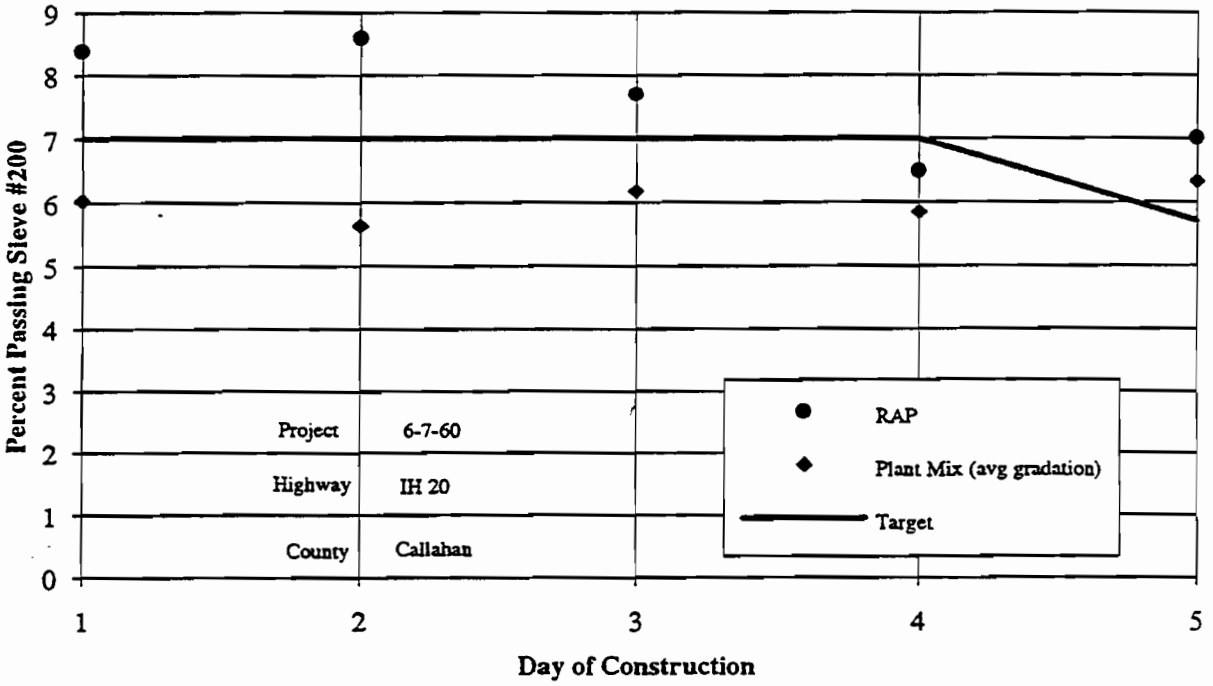


Figure 3.4. Control charts for percent passing sieves No. 10 and No. 200 for the mix average daily gradation and the RAP (Callahan County)

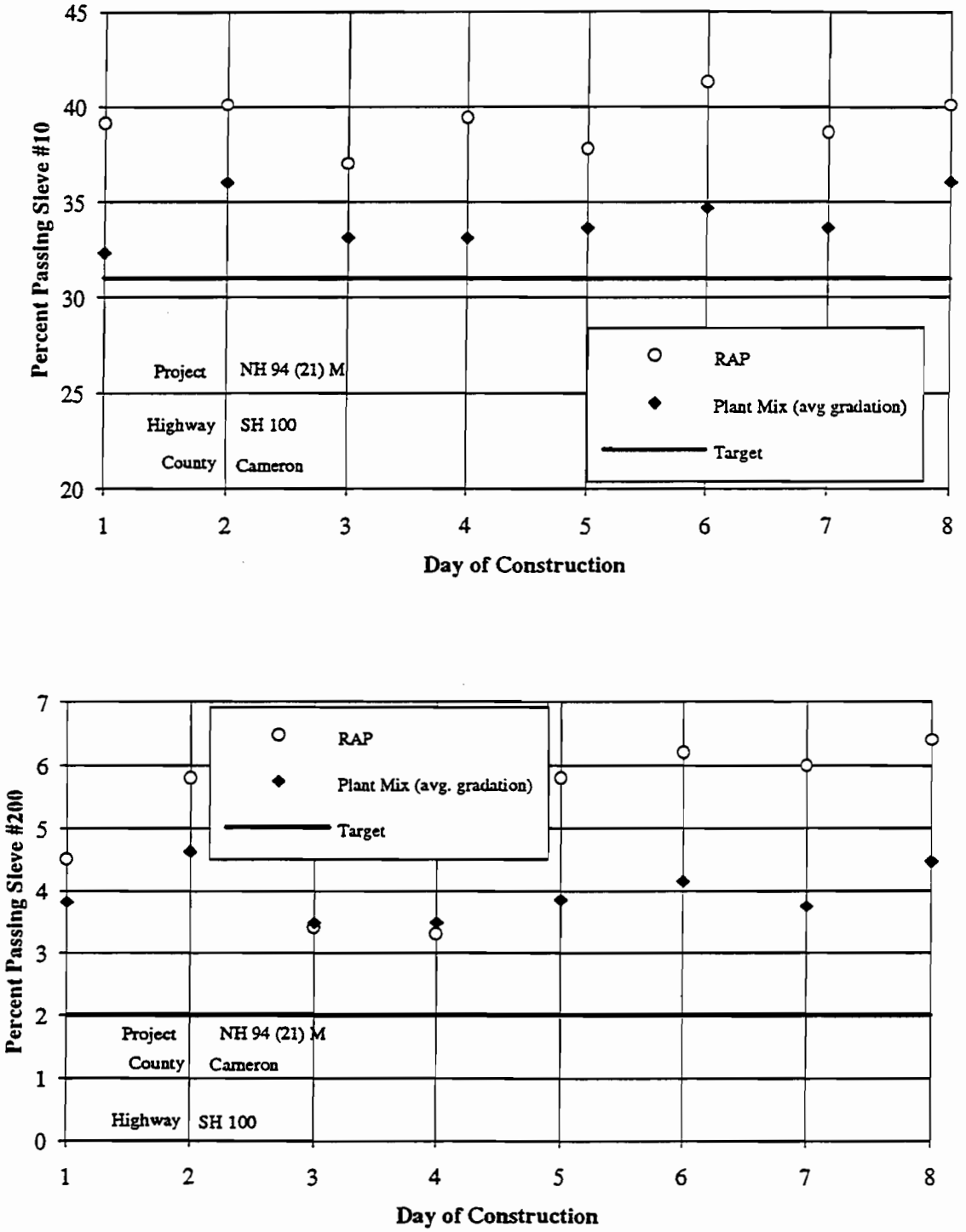
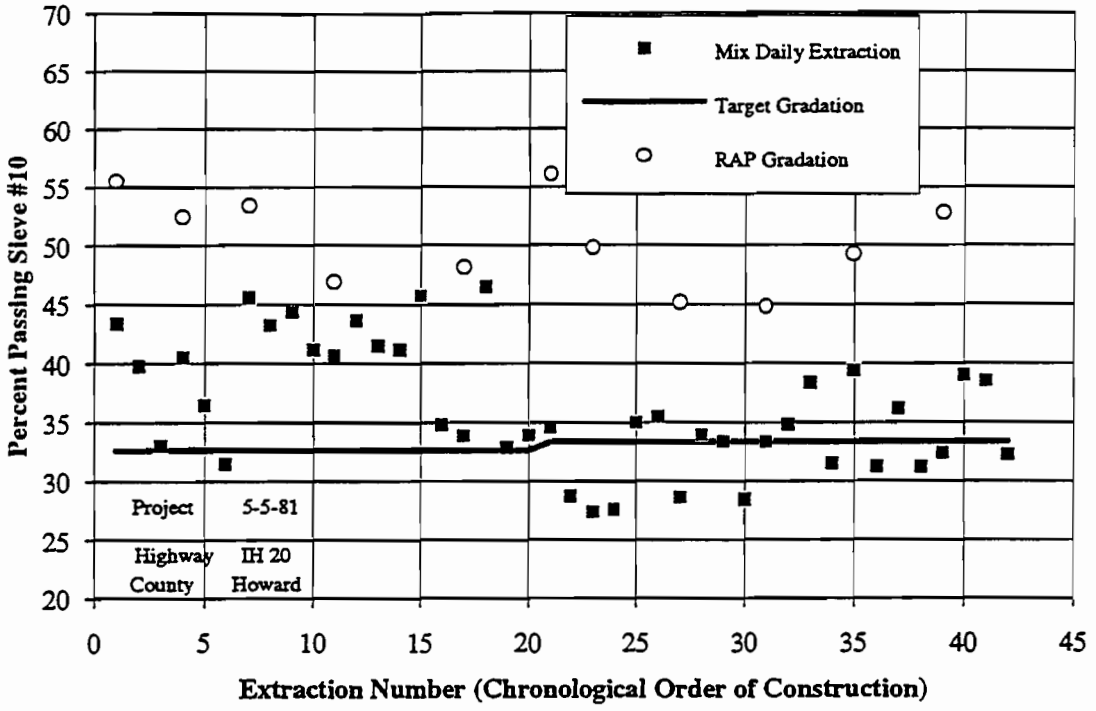


Figure 3.5. Control charts for percent passing sieves No. 10 and No. 200 for the mix average daily gradation and the RAP (Cameron County)



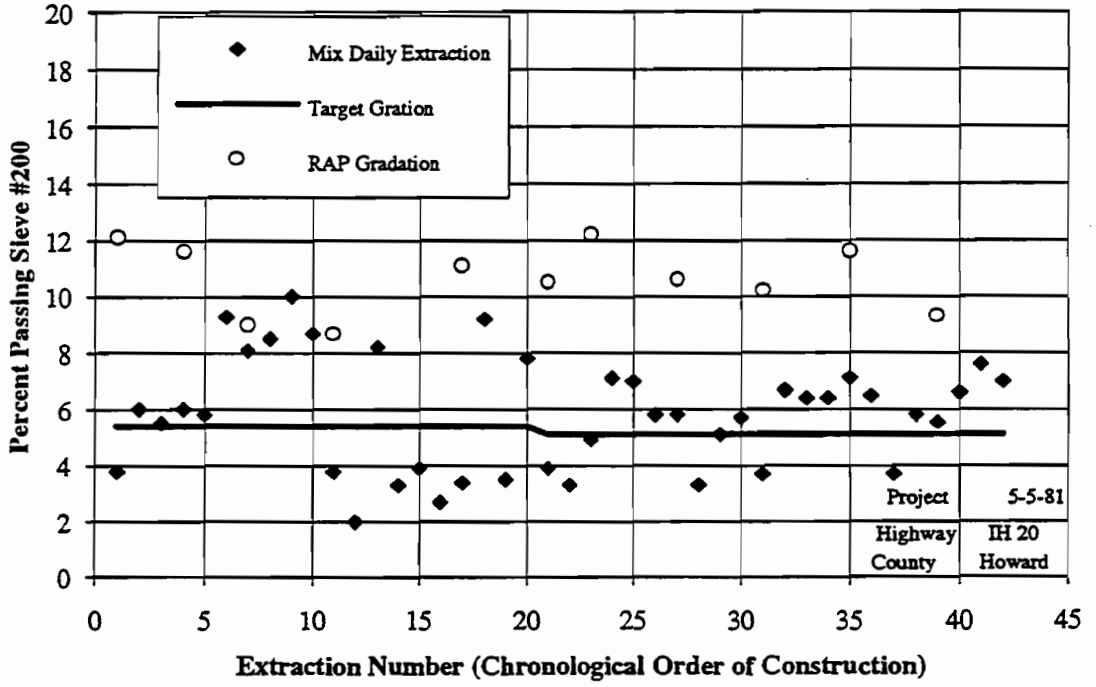


Figure 3.6. Control charts for percent passing sieves No. 10 and No. 200 for the mix and the RAP gradations (Howard County)

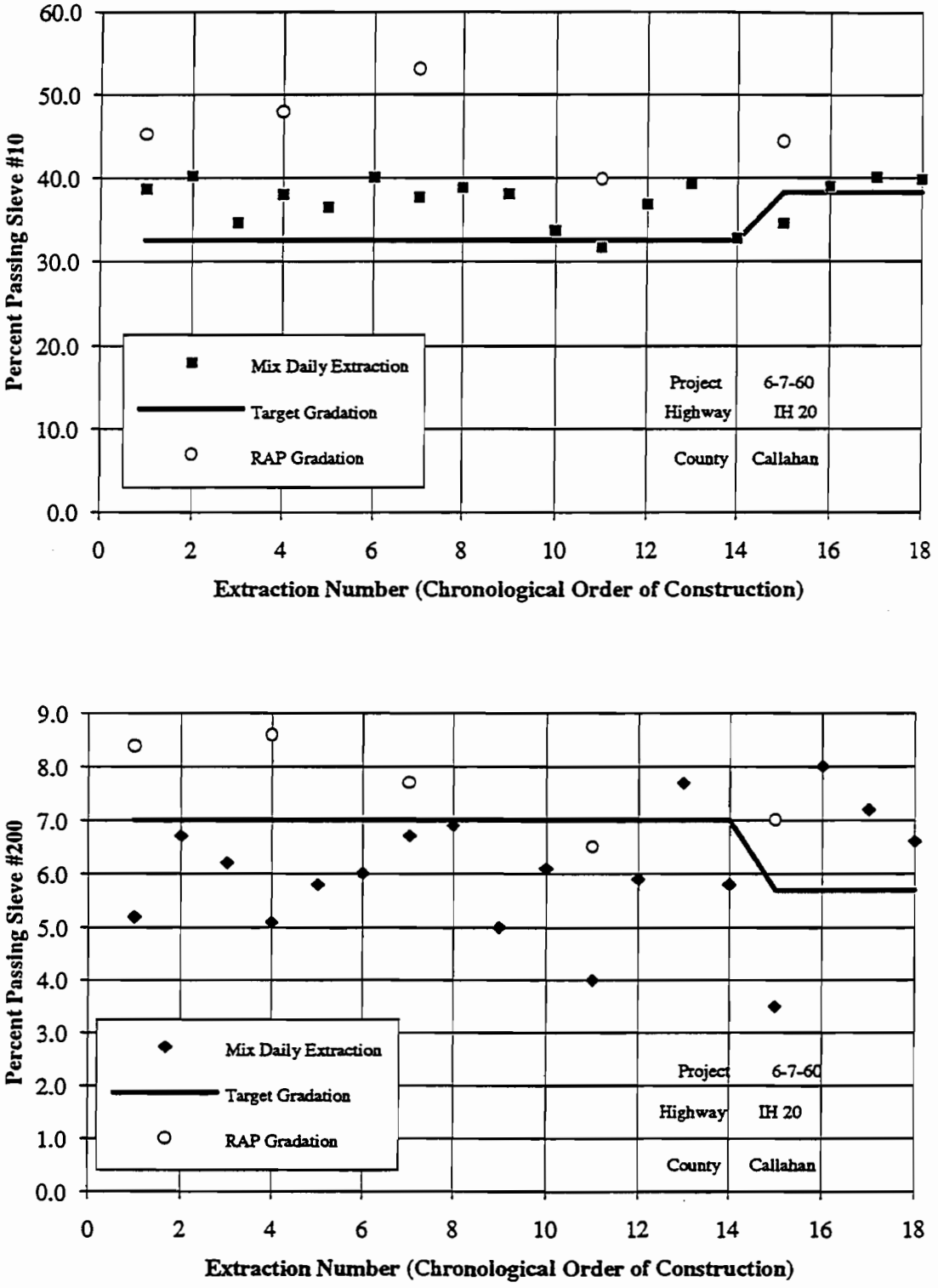
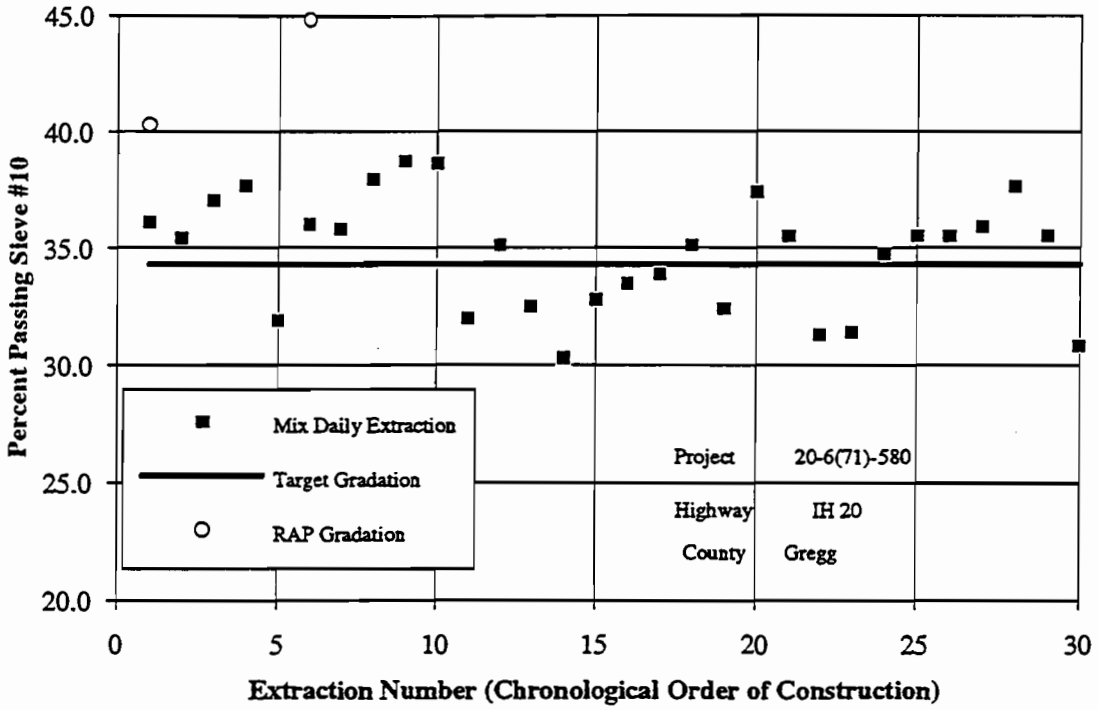


Figure 3.7. Control charts for percent passing sieves No. 10 and No. 200 for the mix and the RAP gradations (Callahan County)



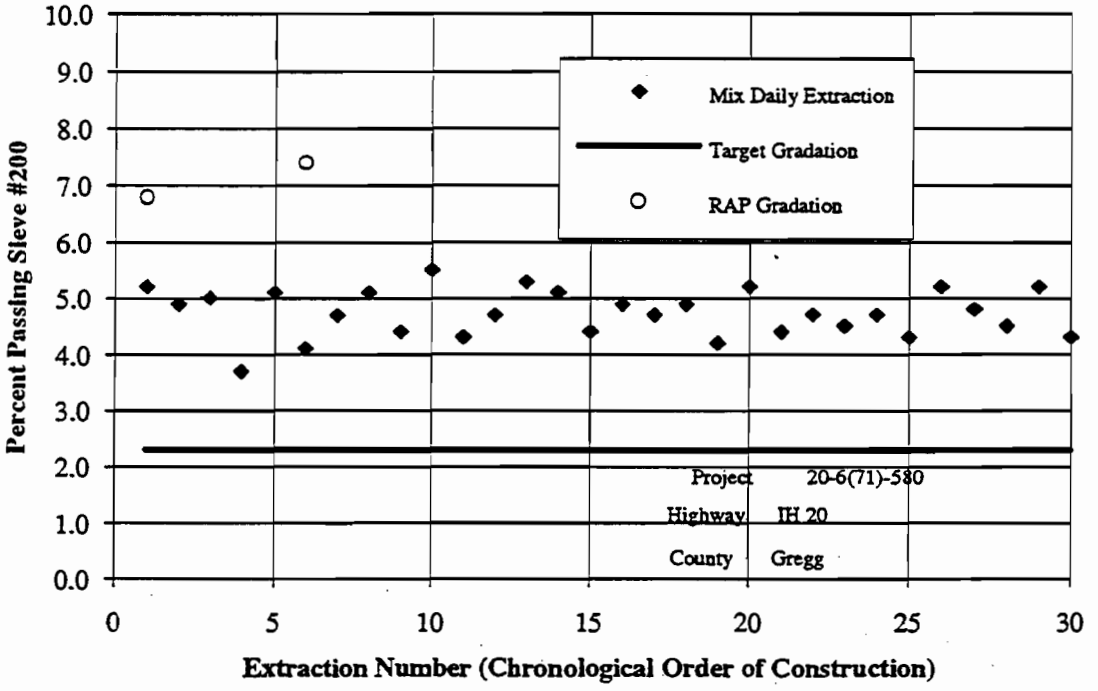
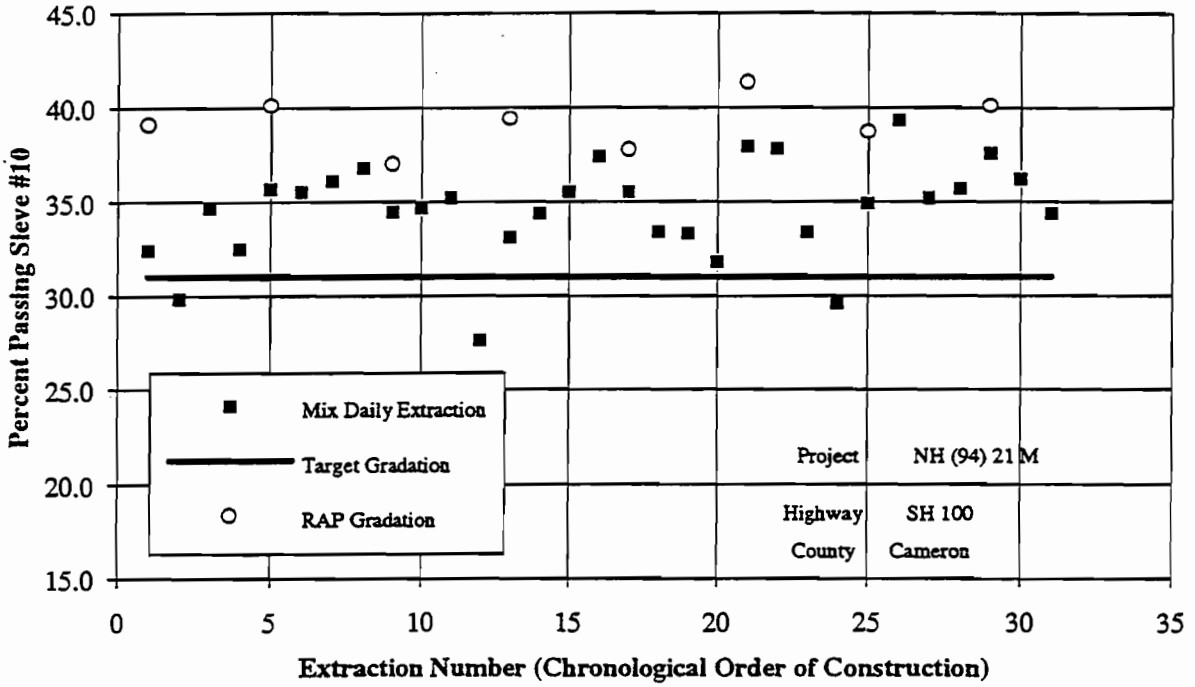


Figure 3.8. Control charts for percent passing sieves No. 10 and No. 200 for the mix and the RAP gradations (Gregg County)



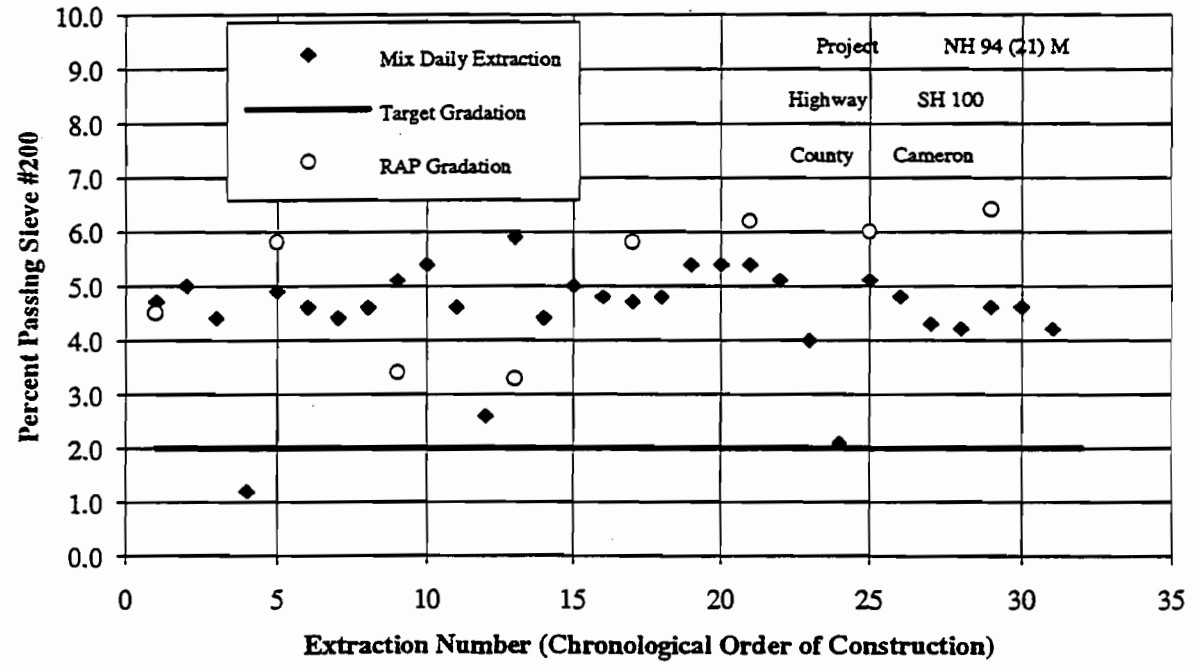


Figure 3.9. Control charts for percent passing sieves No. 10 and No. 200 for the mix and the RAP gradations (Cameron County)

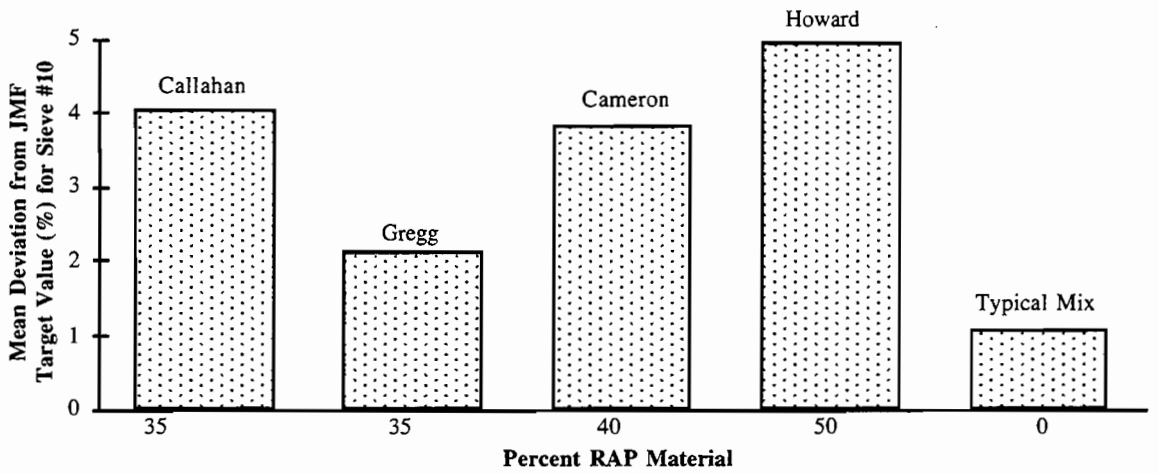


Figure 3.10. Percent mean deviation from job-mix formula target gradation for sieve No. 10

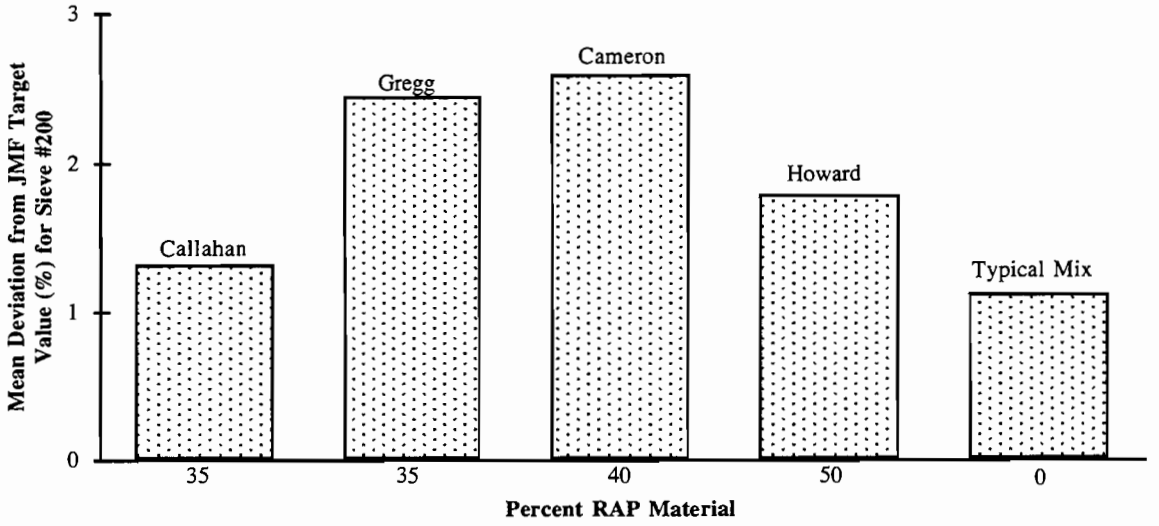


Figure 3.11. Percent mean deviation from job-mix formula target deviation for sieve No. 200

The pay adjustment factors for gradation, based on TxDOT Special Specification 3007, are presented in Tables 3.5 and 3.6. The deviations presented in these figures are from the job-mix-formula target values. It is important to note that Special Specification 3007 requires average values for four sublots of the day. In some cases, it was not possible to obtain samples for all four sublots or, because of low tonnage, the total day's construction could not be divided into four sublots. In order to be able to apply the pay adjustment factors listed in the Specification, however, a sequence of four sublots are used that may not necessarily belong to the same day of construction (except in the case of the Cameron County project, where all sublots belong to the same day). In general, the average pay adjustment factors for gradation deviations on No. 10 and No. 200 sieves are about 0.9 to 0.95, values which are considerably lower than typical average values of about 1.02 for projects with no RAP material.

3.3. ASPHALT CONTENT

Asphalt contents from extraction and nuclear gauge measurement for different projects are provided in Tables A.1 through A.20 (Appendix A). For some projects, nuclear gauge was not used for determination of the asphalt content and, therefore, only extraction values are reported. Daily asphalt content and variation from job-mix formula target values and corresponding pay adjustment factors are presented in Tables C.1 through C.4 and Figures C.1 through C.6 (Appendix C). In general, analysis of asphalt content variations was performed in three ways.

1) the deviations were considered from the grand mean value of all results (Table 3.4). This was done for both the RAP material and HMAC.
2) Algebraic differences between extraction and target asphalt contents are considered (Table 3.7).
3) Absolute differences between extraction and target asphalt contents are considered (Table 3.8).

When one considers coefficient of variation and standard deviation for asphalt content deviation from the mean (Figs 3.12 and 3.13, and Table 3.4), it can be noticed that the projects with 50 percent and 40 percent RAP have higher deviations compared to the projects with lower amount of RAP. It should be noted that the deviations reported in Table 3.4 and in Figures 3.12 and 3.13 are based on the same procedure as that used for the RAP gradation and mix gradation (the procedure is outlined in the RAP section). These deviations are from the mean value and not from the target values.

The higher-percent RAP projects have higher standard deviations for algebraic differences between extracted asphalt content and target asphalt content (Fig 3.14). However, such a conclusion cannot be drawn when absolute differences are considered (Fig 3.15).

The control charts for asphalt content are displayed in Figures 3.16 through 3.19. The solid line in these figures indicates the job-mix formula target asphalt content. The second plot on these figures indicates how the average daily asphalt content varies during construction. The daily RAP asphalt content is also presented in these figures. No clear trend is observed between the variations in RAP asphalt content and the mix asphalt content.

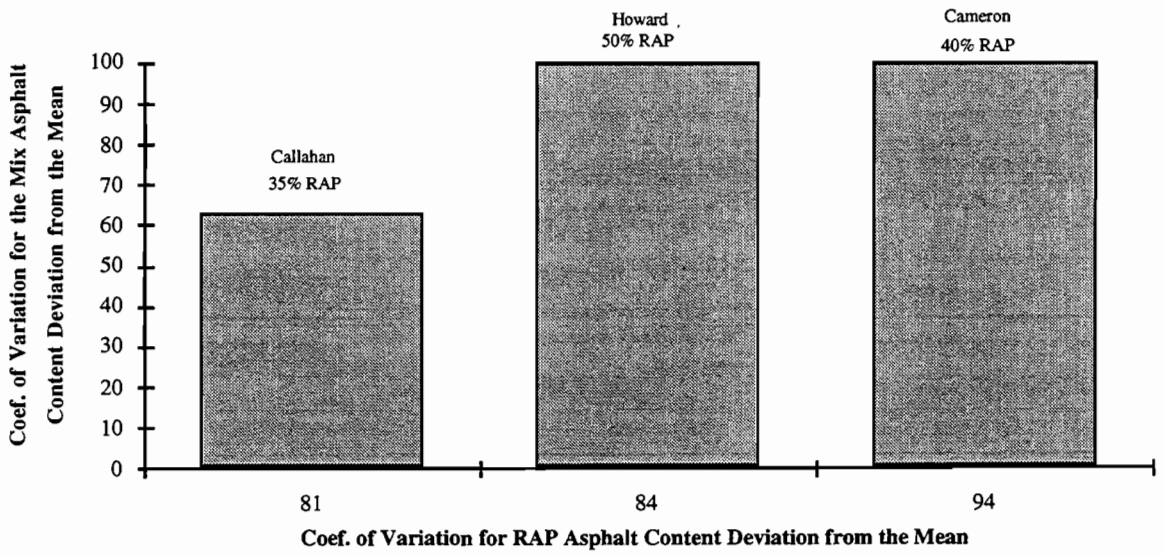


Figure 3.12. Relationship between coefficient of variation of RAP AC deviation with that of the mix

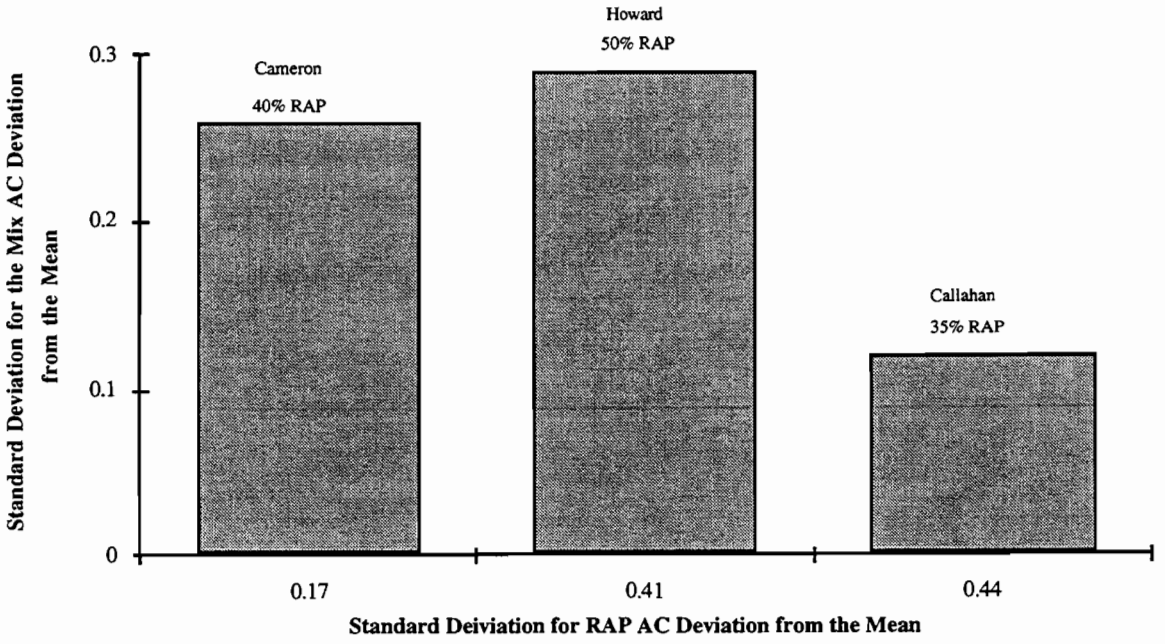


Figure 3.13. Relationship between standard deviation of RAP AC deviation with that of the mix

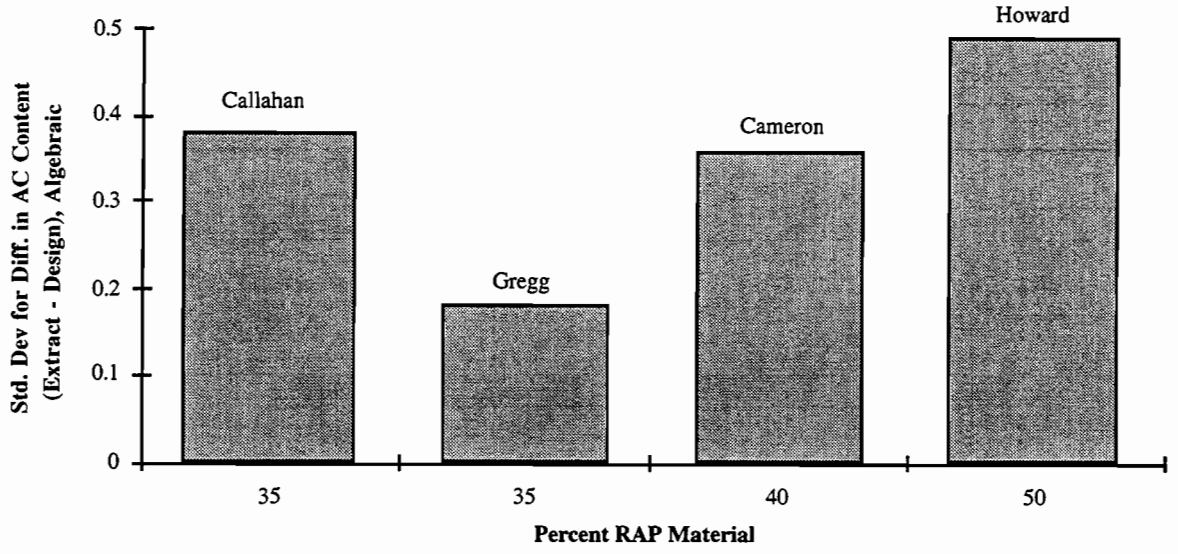


Figure 3.14. Standard deviation of algebraic differences in asphalt content for different projects

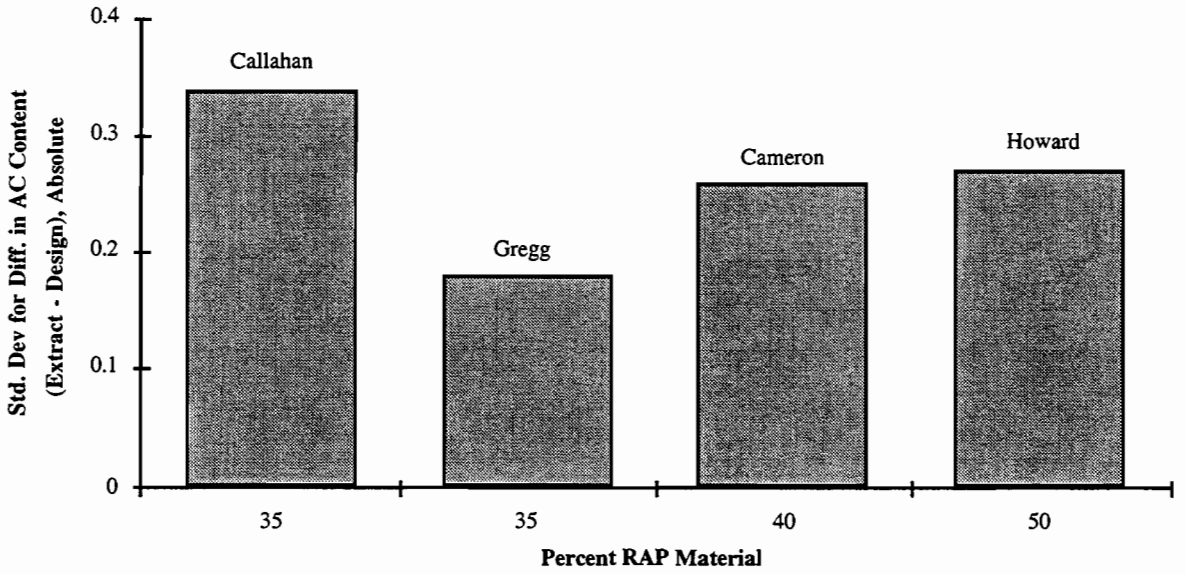
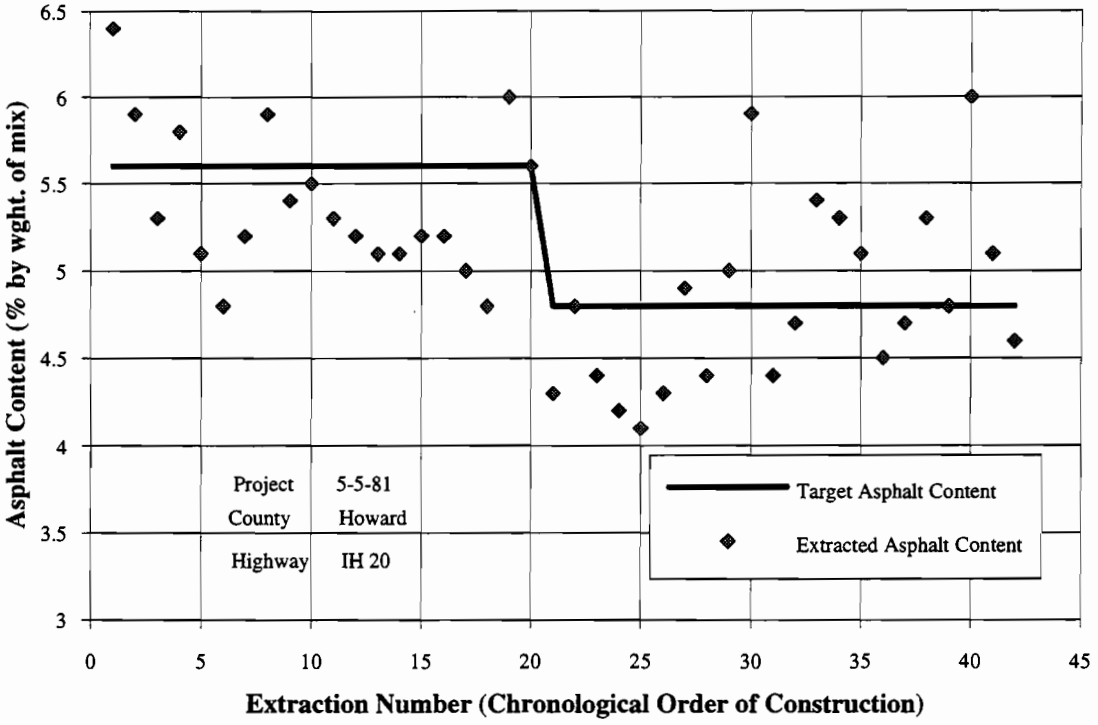


Figure 3.15. Standard deviation of absolute differences in asphalt content for different projects



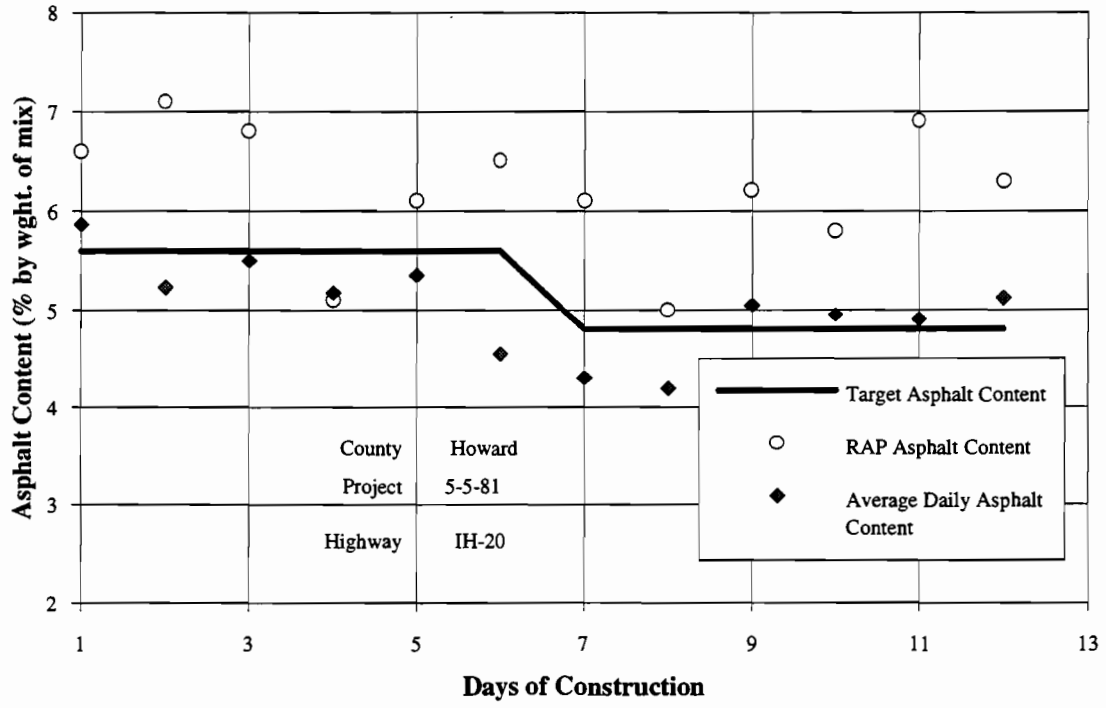
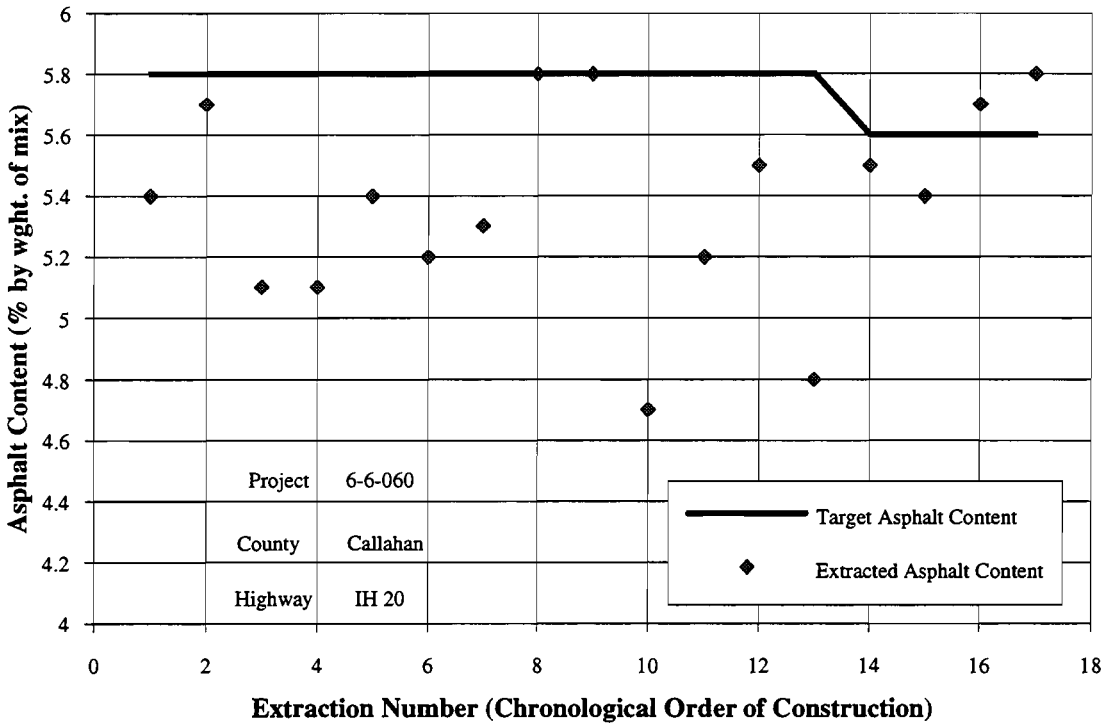


Figure 3.16. Control charts for asphalt content for the project in Howard County



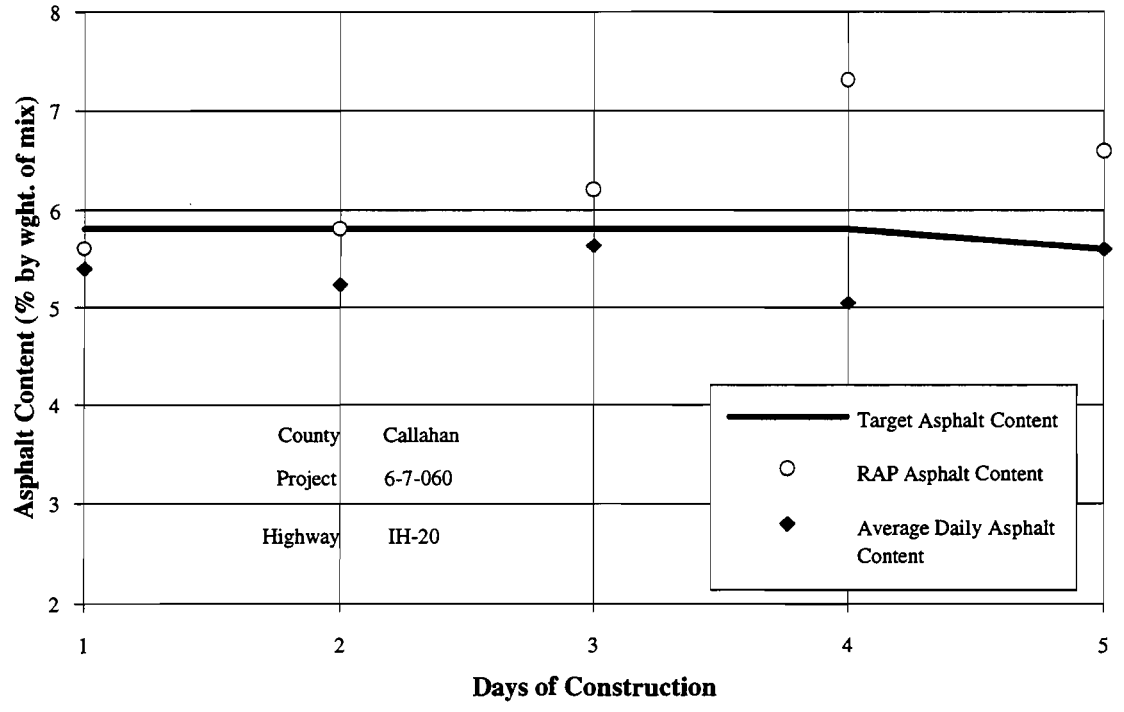


Figure 3.17. Control charts for asphalt content for the project in Callahan County

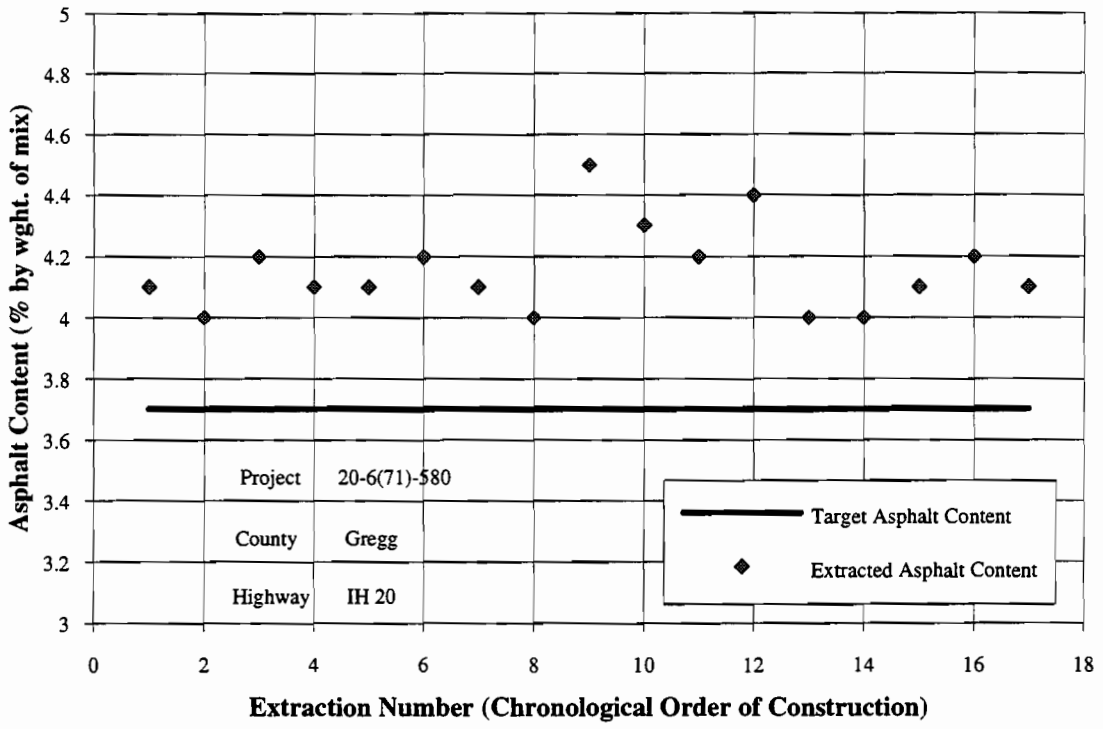


Figure 3.18. Control charts for asphalt content for the project in Gregg County

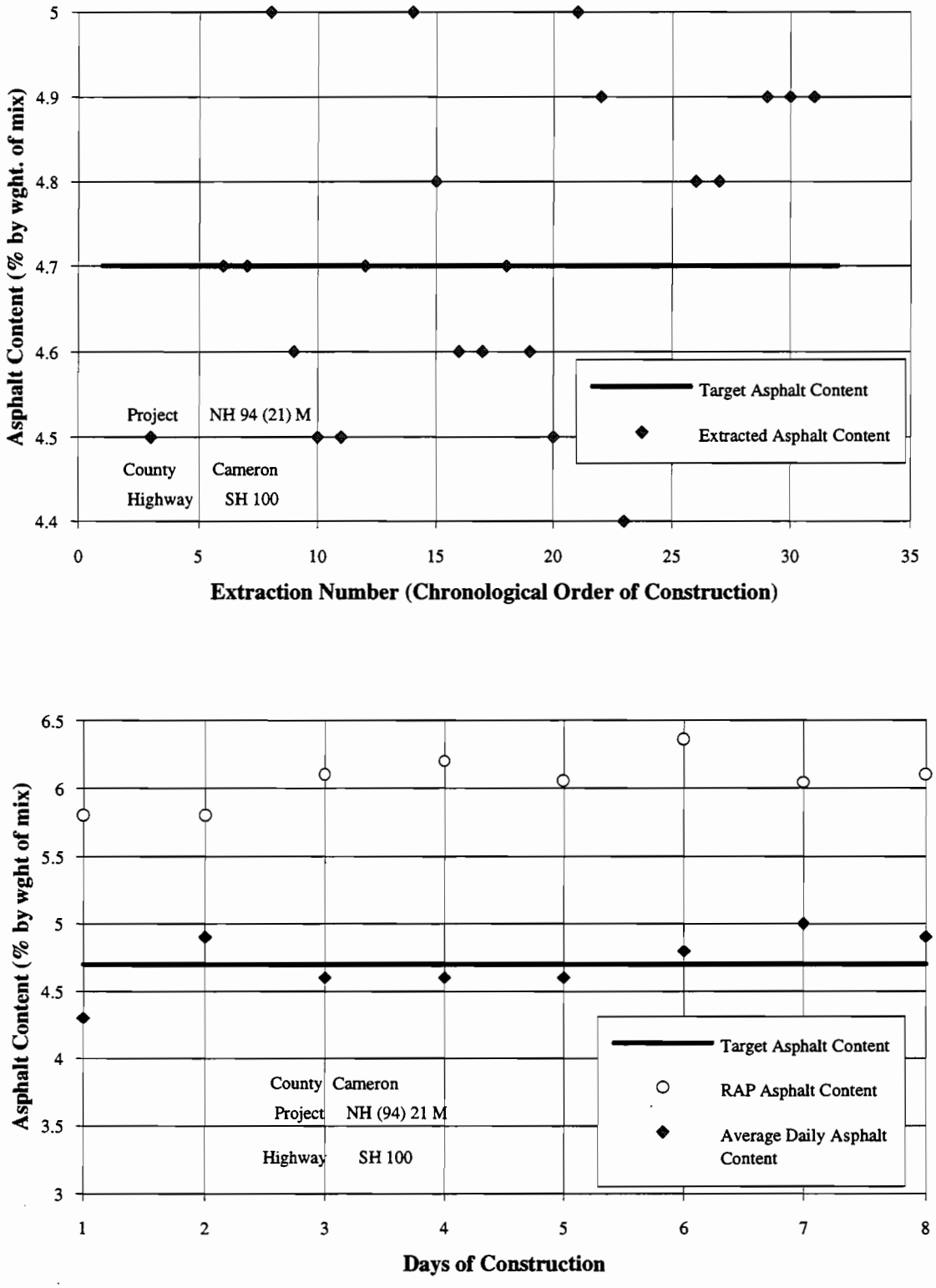


Figure 3.19. Control charts for asphalt content for the project in Cameron County

From Table 3.7, it can be seen that the mixtures with RAP material have higher standard deviations for the asphalt content difference (extracted — design) than a typical mixture with no RAP material. The mean deviations from job-mix formula target values are presented in Figure 3.20. It can be seen from this figure that the mixtures with RAP material have higher mean deviations from the job mix formula for the asphalt content than a typical mixture with no RAP material. The average value reported for a typical mixture is obtained as a result of studying 86 HMAC projects in 1987 (Ref 6). It can be seen that the average mean deviation for a no-RAP mixture is about 0.1 percent, while all the RAP mixtures have mean deviations higher than 0.25 percent.

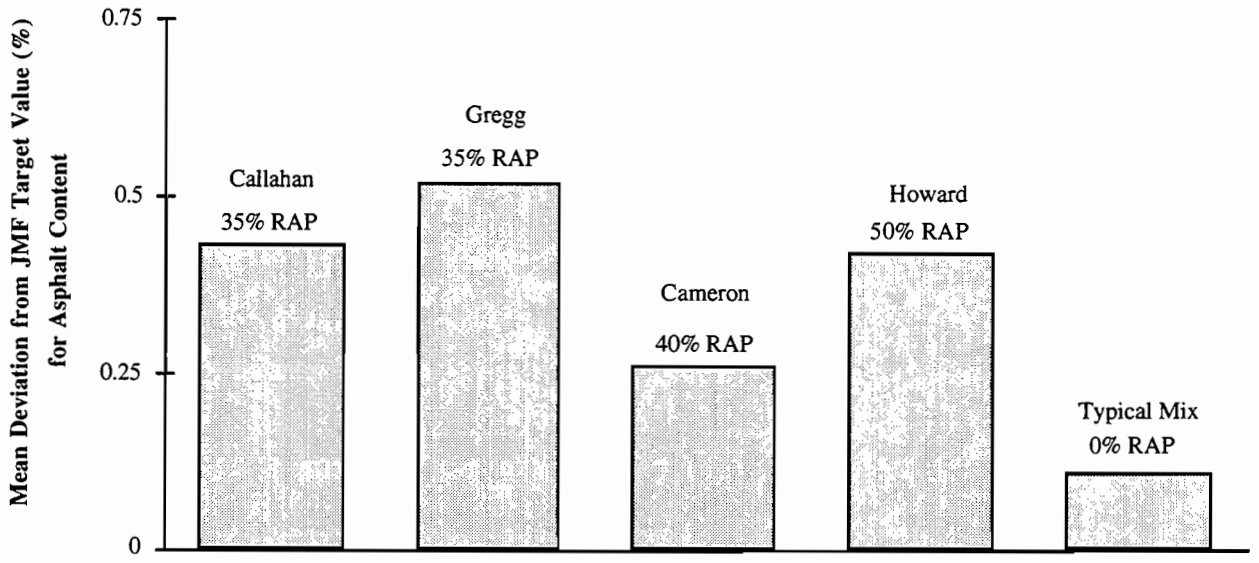


Figure 3.20 Percent mean deviation from job mix formula target value for asphalt cement

The pay adjustment factors for asphalt content material are also presented in Table 3.9. The deviations reported in this table are from the job-mix formula target values. It can be seen that, compared with pay adjustment factors for gradation, the asphalt content causes slightly more reduction in the pay. In general, the average pay factor for asphalt content material deviation is about 0.9, which is considerably lower than the typical average value of about 1.02.

3.4. AIR VOIDS AND STABILITIES

Hveem stabilities and air voids are presented in Tables D.1. through D.4 (Appendix D). For the Howard County project, two sets of stabilities are reported: first, the stabilities for the specimens that were shipped to TxDOT Materials and Tests Division, and, second, the stabilities for the specimens that were tested in the district laboratory. The relationship between the two is

presented in Figure D.1 (Appendix D). In general, a linear relationship is observed. For the project in Callahan County, there are also two sets of stabilities. However, only few days have stabilities from both laboratories. The Cameron County projects also have two sets of stability values. Both sets were tested at TxDOT Materials and Tests Division. However, the first set of specimens were compacted at The University of Texas asphalt laboratory and the second set at the plant laboratory. A plot of standard deviations for stabilities (Fig 3.22) indicates that the RAP projects of this study have higher variability in stability values than typical mixtures with no RAP material.

The air void values for all RAP projects seem to be within the typical range observed for projects without RAP. Even with high percents of RAP material in HMAC, achieving density within acceptable range does not seem to be a problem. Highest pay adjustment factors are obtained for the air voids compared to deviations in gradation and asphalt content. It is important to note that the air voids for which the pay factors are calculated are not exactly determined based on the procedure outlined in TxDOT Special Specifications Item 3007 (Ref 4). In that specification, it is required that for each sublot two cores be taken and used for density measurement. A day's construction tonnage is considered one lot and is divided into four segments, creating four sublots. In this way, four average density measurements are obtained for each day. However, for the projects reported here, in most cases, the road densities are the average values of only three cores for the whole day's construction. The air void values were available for only three of the four RAP projects. The results indicate higher variability in the air voids as the amount of the RAP material increases (Figure 3.21).

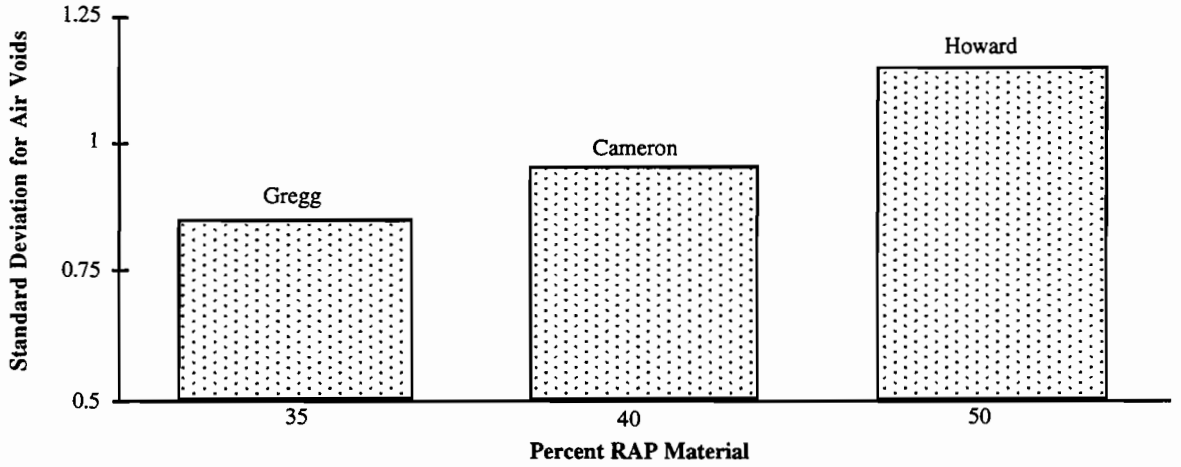


Figure 3.21. Standard deviation for air voids

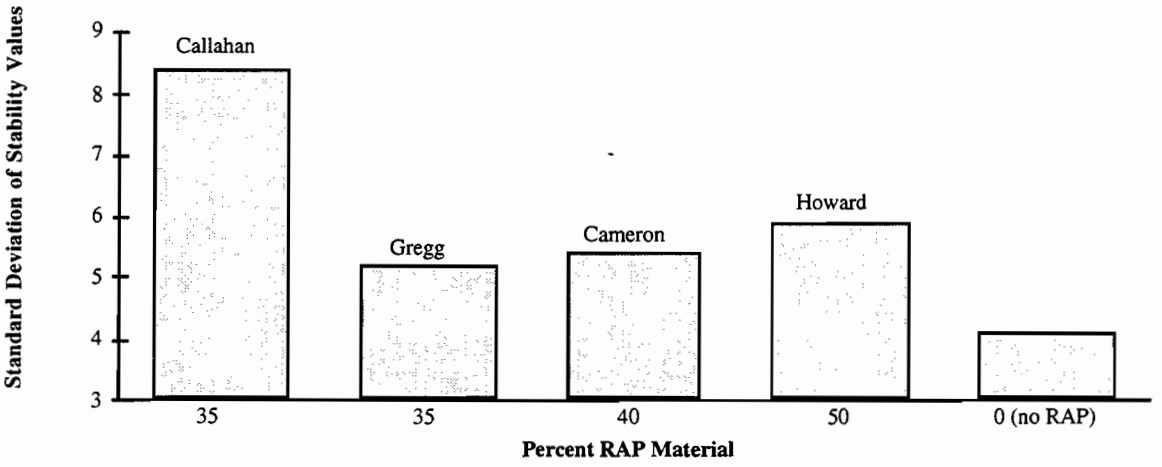


Figure 3.22. Standard deviation for stability values

3.5. VISCOSITIES AND PENETRATIONS

The results of viscosity and penetration tests on asphalt material extracted from both RAP and plant mixes are presented in Table E.1 and Figures E.1 through E.9 (Appendix E). As expected, the RAP asphalt material presents stiffnesses significantly higher than those of the plant mix. There seems to be a larger variability in the viscosity values compared with penetration values (compare the coefficients of variation given in Table E.1). The variability in viscosity values for any of the projects seems significant. The scatter plots of penetration and viscosity values of plant mix versus those of the RAP material did not exhibit any trend or relationship, possibly because the plant mix sample may contain the RAP from a location of the stockpile, which may not be represented by the RAP sample tested. However, as can be seen from Figure E.9 (Appendix E), in general, the higher RAP variation in stiffness results in higher mix variation in stiffness.

CHAPTER 4. CONCLUSIONS AND RECOMMENDATIONS

4.1. CONCLUSIONS

The following conclusions are based on the results and findings of this research project. When drawing conclusions, it is important to note that the determination of asphalt content and gradation deviations — as well as air void values for which the pay adjustment factors are presented — does not exactly follow TxDOT Special Specification Item 3007.

1. The HMAC projects with a high percentage of RAP, studied in the course of this research program, exhibited a larger variation in asphalt content and gradation, compared with typical HMAC projects without RAP material.
2. The average pay factors for gradation deviations on No. 10 and No. 200 sieves are about 0.9 to 0.95, values which are considerably lower than typical average values of around 1.02.
3. The average pay factor for asphalt content material deviation is about 0.9, which is considerably lower than the typical average value of about 1.02.
4. The average pay factor for air voids is around 1.00, which is just about what is obtained for typical mixtures.
5. In general, use of a high percent of RAP material did not influence densities as much as it influenced the asphalt content and gradation.
6. The projects with higher variations in the asphalt content of the RAP material also had higher variation in the asphalt content of the plant mix.
7. The projects with higher variability in the stiffness of the RAP binder also had higher variability in the stiffness of the plant mix binder. The RAP binder with higher coefficient of variation in the penetration also resulted in a higher coefficient of variation in penetration of the plant mix binder.
8. In general, for all projects, the production gradation was finer than the job-mix formula target gradation.
9. As expected, the extracted binder from the RAP material was considerably stiffer than the binder extracted from the plant mix. Significantly higher viscosities and lower penetrations were obtained for the binder from the RAP material than for the binder from the plant mix.

4.2. RECOMMENDATIONS

It is highly recommended that the gradation of the RAP be determined using a procedure that results in an aggregate gradation similar to what is obtained during the milling operation. RAP aggregate gradation from road cores can differ significantly from RAP aggregate gradation from milling, the latter being finer due to possible crushing by the milling machine. The mix design gradation based on road cores may not be representative of the actual gradation during

construction.

It is also recommended that use of a high percentage of RAP be restricted until means are available to reduce the mix variability when a high quantity of RAP is used, or until sufficient evidence exists that further deviations from the target values can be allowed without adversely influencing the pavement performance.

REFERENCES

1. FHWA, *Recycling Asphalt Pavements*, Demonstration Project No. 39, Demonstration Projects Program, Technology Transfer, FHWA-DP-39-1, August 1978.
2. Kennedy, Thomas W., Freddy Roberts, and James N. Anagnos, "Mixture Design Procedure for Recycled Asphalt Pavements," Research Report 252-1, Center for Transportation Research, The University of Texas at Austin, May 1982.
3. Kennedy, Thomas W., Maghsoud Tahmoressi, and James Anagnos, "Guidelines for Design and Construction of Recycled Asphalt Mixtures," Research Report 252-2, Center for Transportation Research, The University of Texas at Austin, September 1985.
4. Texas Department of Transportation, "Quality Control/Quality Assurance of Hot Mix Asphalt," Special Specification Item 3007, Texas Department of Transportation, 1993.
5. Tahmoressi, Maghsoud, and Thomas W. Kennedy, "Organization and Analysis of 1987 HMAC Field Construction Data," Research Report 1197-1F, Center for Transportation Research, The University of Texas at Austin, November 1988.
6. Solaimanian, Mansour, and Thomas W. Kennedy, "Evaluation of Filed Compaction, Density Variations, and Factors Affecting Density through 1987 HMAC Field Construction Data," Research Report 468-4F, Center for Transportation Research, The University of Texas at Austin, October 1989.

APPENDIX A

DAILY GRADATIONS AND ASPHALT CONTENTS FOR THE RAP MATERIAL

Table A.1. Daily Gradation and Asphalt Content for the RAP material for the Project in Howard County (Extraction Results).

Project CPM 0005-05-081	Aggregate Source: Transit Materials Inc., Midland, TX		
Highway IH 20	Asphalt Source: Fina AC-10, Big Springs, TX		
County Howard			
Type D (Surface) with RAP	**Amount of RAP (%) 50**	**Dedicated Stockpile**	

Sampling Date	5/16/94	5/17/94	5/18/94	5/19/94	5/23/94	5/24/94	5/25/94	5/26/94	5/27/94	5/31/94	6/1/94	6/2/94	Sieve	Size	Average
Sample No	1	2	3	4	5	6	7	8	9	10	11	12	No.	mm	Gradation
gradation	100	100	100	100	100	100	100	100	100	100	100	100	1/2"	12.50	100.0
Percent	98.7	98.8	98.6	99.3	98.1	99.2	99.1	99	96.4	97.6	98.7	98.9	3/8"	9.50	98.5
Passing	80.9	78.9	79.5	76.0	76.0	81.7	81.7	76.6	71.7	71.7	77.8	79.6	#4	4.75	77.7
for RAP	55.5	52.4	53.4	46.9	48.1	53.6	56.1	49.8	45.1	44.8	49.2	52.8	#10	2.00	50.6
	36.2	34.9	34.0	29.1	31.3	35.4	36.5	33.2	29.6	27.9	31.4	30.5	#40	0.43	32.5
	23.7	22.3	21.0	18.9	21.0	22.5	22.5	22.1	20.1	18.8	21.6	20.1	#80	0.18	21.2
	12.1	11.6	9.0	8.7	11.1	11.1	10.5	12.2	10.6	10.2	11.6	9.3	#200	0.08	10.7
	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0	0	pan	0.00	0.0
% AC	6.6	7.1	6.8	5.1	6.1	6.5	6.1	5.0	6.2	5.8	6.9	6.3			6.2

Gradation Deviation from the mean for RAP														
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1/2"	12.50
	0.2	0.3	0.1	0.8	-0.4	0.7	0.6	0.5	-2.1	-0.9	0.2	0.4	3/8"	9.50
	3.2	1.2	1.8	-1.7	-1.7	4.0	4.0	-1.1	-6.0	-6.0	0.1	1.9	#4	4.75
	4.9	1.8	2.8	-3.7	-2.5	3.0	5.5	-0.8	-5.5	-5.8	-1.4	2.2	#10	2.00
	3.7	2.4	1.5	-3.4	-1.2	2.9	4.0	0.7	-2.9	-4.6	-1.1	-2.0	#40	0.43
	2.5	1.1	-0.2	-2.3	-0.2	1.3	1.3	0.9	-1.1	-2.4	0.4	-1.1	#80	0.18
	1.4	0.9	-1.7	-2.0	0.4	0.4	-0.2	1.5	-0.1	-0.5	0.9	-1.4	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
% AC	0.4	0.9	0.6	-1.1	-0.1	0.3	-0.1	-1.2	0.0	-0.4	0.7	0.1		

Table A.2. Daily Gradation and Asphalt Content for the RAP material for the Project in Callahan County (Extraction Results).

Project	**CPM 0006-07-060**	Aggregate Source: Vulcan Materials	
Highway	**IH 20**	Asphalt Source: Coastal AC-10	
County	**Callahan**		
Type C (Surface) with RAP		**Amount of RAP (%) 35**	**Dedicated Stockpile**

Sampling Date	7/19/94	7/20/94	7/21/94	7/22/94	7/25/94	Sieve	Size	Average
Sample No	1	2	3	4	5	No.	mm	Gradation
gradation	100	100	100	100	100	5/8"	15.88	99.9
Percent	96.3	96.9	98.2	97.4	96.9	3/8"	9.50	97.1
Passing	75.7	76.9	80.3	71.8	75.3	#4	4.75	76.0
for RAP	45.2	47.9	53.1	39.8	44.4	#10	2.00	46.1
	26.9	27.2	31.2	21.1	24.7	#40	0.43	26.2
	15.8	16.8	17.1	13.6	15.0	#80	0.18	15.7
	8.4	8.6	7.7	6.5	7.0	#200	0.08	7.6
	0.0	0.0	0.0	0.0	0.0	pan	0.00	0.0
% AC	5.6	5.8	6.2	7.3	6.6			6.3

Gradation							
Deviation	0.1	-0.4	0.1	0.1	0.1	5/8"	15.88
from	-0.8	-0.2	1.1	0.3	-0.2	3/8"	9.50
the mean	-0.3	0.9	4.3	-4.2	-0.7	#4	4.75
for RAP	-0.9	1.8	7.0	-6.3	-1.7	#10	2.00
	0.7	1.0	5.0	-5.1	-1.5	#40	0.43
	0.1	1.1	1.4	-2.1	-0.7	#80	0.18
	0.8	1.0	0.1	-1.1	-0.6	#200	0.08
	0.0	0.0	0.0	0.0	0.0	pan	0.00
% AC	-0.7	-0.5	-0.1	1.0	0.3	0.0	0.0

Table A.3. Daily Gradation and Asphalt Content for the RAP material for the Project in Gregg County (Extraction Results).

Project	**IM 20-6(71(580**	Aggregate Source	G-H Perch & C.X.I
Highway	**IH 20**	Asphalt Source	AC-10, Lion Oil, El Dorado, AR
County	**Gregg**		
Type C (Base) with RAP		**Amount of RAP (%) 35**	**Dedicated Stockpile**

Sampling Date	5/4/94	5/6/94	5/29/94	Sieve	Size	Average
Sample No	1	2	3	No.	mm	Gradation
gradation	100	100	100	5/8"	15.88	99.8
Percent	92.0	94.4	88.2	3/8"	9.50	91.5
Passing	57.4	65.4	64.9	#4	4.75	62.6
for RAP	40.3	44.8	42.6	#10	2.00	42.6
	31.9	33.1	29.0	#40	0.43	31.3
	18.9	22.2	17.9	#80	0.18	19.7
	6.8	7.4	4.9	#200	0.08	6.4
	0.0	0.0	0.0	pan	0.00	0.0
% AC	2.9	6.0	5.7			4.9

Gradation					
Deviation	0.2	-0.3	0.2	5/8"	15.88
from	0.5	2.9	-3.3	3/8"	9.50
the mean	-5.2	2.8	2.3	#4	4.75
for RAP	-2.3	2.2	0.0	#10	2.00
	0.6	1.8	-2.3	#40	0.43
	-0.8	2.5	-1.8	#80	0.18
	0.4	1.0	-1.5	#200	0.08
	0.0	0.0	0.0	pan	0.00
% AC	-2.0	1.2	0.9		

Table A.4. Daily Gradation and Asphalt Content for the RAP material for the Project in Cameron County (Extraction Results).

Project NH 94 (21) M	Aggregate Source: Parker La Farge and Fordyce		
Highway SH 100	Asphalt Source: Coastal AC-5		
County Cameron			
Type B (Base) with RAP	**Amount of RAP (%) 40**	**Dedicated Stockpile**	

Sampling Date	8/9/94	8/15/94	8/17/94	8/18/94	8/22/94	8/23/94	8/25/94	8/26/94	8/29/94	8/30/94	Sieve No.	Size mm	Average Gradation
Sample No	1	2	3	4	5	6	7	8	9	10			
gradation	100	100	100	100	100	100	100	100	100	100	7/8"	22.23	100.0
Percent	100	100	100	100	100	100	100	100	100	100	5/8"	15.88	100.0
Passing	94.6	95.5	93.2	97.4	93.6	94.8	93.6	95.5	95.4	94.8	3/8"	9.50	94.8
for RAP	65.3	66.0	61.8	67.0	58.2	61.4	61.5	67.2	65.2	65.4	#4	4.75	63.9
	40.6	40.9	39.1	40.1	37.0	39.4	37.8	41.3	38.7	40.1	#10	2.00	39.5
	32.7	33.4	31.7	32.8	30.7	31.9	30.7	32.9	31.3	32.2	#40	0.43	32.0
	19.4	14.9	18.7	21.9	17.0	16.8	21.1	20.3	21.6	19.7	#80	0.18	19.1
	4.7	4.2	4.5	5.8	3.4	3.3	5.8	6.2	6.0	6.4	#200	0.08	5.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00	0.0
% AC	6.6	6.0	5.8	5.8	6.1	6.2	6.1	6.4	6.0	6.1			6.1

Gradation Deviation												
from	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7/8"	22.23
the mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5/8"	15.88
for RAP	-0.2	0.7	-1.6	2.6	-1.2	0.0	-1.2	0.7	0.6	0.0	3/8"	9.50
	1.4	2.1	-2.1	3.1	-5.7	-2.5	-2.4	3.3	1.3	1.5	#4	4.75
	1.1	1.4	-0.4	0.6	-2.5	-0.1	-1.7	1.8	-0.8	0.6	#10	2.00
	0.7	1.4	-0.3	0.8	-1.3	-0.1	-1.3	0.9	-0.7	0.2	#40	0.43
	0.3	-4.2	-0.4	2.8	-2.1	-2.3	2.0	1.2	2.5	0.6	#80	0.18
	-0.3	-0.8	-0.5	0.8	-1.6	-1.7	0.8	1.2	1.0	1.4	#200	0.08
% AC	0.5	-0.2	-0.3	-0.3	0.0	0.1	-0.1	0.3	-0.1	0.0	pan	0.00

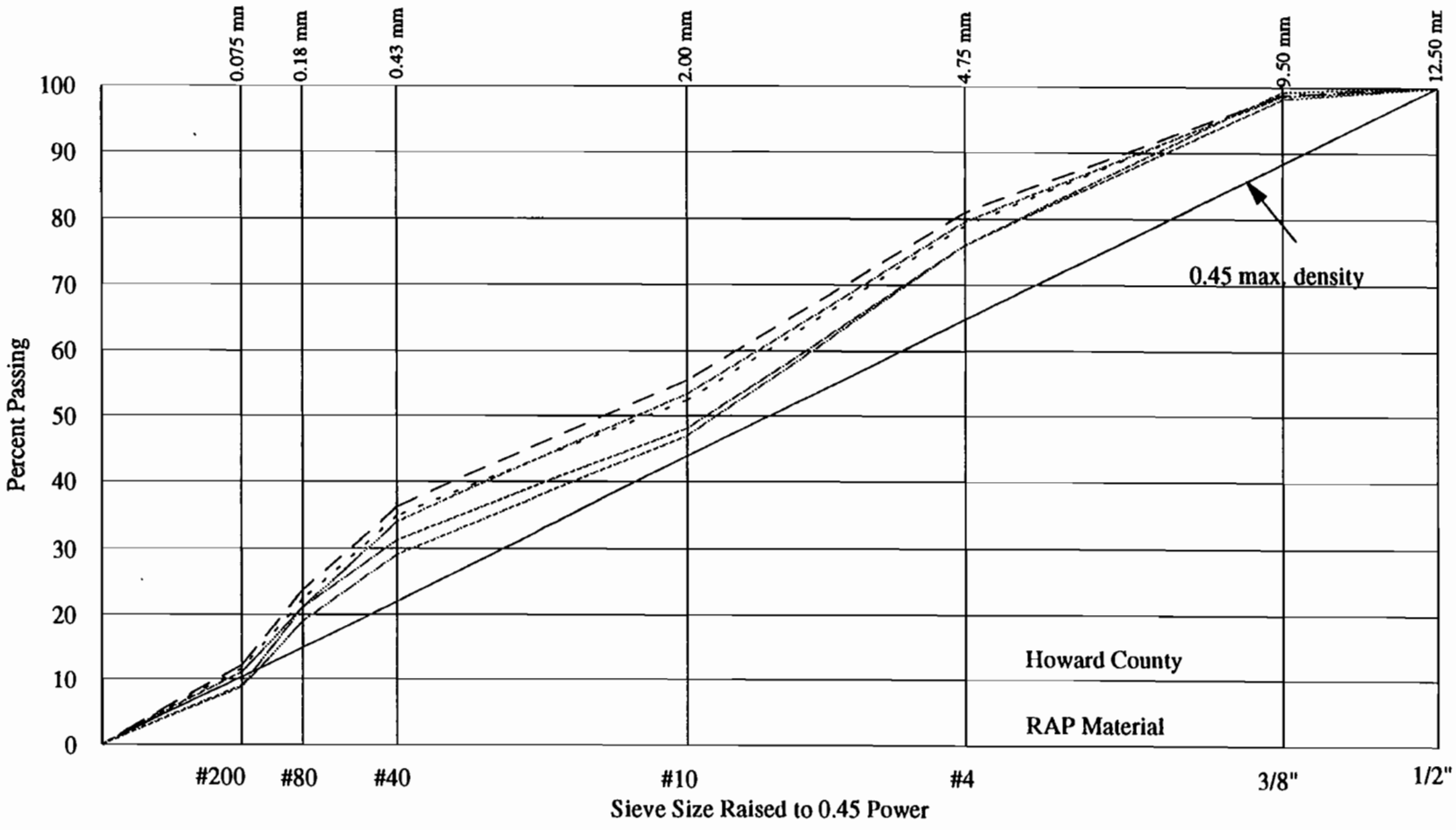


Figure A.1. Daily RAP Gradations from Extraction for the Project in Howard County.

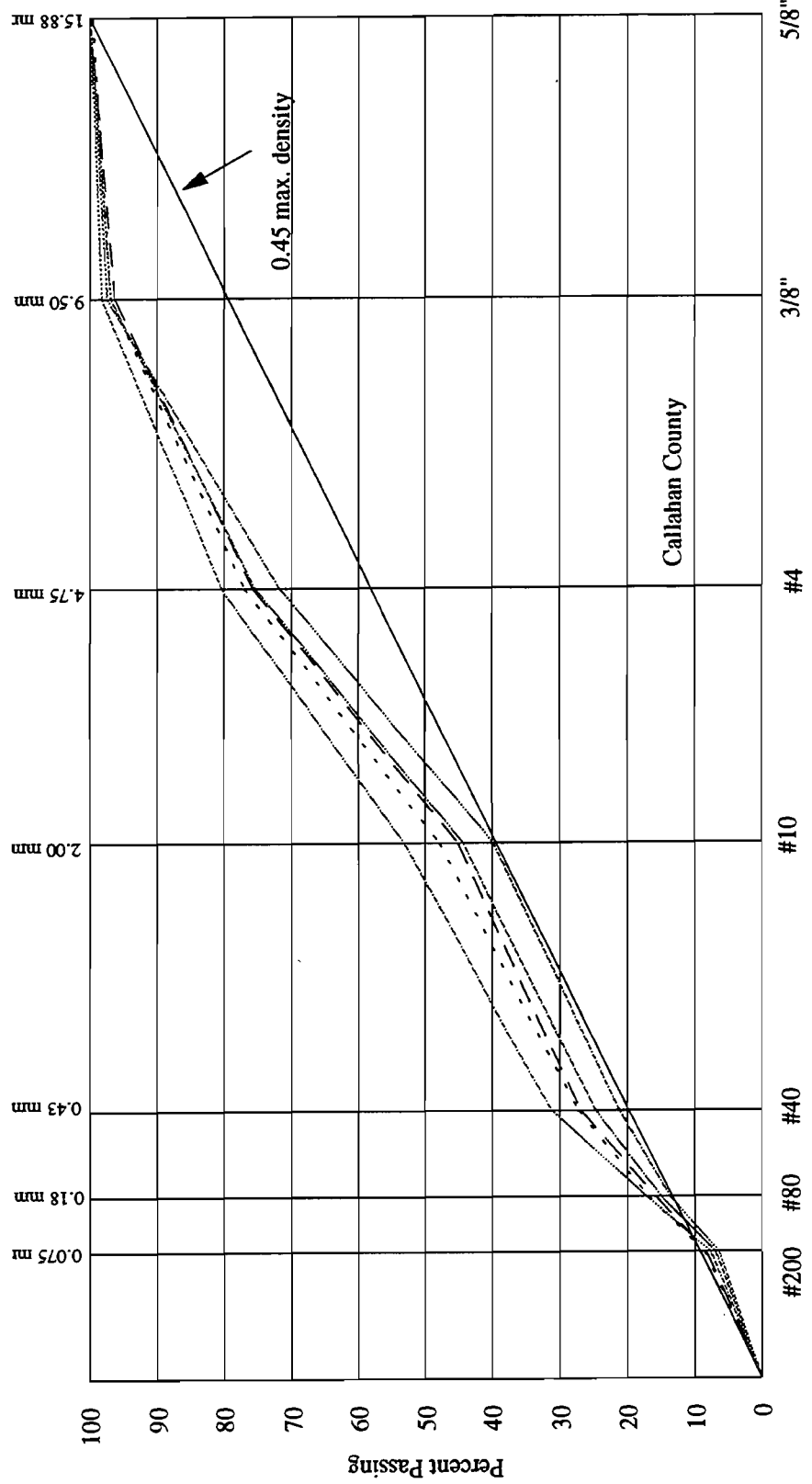


Figure A.2. Daily RAP Gradations for the Project in Callahan County.

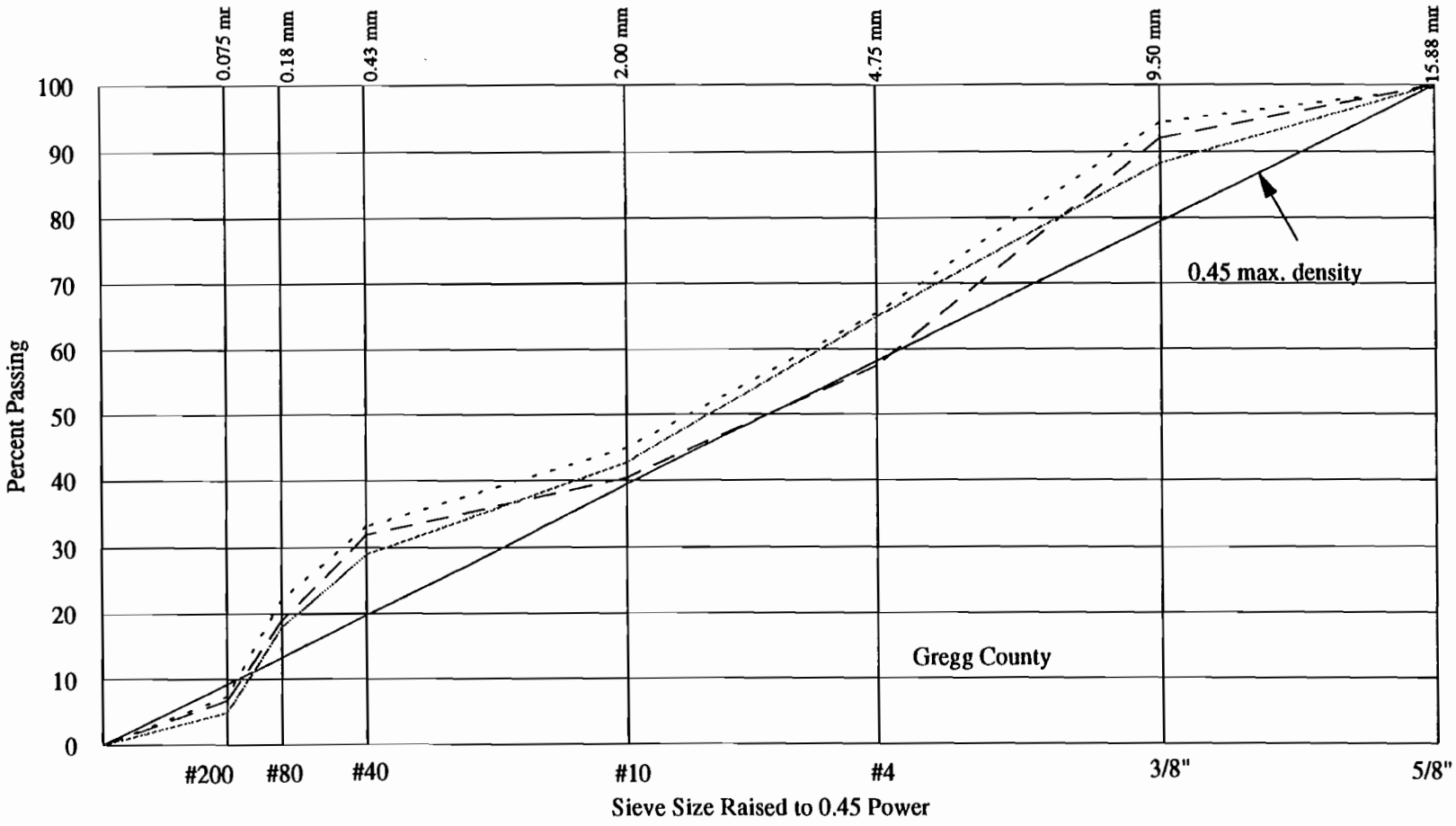


Figure A.3. Daily RAP Gradations from Extraction for the Project in Gregg County.

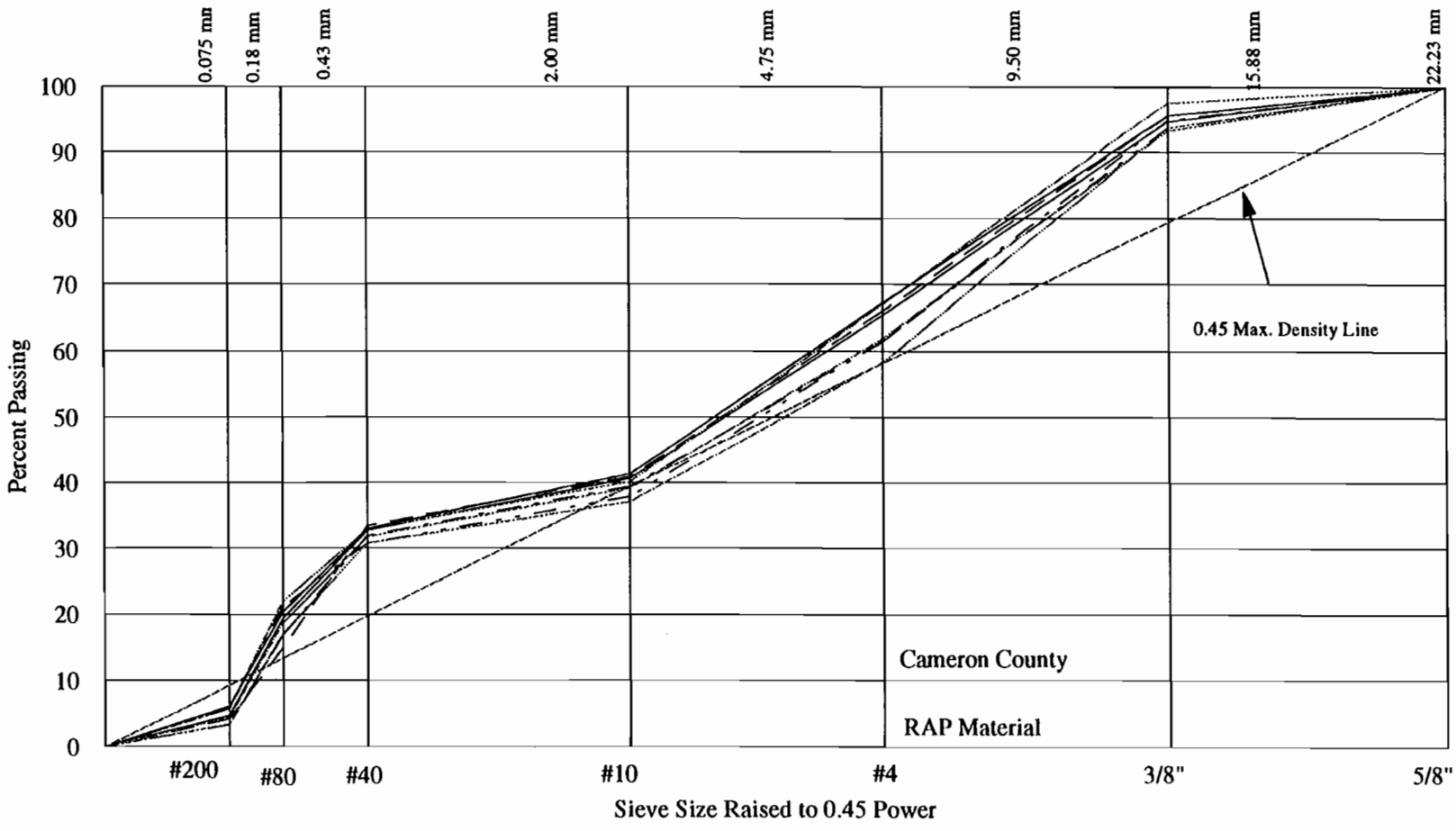


Figure A.4. Daily RAP Gradations from Extraction for the Project in Cameron County.

APPENDIX B

DAILY GRADATIONS AND ASPHALT CONTENTS FOR THE PLANT MIXTURE CONTAINING RAP

Table B.1. Daily Gradation and Asphalt Content for the Project in Howard County.

Project	**CPM 0005-05-081**	Aggregate Source	Transit Materials Inc., Midland, TX
Highway	**IH 20**	Asphalt Source	Fina AC-10, Big Springs, TX
County	**Howard**		
Type D (Surface) with RAP	**Amount of RAP (%) 50**		**Dedicated Stockpile**

SAMPLING DATE 5/16/94

Sample No Tonnage Temperature,F	Target	Plant 1 N/A 300 extract	Plant 2 146 285 extract	UT 3 300 extract	Average Gradation	Sieve No.	Size mm
gradation	**100**	100	100	100.0	100.0	1/2"	12.50
Percent	**96.6**	99.0	98.4	98.2	98.5	3/8"	9.50
Passing	**60.6**	72.9	69.5	59.3	67.2	#4	4.75
	32.6	43.4	39.8	33.0	38.7	#10	2.00
	22.8	26.6	25.9	21.5	24.7	#40	0.43
	13.8	13.1	14.7	13.0	13.6	#80	0.18
	5.4	3.8	6.0	5.5	5.1	#200	0.08
	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	**5.6**	6.4	5.9	5.3	5.9		
Nuclear		5.6	5.7		5.7		

SAMPLING DATE 5/17/94

Sample No Tonnage Temperature,F	Target	Plant 1 206 308 extract	UT 2 160 extract	UT 3 420 extract	Average Gradation	Sieve No.	Size mm
gradation	**100**	100	100	100	100.0	1/2"	12.50
Percent	**96.6**	99.4	98.2	97.2	98.3	3/8"	9.50
Passing	**60.6**	73.1	69.2	58.5	66.9	#4	4.75
	32.6	40.5	36.4	31.5	36.1	#10	2.00
	22.8	26.9	22.9	22.3	24.0	#40	0.43
	13.8	15.6	14.1	16.3	15.3	#80	0.18
	5.4	6.0	5.8	9.3	7.0	#200	0.08
	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	**5.6**	5.8	5.1	4.8	5.2		
Nuclear		5.6			5.6		

NOTE: The asphalt contents from the nuclear gauge measurement do not necessarily correspond to the same sublot and tonnage for extraction tests.

Table B.2. Daily Gradation and Asphalt Content for the Project in Howard County.

Project	**CPM 0005-05-081**	Aggregate Source	Transit Materials Inc., Midland, TX
Highway	**IH 20**	Asphalt Source	Fina AC-10, Big Springs, TX
County	**Howard**		
Type D (Surface) with RAP	**Amount of RAP (%) 50**	**Dedicated Stockpile**	

SAMPLING DATE 5/18/94

Sample No		Plant 1	UT 2	UT 3	UT 4			
Tonnage		90	110	N/A	965	Average	Sieve	Size
Temperature,F	Target	309 extract	extract	extract	extract	Gradation	No.	mm
gradation	100	100	100	100	100	100.0	1/2"	12.50
Percent	96.6	99.6	98.5	98.6	97.6	98.6	3/8"	9.50
Passing	60.6	76.6	75.6	74.5	70.2	74.2	#4	4.75
	32.6	45.6	43.2	44.3	41.1	43.6	#10	2.00
	22.8	30.0	26.6	27.9	27.9	28.1	#40	0.43
	13.8	17.8	17.6	18.9	18.3	18.2	#80	0.18
	5.4	8.1	8.5	10.0	8.7	8.8	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	5.6	5.2	5.9	5.4	5.5	5.5		
Nuclear		5.9	5.2			5.6		

SAMPLING DATE 5/19/94

Sample No		Plant 1	Plant 2	Plant 3	Plant 4	UT 5		
Tonnage		68	660	1582	2055	660	Average	Sieve
Temperature,F	Target	285 extract	292 extract	294 extract	238 extract	extract	Gradation	No.
gradation	100	100	100	100	100	100	100.0	1/2"
Percent	96.6	98.5	98.7	97.9	98.9	98.4	98.5	3/8"
Passing	60.6	70.2	73.0	68.4	73.2	74.3	71.8	#4
	32.6	40.7	43.6	41.1	45.7	41.5	42.5	#10
	22.8	24.4	25.8	25.3	28.7	25.9	26.0	#40
	13.8	12.2	11.6	12.5	14.7	17.1	13.6	#80
	5.4	3.8	2.0	3.3	3.9	8.2	4.2	#200
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	pan
AC content	5.6	5.3	5.2	5.1		5.1	5.2	
Nuclear		5.5	5.7	5.8			5.7	

NOTE: The asphalt contents from the nuclear gauge measurement do not necessarily correspond to the same sublot and tonnage for extraction tests.

Table B.3. Daily Gradation and Asphalt Content for the Project in Howard County.

Project	**CPM 0005-05-081**	Aggregate Source	Transit Materials Inc., Midland, TX
Highway	**IH 20**	Asphalt Source	Fina AC-10, Big Springs, TX
County	**Howard**		
Type D (Surface) with RAP	**Amount of RAP (%) 50**	**Dedicated Stockpile**	

SAMPLING DATE 5/20/94

Sample No Tonnage Temperature,F	Target	Plant 1 90 266 extract				Sieve No.	Size mm
gradation	**100**	100				1/2"	12.50
Percent	**96.6**	98.7				3/8"	9.50
Passing	**60.6**	62.3				#4	4.75
	32.6	34.8				#10	2.00
	22.8	21.1				#40	0.43
	13.8	10.8				#80	0.18
	5.4	2.7				#200	0.08
	0.0	0.0				pan	0.00
AC content	**5.6**	5.2					
Nuclear		5.7					

SAMPLING DATE 5/23/94

Sample No Tonnage Temperature,F	Target	Plant 1 500 300 extract	UT 3 615 extract	Plant 2 1692 286 extract	UT 4 2054 extract	Average Gradation	Sieve No.	Size mm
gradation	**100**	100	100	100	100	100.0	1/2"	12.50
Percent	**96.6**	97.3	98.8	98.2	96.6	97.7	3/8"	9.50
Passing	**60.6**	58.1	74.0	60.9	61.7	63.7	#4	4.75
	32.6	33.8	46.5	32.9	33.9	36.8	#10	2.00
	22.8	20.2	29.9	19.3	21.9	22.8	#40	0.43
	13.8	11.0	18.6	10.7	15.2	13.9	#80	0.18
	5.4	3.4	9.2	3.5	7.8	6.0	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	**5.6**	5.0	6.0	4.8	5.6	5.4		
Nuclear		6.0	5.9	6.1		6.0		

NOTE: The asphalt contents from the nuclear gauge measurement do not necessarily correspond to the same sublot and tonnage for extraction tests.

Table B.4. Daily Gradation and Asphalt Content for the Project in Howard County.

Project	**CPM 0005-05-081**	Aggregate Source	Transit Materials Inc., Midland, TX
Highway	**IH 20**	Asphalt Source	Fina AC-10, Big Springs, TX
County	**Howard**		
Type D (Surface) with RAP	**Amount of RAP (%) 50**	**Dedicated Stockpile**	

SAMPLING DATE 5/24/94

Sample No Tonnage Temperature,F	Target	1 Redesign 283 extract				Sieve No.	Size mm
gradation	**100**	100				1/2"	12.50
Percent	**96.6**	96.7				3/8"	9.50
Passing	**60.6**	58.7				#4	4.75
	32.6	32.8				#10	2.00
	22.8	20.6				#40	0.43
	13.8	11.9				#80	0.18
	5.4	4.1				#200	0.08
	0.0	0.0				pan	0.00
AC content	**4.8**	4.3					
Nuclear		4.8					

SAMPLING DATE 5/25/94

Sample No Tonnage Temperature,F	Target	1 90 307 extract	2 N/A 300 extract		Average Gradation	Sieve No.	Size mm
gradation	**100**	100	100		100.0	1/2"	12.50
Percent	**97.9**	98.0	95.5		96.8	3/8"	9.50
Passing	**58.5**	61.7	51.0		56.4	#4	4.75
	33.3	34.6	28.8		31.7	#10	2.00
	20.6	20.4	18.3		19.4	#40	0.43
	13.2	11.7	10.5		11.1	#80	0.18
	5.1	3.9	3.3		3.6	#200	0.08
	0.0	0.0	0.0		0.0	pan	0.00
AC content	**4.8**	4.4	4.2		4.3		
Nuclear		4.5	3.8		4.2		

NOTE: The asphalt contents from the nuclear gauge measurement do not necessarily correspond to the same sublot and tonnage for extraction tests.

Table B.5. Daily Gradation and Asphalt Content for the Project in Howard County.

Project	**CPM 0005-05-081**	Aggregate Source	Transit Materials Inc., Midland, TX
Highway	**IH 20**	Asphalt Source	Fina AC-10, Big Springs, TX
County	**Howard**		
Type D (Surface) with RAP	**Amount of RAP (%) 50**	**Dedicated Stockpile**	

SAMPLING DATE 5/26/94

Sample No		Plant 1	UT 3	UT 4	Plant 2			
Tonnage		90	95	452	792	Average	Sieve	Size
Temperature,F		300			290	Gradation	No.	mm
	Target	extract	extract	extract	extract			
gradation	100	100	100	100	100	100.0	1/2"	12.50
Percent	97.9	96.3	97.0	97.2	99.0	97.4	3/8"	9.50
Passing	58.5	49.9	52.6	65.4	65.0	58.2	#4	4.75
	33.3	27.4	27.6	35.0	35.5	31.4	#10	2.00
	20.6	19.5	19.1	21.7	24.2	21.1	#40	0.43
	13.2	12.0	13.2	14.5	15.0	13.7	#80	0.18
	5.1	4.9	7.1	7.0	5.8	6.2	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	4.8	4.1	5.7	4.9	4.9	4.9		
Nuclear		4.3			4.5	4.4		

SAMPLING DATE 5/27/94

Sample No		UT 3	Plant 1	Plant 2	UT 4			
Tonnage		91	193	1308	1313	Average	Sieve	Size
Temperature,F			280	297		Gradation	No.	mm
	Target	extract	extract	extract	extract			
gradation	100	100	100	100	100	100.0	1/2"	12.50
Percent	97.9	96.2	98.5	97.9	96.8	97.7	3/8"	9.50
Passing	58.5	59.7	62.8	58.5	58.8	60.0	#4	4.75
	33.3	28.6	33.9	33.3	28.4	31.9	#10	2.00
	20.6	17.5	19.8	20.6	17.5	19.3	#40	0.43
	13.2	12.1	10.6	13.2	11.8	11.9	#80	0.18
	5.1	5.8	3.3	5.1	5.7	4.7	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	4.8	5.0	4.9	4.4	5.9	5.1		
Nuclear			4.6	4.4		4.5		

NOTE: The asphalt contents from the nuclear gauge measurement do not necessarily correspond to the same sublot and tonnage for extraction tests.

Table B.6. Daily Gradation and Asphalt Content for the Project in Howard County.

Project	**CPM 0005-05-081**	Aggregate Source	Transit Materials Inc., Midland, TX
Highway	**IH 20**	Asphalt Source	Fina AC-10, Big Springs, TX
County	**Howard**		
Type D (Surface) with RAP	**Amount of RAP (%) 50**	**Dedicated Stockpile**	

SAMPLING DATE 5/31/94

Sample No		1	2	3	4			
		Plant	UT	Plant	UT			
Tonnage		135	658	1015	2035	Average	Sieve	Size
Temperature,F		300		280		Gradation	No.	mm
	Target	extract	extract	extract	extract			
gradation	**100**	100	100	100	100	100.0	1/2"	12.50
Percent	**97.9**	98.1	96.7	98.7	97.2	97.7	3/8"	9.50
Passing	**58.5**	60.3	65.1	67.7	60.9	63.5	#4	4.75
	33.3	33.3	34.8	38.4	31.5	34.5	#10	2.00
	20.6	18.5	21.2	23.9	19.4	20.8	#40	0.43
	13.2	10.3	13.8	14.4	13.1	12.9	#80	0.18
	5.1	3.7	6.7	6.4	6.4	5.8	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	**4.8**	4.4	5.4	4.7	5.3	5.0		
Nuclear		4.8		4.8		4.8		

SAMPLING DATE 6/1/94

Sample No		1	2	3	4			
Tonnage		266	630	1060	2375	Average	Sieve	Size
Temperature,F		290		N/A		Gradation	No.	mm
	Target	extract	extract	extract	extract			
gradation	**100**	100	100	100	100	100.0	1/2"	12.50
Percent	**97.9**	99.2	97.7	99.0	96.7	98.2	3/8"	9.50
Passing	**58.5**	69.9	62.0	65.9	58.8	64.2	#4	4.75
	33.3	39.4	31.3	36.2	31.2	34.5	#10	2.00
	20.6	24.2	19.6	23.1	19.4	21.6	#40	0.43
	13.2	15.2	13.0	13.5	12.6	13.6	#80	0.18
	5.1	7.1	6.5	3.7	5.8	5.8	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	**4.8**	5.1	4.7	4.5	5.3	4.9		
Nuclear		5.2	4.5	4.9		4.9		

NOTE: The asphalt contents from the nuclear gauge measurement do not necessarily correspond to the same sublot and tonnage for extraction tests.

Table B.7. Daily Gradation and Asphalt Content for the Project in Howard County.

Project	**CPM 0005-05-081**	Aggregate Source	Transit Materials Inc., Midland, TX
Highway	**IH 20**	Asphalt Source	Fina AC-10, Big Springs, TX
County	**Howard**		
Type D (Surface) with RAP	**Amount of RAP (%) 50**	**Dedicated Stockpile**	

SAMPLING DATE 6/2/94

Sample No Tonnage Temperature,F	Target	1 90 extract	UT 2 135 270 extract	Plant 3 640 extract	UT 4 878 extract	Average Gradation	Sieve No.	Size mm
gradation	**100**	100.0	100	100.0	100.0	100.0	1/2"	12.50
Percent	**97.9**	97.3	99.2	98.2	96.2	97.7	3/8"	9.50
Passing	**58.5**	60.3	68.2	66.2	57.7	63.1	#4	4.75
	33.3	32.4	39.0	38.5	32.2	35.5	#10	2.00
	20.6	19.9	23.9	23.8	21.6	22.3	#40	0.43
	13.2	13.2	14.5	15.9	14.3	14.5	#80	0.18
	5.1	5.5	6.6	7.6	7.0	6.7	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00

AC content	**4.8**	6.0	4.8	5.1	4.6	5.1
Nuclear		4.6	5.0			4.8

NOTE: The asphalt contents from the nuclear gauge measurement do not necessarily correspond to the same sublot and tonnage for extraction tests.

Table B.8. Daily Gradation and Asphalt Content for the Project in Callahan County.

Project	**CPM 0006-07-060**
Highway	**IH 20**
County	**Callahan**

Aggregate Source	Vulcan Materials, Limestone
Asphalt Source	Coastal AC-10

Type C (Surface) with RAP	**Amount of RAP (%) 35**	**Dedicated Stockpile**

SAMPLING DATE 7/19/94

Sample No Tonnage Temperature,F	Target	Plant 1 110 extract	UT 2 497 extract	UT 3 1330 extract	Average Gradation	Sieve No.	Size mm
gradation	100	100	100	100	100.0	5/8	15.88
Percent	73.4	82.5	85.9	82.5	83.6	3/8"	9.50
Passing	45.4	59.5	63.8	54.9	59.4	#4	4.75
	32.5	38.7	40.2	34.6	37.8	#10	2.00
	17.1	19.1	21.0	18.8	19.6	#40	0.43
	10.8	11.1	13.2	12.0	12.1	#80	0.18
	7.0	5.2	6.7	6.2	6.0	#200	0.08
	0.0	0.0	0.0	0.0	0.0	pan	0.00
	1						
AC content	5.8	5.4	5.7	5.1	5.4		
Nuclear							

SAMPLING DATE 7/20/94

Sample No Tonnage Temperature,F	Target	Plant 1 82 extract	Plant 2 489 extract	Plant 3 2225 extract	Average Gradation	Sieve No.	Size mm
gradation	100	100	100	100	100.0	5/8"	15.88
Percent	73.4	82.3	83.7	84.5	83.5	3/8"	9.50
Passing	45.4	58.5	58.9	60.7	59.4	#4	4.75
	32.5	38.0	36.5	40.1	38.2	#10	2.00
	17.1	19.4	19.7	19.8	19.6	#40	0.43
	10.8	11.1	11.9	12.1	11.7	#80	0.18
	7.0	5.1	5.8	6.0	5.6	#200	0.08
	0.0	0.0	0.0	0.0	0.0	pan	0.00
	1						
AC content	5.8	5.1	5.4	5.2	5.2		
Nuclear							

Table B.9. Daily Gradation and Asphalt Content for the Project in Callahan County.

Project	**CPM 0006-07-060**
Highway	**IH 20**
County	**Callahan**

Aggregate Source	Vulcan Materials, Limestone
Asphalt Source	Coastal AC-10

Type C (Surface) with RAP	**Amount of RAP (%) 35**	**Dedicated Stockpile**

SAMPLING DATE 7/21/94

Sample No		Plant 1	Plant 2	UT 3	UT 4			
Tonnage		125	620	1099	1495	Average	Sieve	Size
Temperature,F	Target	extract	extract	extract	extract	Gradation	No.	mm
gradation	100	100	100	100	100	100.0	5/8"	15.88
Percent	73.4	77.7	84.6	82.9	74.2	79.9	3/8"	9.50
Passing	45.4	58.0	61.9	60.7	50.4	57.8	#4	4.75
	32.5	37.7	38.8	38.1	33.7	37.1	#10	2.00
	17.1	20.3	20.8	18.6	18.6	19.6	#40	0.43
	10.8	12.8	13.3	11.1	11.9	12.3	#80	0.18
	7.0	6.7	6.9	5.0	6.1	6.2	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
	1							
AC content	5.8	5.3	5.8	5.8	5.3			
Nuclear								

SAMPLING DATE 7/22/94

Sample No		Plant 1	UT 2	UT 3	UT 4			
Tonnage		206	771	1180	1804	Average	Sieve	Size
Temperature,F	Target	extract	extract	extract	extract	Gradation	No.	mm
gradation	100	100	100	100	100	100.0	5/8"	15.88
Percent	73.4	73.6	82.2	83.1	72.1	77.8	3/8"	9.50
Passing	45.4	47.9	57.6	60.1	50.3	54.0	#4	4.75
	32.5	31.7	36.8	39.2	32.8	35.1	#10	2.00
	17.1	15.3	21.0	21.6	18.1	19.0	#40	0.43
	10.8	8.9	13.3	13.8	11.5	11.9	#80	0.18
	7.0	4.0	5.9	7.7	5.8	5.9	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	5.8	4.7	5.2	5.5	4.8			
Nuclear								

Table B.10. Daily Gradation and Asphalt Content for the Project in Callahan County.

Project	**CPM 0006-07-060**
Highway	**IH 20**
County	**Callahan**

Aggregate Source	Vulcan Mat'ls, Limestone
Asphalt Source	Coastal AC-10

Type C (Surface) with RAP	**Amount of RAP (%) 35**	**Dedicated Stockpile**

SAMPLING DATE		7/25/94						
		Plant	UT	UT	UT			
Sample No		1	2	3	4			
Tonnage			508	967	1394	Average	Sieve	Size
Temperature,F		290				Gradation	No.	mm
	Target	extract	extract	extract	extract			
gradation	100	100	100	100	100	100	5/8"	15.88
Percent	82.1	72.4	76.2	81.6	79.9	77.5	3/8"	9.50
Passing	59.1	51.6	58.0	60.6	61.3	57.9	#4	4.75
	38.2	34.5	39.0	40.1	39.8	38.4	#10	2.00
	19.6	16.5	21.8	21.9	20.9	20.3	#40	0.43
	11.8	9.2	14.7	13.7	13.0	12.7	#80	0.18
	5.7	3.5	8.0	7.2	6.6	6.3	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
	2							
AC content	5.6	5.5	5.4	5.7	5.8	5.6		
Nuclear								

Table B.11. Daily Gradation and Asphalt Content for the Project in Gregg County.

Project	**IM 20-6(71) 580**
Highway	**IH 20**
County	**Gregg**

Aggregate Source	G-H Perch & C.X.I , Crushed Stone
Asphalt Source	AC-10, Lion Oil, El Dorado, AR

Type C (Base) with RAP	**Amount of RAP (%) 35**	**Dedicated Stockpile**

SAMPLING DATE 5/4/94

Sample No Tonnage Temperature,F	Target	Plant 1 N/A 315 extract	Plant 2 N/A 320 extract	UT 3 extract	UT 4 extract	UT 5 extract	Average Gradation	Sieve No.	Size mm
gradation	100	100	100	100	100	99	99.8	5/8"	15.88
Percent	81.0	84.5	83.8	82.1	84.9	75.7	82.2	3/8"	9.50
Passing	52.5	56.6	55.5	57.4	56.9	50.8	55.4	#4	4.75
	34.3	36.1	35.4	37.0	37.6	31.9	35.6	#10	2.00
	19.3	22.0	22.2	22.3	21.3	20.8	21.7	#40	0.43
	10.7	13.5	13.7	14.1	13.5	14.3	13.8	#80	0.18
	2.3	5.2	4.9	5.0	3.7	5.1	4.8	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0	0.0	pan	0.00
AC content	3.7	4.1	4.0	4.2	4.1	4.1	4.1		

SAMPLING DATE 5/6/94

Sample No Tonnage Temperature,F	Target	Plant 1 N/A 315 extract	Plant 2 N/A 320 extract	UT 3 extract	UT 4 extract	UT 5 extract	Average Gradation	Sieve No.	Size mm
gradation	100	100	100	100	100	100	100.0	5/8"	15.88
Percent	81.0	85.1	84.0	81.2	86.9	85.2	84.5	3/8"	9.50
Passing	52.5	55.2	55.4	57.8	60.0	58.9	57.5	#4	4.75
	34.3	36.0	35.8	37.9	38.7	38.6	37.4	#10	2.00
	19.3	21.9	21.5	22.8	23.4	23.5	22.6	#40	0.43
	10.7	13.6	13.4	15.0	14.9	16.2	14.6	#80	0.18
	2.3	4.1	4.7	5.1	4.4	5.5	4.8	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0	0.0	pan	0.00
AC content	3.7	4.2	4.1	4.0	4.5	4.3	4.2		

Table B.13. Daily Gradation and Asphalt Content for the Project in Gregg County.

Project	**IM 20-6(71) 580**
Highway	**IH 20**
County	**Gregg**

Aggregate Source	G-H Perch & C.X.I
Asphalt Source	AC-10, Lion Oil, El Dorado, AR

Type C (Base) with RAP	**Amount of RAP (%) 35**	**Dedicated Stockpile**

SAMPLING DATE 5/16/94 5/17/94

Sample No Tonnage Temperature,F	Target	1 Plant N/A 295 extract	2 UT extract	Average Gradation		Sieve No.	Size mm
gradation	**100**	100	99	99.6		5/8"	15.88
Percent	**81.0**	77.1	79.5	78.3		3/8"	9.50
Passing	**52.5**	50.9	55.7	53.3		#4	4.75
	34.3	32.0	35.1	33.6		#10	2.00
	19.3	19.1	21.7	20.4		#40	0.43
	10.7	11.9	13.9	12.9		#80	0.18
	2.3	4.3	4.7	4.5		#200	0.08
	0.0	0.0	0.0	0.0		pan	0.00
AC content	**3.7**	4.2	4.4	4.3			

SAMPLING DATE 5/18/94

Sample No Tonnage Temperature,F	Target	1 Plant N/A 305 extract	2 Plant N/A 305 extract	3 Plant N/A 310 extract	Average Gradation	Sieve No.	Size mm
gradation	**100**	100	100	100	100.0	5/8"	15.88
Percent	**81.0**	80.1	76.0	77.4	77.8	3/8"	9.50
Passing	**52.5**	52.3	48.2	52.9	51.1	#4	4.75
	34.3	32.5	30.3	32.8	31.9	#10	2.00
	19.3	20.3	19.0	18.9	19.4	#40	0.43
	10.7	13.7	13.3	12.4	13.1	#80	0.18
	2.3	5.3	5.1	4.4	4.9	#200	0.08
	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	**3.7**	4.0	4.0	4.1	4.0		

Table B.14. Daily Gradation and Asphalt Content for the Project in Gregg County.

Project	**IM 20-6(71) 580**
Highway	**IH 20**
County	**Gregg**

Aggregate Source	G-H Perch & C.X.I
Asphalt Source	AC-10, Lion Oil, El Dorado, AR

Type C (Base) with RAP	**Amount of RAP (%) 35**	**Dedicated Stockpile**

SAMPLING DATE 5/19/94

Sample No Tonnage Temperature,F	Target	Plant 1 N/A 315 extract	Plant 2 N/A 315 extract		Average Gradation	Sieve No.	Size mm
gradation	100	100	100		100	5/8"	15.88
Percent	81.0	79.1	79.7		79.4	3/8"	9.50
Passing	52.5	54.2	54.0		54.1	#4	4.75
	34.3	33.5	33.9		33.7	#10	2.00
	19.3	20.1	20.0		20.1	#40	0.43
	10.7	13.4	13.1		13.3	#80	0.18
	2.3	4.9	4.7		4.8	#200	0.08
	0.0	0.0	0.0		0.0	pan	0.00
AC content	3.7	4.2	4.1		4.2		

SAMPLING DATE 5/23/94

Sample No Tonnage Temperature,F	Target	Plant 1 N/A 310 extract	Plant 2 N/A 310 extract	UT 3 extract	UT 4 extract	Average Gradation	Sieve No.	Size mm
gradation	100	100	100	100	100	100	5/8"	15.90
Percent	81.0	82.2	81.1	85.4	85.5	83.6	3/8"	9.50
Passing	52.5	57.3	53.0	59.3	56.6	56.6	#4	4.75
	34.3	35.1	32.4	37.4	35.5	35.1	#10	2.00
	19.3	21.0	20.2	23.1	22.4	21.7	#40	0.43
	10.7	13.4	13.1	15.9	14.6	14.3	#80	0.18
	2.3	4.9	4.2	5.2	4.4	4.7	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	3.7	3.9	4.2	4.7	4.4	4.3		

Table B.15. Daily Gradation and Asphalt Content for the Project in Gregg County.

Project	**IM 20-6(71) 580**
Highway	**IH 20**
County	**Gregg**

Aggregate Source	G-H Perch & C.X.I
Asphalt Source	AC-10, Lion Oil, El Dorado, AR

Type C (Base) with RAP	**Amount of RAP (%) 35**	**Dedicated Stockpile**

SAMPLING DATE 5/25/94

Sample No Tonnage Temperature,F	Target	1 N/A 310 extract	2 N/A 320 extract	3 extract	4 extract	Average Gradation	Sieve No.	Size mm
gradation	100	99.4	100	99.4	100	99.5	5/8"	15.9
Percent	81.0	77.6	78.8	80.9	78.6	79.0	3/8"	9.50
Passing	52.5	51.4	51.2	57.8	56.2	54.2	#4	4.75
	34.3	31.3	31.4	34.7	35.5	33.2	#10	2.00
	19.3	18.6	19.1	19.8	21.3	19.7	#40	0.43
	10.7	12.0	12.0	13.1	13.8	12.7	#80	0.18
	2.3	4.7	4.5	4.7	4.3	4.6	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	3.7	4.2	4.2	4.4	4.5	4.3		

SAMPLING DATE 5/31/94

		plant	Plant	UT				
Sample No Tonnage Temperature,F	Target	1 N/A 315 extract	2 N/A 320 extract	3 extract	Average Gradation	Sieve No.	Size mm	
gradation	100	100.0	100	100	99.8	5/8"	15.90	
Percent	81.0	86.0	85.0	84.4	85.1	3/8"	9.50	
Passing	52.5	57.0	56.0	60.6	57.9	#4	4.75	
	34.3	35.5	35.9	37.6	36.3	#10	2.00	
	19.3	22.3	21.9	23.0	22.4	#40	0.43	
	10.7	13.7	12.4	15.3	13.8	#80	0.18	
	2.3	5.2	4.8	4.5	4.8	#200	0.08	
	0.0	0.0	0.0	0.0	0.0	pan	0.00	
AC content	3.7	4.2			4.2			

Table B.16. Daily Gradation and Asphalt Content for the Project in Gregg County.

Project	**IM 20-6(71) 580**
Highway	**IH 20**
County	**Gregg**

Aggregate Source	G-H Perch & C.X.I
Asphalt Source	AC-10, Lion Oil, El Dorado, AR

Type C (Base) with RAP	**Amount of RAP (%) 35**	**Dedicated Stockpile**

SAMPLING DATE		6/7/94 plant	6/8/94 Plant				
Sample No Tonnage Temperature,F	Target	1 N/A 315 extract	2 N/A 320 extract		Average Gradation	Sieve No.	Size mm
gradation	**100**	100.0	100		100.0	5/8"	15.90
Percent	**81.0**	86.0	78.6		82.3	3/8"	9.50
Passing	**52.5**	57.0	51.3		54.2	#4	4.75
	34.3	35.5	30.8		33.2	#10	2.00
	19.3	22.3	18.6		20.5	#40	0.43
	10.7	13.7	12.3		13.0	#80	0.18
	2.3	5.2	4.3		4.8	#200	0.08
	0.0	0.0	0.0		0.0	pan	0.00
AC content	**3.7**	4.1	4.0		4.1		

Table B.17. Daily Gradation and Asphalt Content for the Project in Cameron County.

Project	**NH 94 (21) M**		Aggregate Source	Limestone and Crushed Gravel
Highway	**SH 100**			Parker La Farge and Fordyce
County	**Cameron**		Asphalt Source	Coastal AC-5
Type B (Base) with RAP		**Amount of RAP (%) 40**		**Dedicated Stockpile**

SAMPLING DATE 8/17/94

Sample No Tonnage Temperature,F	Target	UT 1 1085 extract	UT 2 1711 extract	Plant 3 N/A extract	Plant 4 N/A extract	Average Gradation	Sieve No.	Size mm
gradation	**100**	100	100	100.0	100.0	100.0	7/8"	22.23
	93.0	91.9	86.5	95.2	94.8	92.1	5/8"	15.88
Percent	**73.0**	73.7	71.1	76.7	75.1	74.2	3/8"	9.50
Passing	**44.0**	50.9	48.0	49.0	49.2	49.3	#4	4.75
	31.0	32.4	29.8	34.7	32.5	32.4	#10	2.00
	14.0	20.8	20.3	19.3	10.4	17.7	#40	0.43
	5.0	13.6	13.6	10.6	4.2	10.5	#80	0.18
	2.0	4.7	5.0	4.4	1.2	3.8	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	**4.7**	4.2	4.0	4.5	4.3	4.3		
Nuclear		3.9	4.4	4.9		4.4		

SAMPLING DATE 8/18/94

Sample No Tonnage Temperature,F	Target	UT 1 830 extract	UT 2 1271 extract	UT 3 2517 extract	UT 4 2900 extract	Average Gradation	Sieve No.	Size mm
gradation	**100**	100	99	100.0	100.0	99.7	7/8"	22.23
	93.0	93.3	93.6	87.8	93.9	92.2	5/8"	15.88
Percent	**73.0**	81.8	81.8	75.1	83.9	80.7	3/8"	9.50
Passing	**44.0**	57.2	56.3	55.9	59.7	57.3	#4	4.75
	31.0	35.7	35.5	36.1	36.8	36.0	#10	2.00
	14.0	23.9	23.6	23.4	23.2	23.5	#40	0.43
	5.0	14.5	14.0	13.7	14.0	14.1	#80	0.18
	2.0	4.9	4.6	4.4	4.6	4.6	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	**4.7**	5.1	4.7	4.7	5.0	4.9		
Nuclear		4.1	4.5	4.3		4.3		

NOTE: The asphalt contents from the nuclear gauge measurement do not necessarily correspond to the same sublot and tonnage for extraction tests.

Table B.18. Daily Gradation and Asphalt Content for the Project in Cameron County.

Project	**NH 94 (21) M**		Aggregate Source	Limestone and Crushed Gravel
				Parker La Farge and Fordyce
Highway	**SH 100**			
County	**Cameron**		Asphalt Source	Coastal AC-5
Type B (Base) with RAP		**Amount of RAP (%) 40**		**Dedicated Stockpile**

SAMPLING DATE 8/22/94

Sample No Tonnage Temperature,F	Target	UT 1 550 extract	UT 2 1820 extract	UT 3 2230 extract	UT 4 2585 extract	Average Gradation	Sieve No.	Size mm
gradation	**100**	100	100	100.0	100.0	100.0	7/8"	22.23
	93.0	93.4	92.0	93.0	90.0	92.1	5/8"	15.88
Percent	**73.0**	78.7	79.2	82.3	75.7	79.0	3/8"	9.50
Passing	**44.0**	56.1	56.2	57.2	48.7	54.6	#4	4.75
	31.0	34.5	34.7	35.2	27.6	33.0	#10	2.00
	14.0	22.6	22.6	22.6	16.6	21.1	#40	0.43
	5.0	13.4	14.3	14.1	9.8	12.9	#80	0.18
	2.0	5.1	5.4	4.6	2.6	4.4	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	**4.7**	4.6	4.5	4.5	4.7	4.6		
Nuclear		4.3	4.4	3.7		4.1		

SAMPLING DATE 8/23/94

Sample No Tonnage Temperature,F	Target	UT 1 688 extract	UT 2 1300 extract	UT 3 1890 extract	UT 4 2880 extract	Average Gradation	Sieve No.	Size mm
gradation	**100**	100	100	100.0	100.0	100.0	7/8"	22.23
	93.0	89.8	93.8	94.1	95.7	93.4	5/8"	15.88
Percent	**73.0**	72.8	79.2	83.8	83.2	79.8	3/8"	9.50
Passing	**44.0**	52.5	56.2	58.8	61.5	57.3	#4	4.75
	31.0	33.1	34.4	35.5	37.4	35.1	#10	2.00
	14.0	22.1	22.6	23.0	22.9	22.7	#40	0.43
	5.0	14.5	13.1	14.4	13.7	13.9	#80	0.18
	2.0	5.9	4.4	5.0	4.8	5.0	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	**4.7**	3.8	5.0	4.8	4.6	4.6		
Nuclear		4.4	4.4	4.4		4.4		

NOTE: The asphalt contents from the nuclear gauge measurement do not necessarily correspond to the same sublot and tonnage for extraction tests.

Table B.19. Daily Gradation and Asphalt Content for the Project in Cameron County.

Project	**NH 94 (21) M**	Aggregate Source	Limestone and Crushed Gravel
Highway	**SH 100**		Parker La Farge and Fordyce
County	**Cameron**	Asphalt Source	Coastal AC-5
Type B (Base) with RAP		**Amount of RAP (%) 40**	**Dedicated Stockpile**

SAMPLING DATE 8/25/94

Sample No Tonnage Temperature,F	Target	UT 1 633 extract	UT 2 1315 extract	UT 3 1903 extract	UT 4 2705 extract	Average Gradation	Sieve No.	Size mm
gradation	**100**	100	100	100.0	100.0	100.0	7/8"	22.23
	93.0	90.5	91.0	92.0	94.8	92.1	5/8"	15.88
Percent	**73.0**	80.5	76.0	80.7	81.2	79.6	3/8"	9.50
Passing	**44.0**	58.0	54.1	54.8	53.6	55.1	#4	4.75
	31.0	35.5	33.4	33.3	31.8	33.5	#10	2.00
	14.0	22.6	22.7	22.1	21.2	22.2	#40	0.43
	5.0	13.8	14.1	14.8	13.9	14.2	#80	0.18
	2.0	4.7	4.8	5.4	5.4	5.1	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	**4.7**	4.6	4.7	4.6	4.5	4.6		
Nuclear		3.9	4.2	4.4		4.2		

SAMPLING DATE 8/26/94

Sample No Tonnage Temperature,F	Target	UT 1 862 extract	UT 2 1546 extract	UT 3 2311 extract	Plant N/A extract	Average Gradation	Sieve No.	Size mm
gradation	**100**	100	100	100.0	100.0	100.0	7/8"	22.23
	93.0	92.4	94.4	89.4	96.4	93.2	5/8"	15.88
Percent	**73.0**	81.0	80.3	74.4	76.9	78.2	3/8"	9.50
Passing	**44.0**	60.7	59.4	52.3	49.4	55.5	#4	4.75
	31.0	37.9	37.8	33.4	29.6	34.7	#10	2.00
	14.0	24.5	24.4	21.7	16.7	21.8	#40	0.43
	5.0	14.6	14.9	13.2	6.2	12.2	#80	0.18
	2.0	5.4	5.1	4.0	2.1	4.2	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	**4.7**	5.0	4.9	4.8	4.2	4.7		
Nuclear		4.4	4.3	4.4		4.4		

NOTE: The asphalt contents from the nuclear gauge measurement do not necessarily correspond to the same sublot and tonnage for extraction tests.

Table B.20. Daily Gradation and Asphalt Content for the Project in Cameron County.

Project	**NH 94 (21) M**		Aggregate Source	Limestone and Crushed Gravel
Highway	**SH 100**			Parker La Farge and Fordyce
County	**Cameron**		Asphalt Source	Coastal AC-5
Type B (Base) with RAP		**Amount of RAP (%) 40**		**Dedicated Stockpile**

SAMPLING DATE 8/29/94

Sample No		UT 1	UT 2	UT 3	UT 4			
Tonnage		840	1417	2250	2530	Average	Sieve	Size
Temperature,F	Target	extract	extract	extract	extract	Gradation	No.	mm
gradation	100	100	100	100.0	100.0	100.0	7/8"	22.23
	93.0	93.7	94.1	94.4	91.1	93.3	5/8"	15.88
Percent	73.0	82.8	87.6	81.0	81.9	83.3	3/8"	9.50
Passing	44.0	55.9	61.8	58.3	58.0	58.5	#4	4.75
	31.0	34.9	39.3	35.2	35.7	36.3	#10	2.00
	14.0	23.3	25.6	22.4	23.0	23.6	#40	0.43
	5.0	14.4	14.8	13.6	14.0	14.2	#80	0.18
	2.0	5.1	4.8	4.3	4.2	4.6	#200	0.08
	0.0	0.0	0.0	0.0	0.0	0.0	pan	0.00
AC content	4.7	5.8	4.8	4.8	4.5	5.0		
Nuclear		4.5	4.7	4.5		4.6		

SAMPLING DATE 8/30/94

Sample No		UT 1	UT 2	UT 3				
Tonnage		800	1400	1960		Average	Sieve	Size
Temperature,F	Target	extract	extract	extract		Gradation	No.	mm
gradation	100	100	100	100.0		100.0	7/8"	22.23
	93.0	98.2	95.2	91.5		95.0	5/8"	15.88
Percent	73.0	87.9	85.9	80.5		84.8	3/8"	9.50
Passing	44.0	60.3	58.1	55.6		58.0	#4	4.75
	31.0	37.6	36.2	34.4		36.1	#10	2.00
	14.0	23.9	23.7	22.8		23.5	#40	0.43
	5.0	14.3	14.3	13.7		14.1	#80	0.18
	2.0	4.6	4.6	4.2		4.5	#200	0.08
	0.0	0.0	0.0	0.0		0.0	pan	0.00
AC content	4.7	4.9	4.9	4.9		4.9		
Nuclear								

NOTE: The asphalt contents from the nuclear gauge measurement do not necessarily correspond to the same sublot and tonnage for extraction tests.

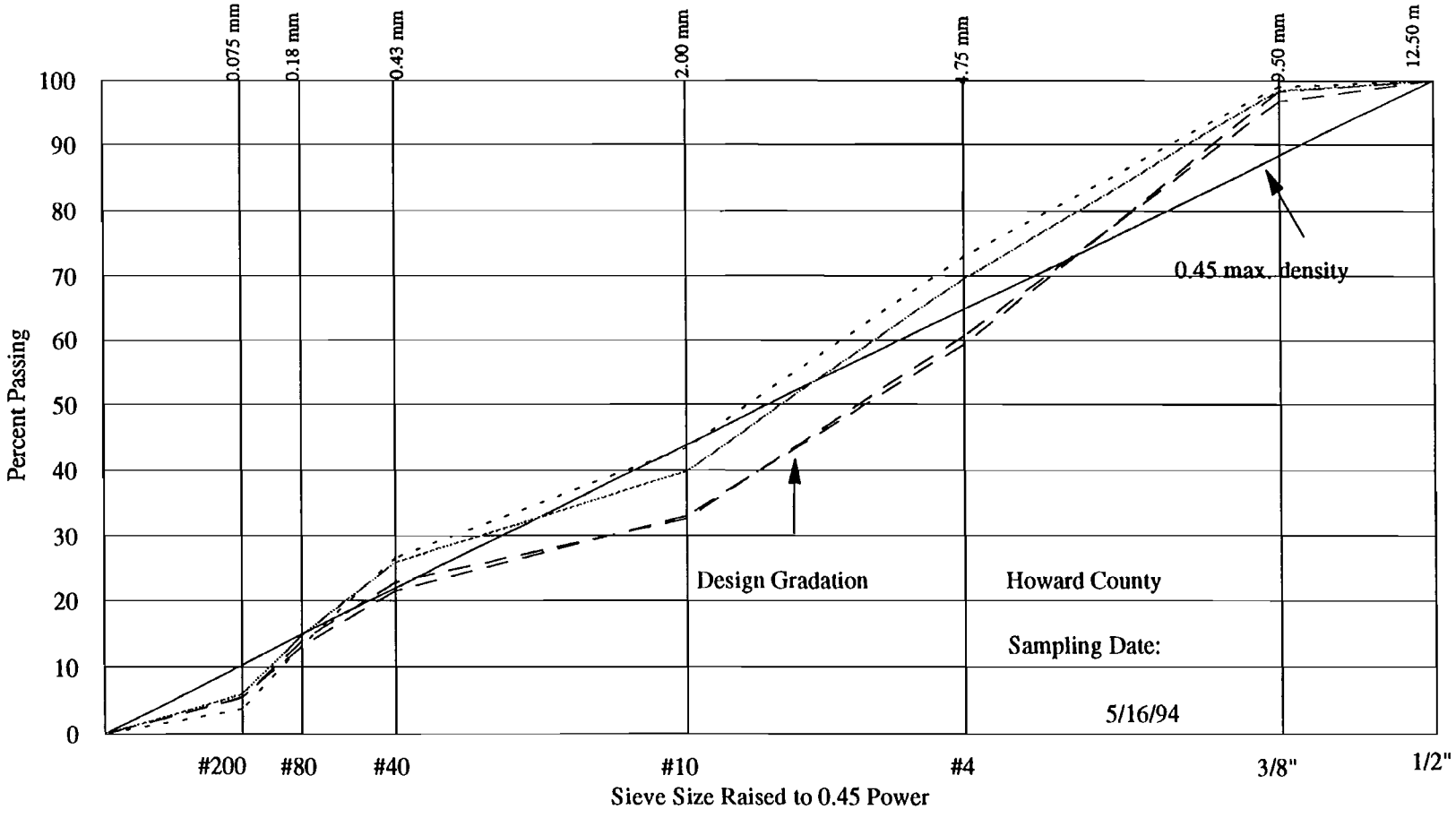


Figure B.1. Daily Gradations from Extraction for the Project in Howard County.

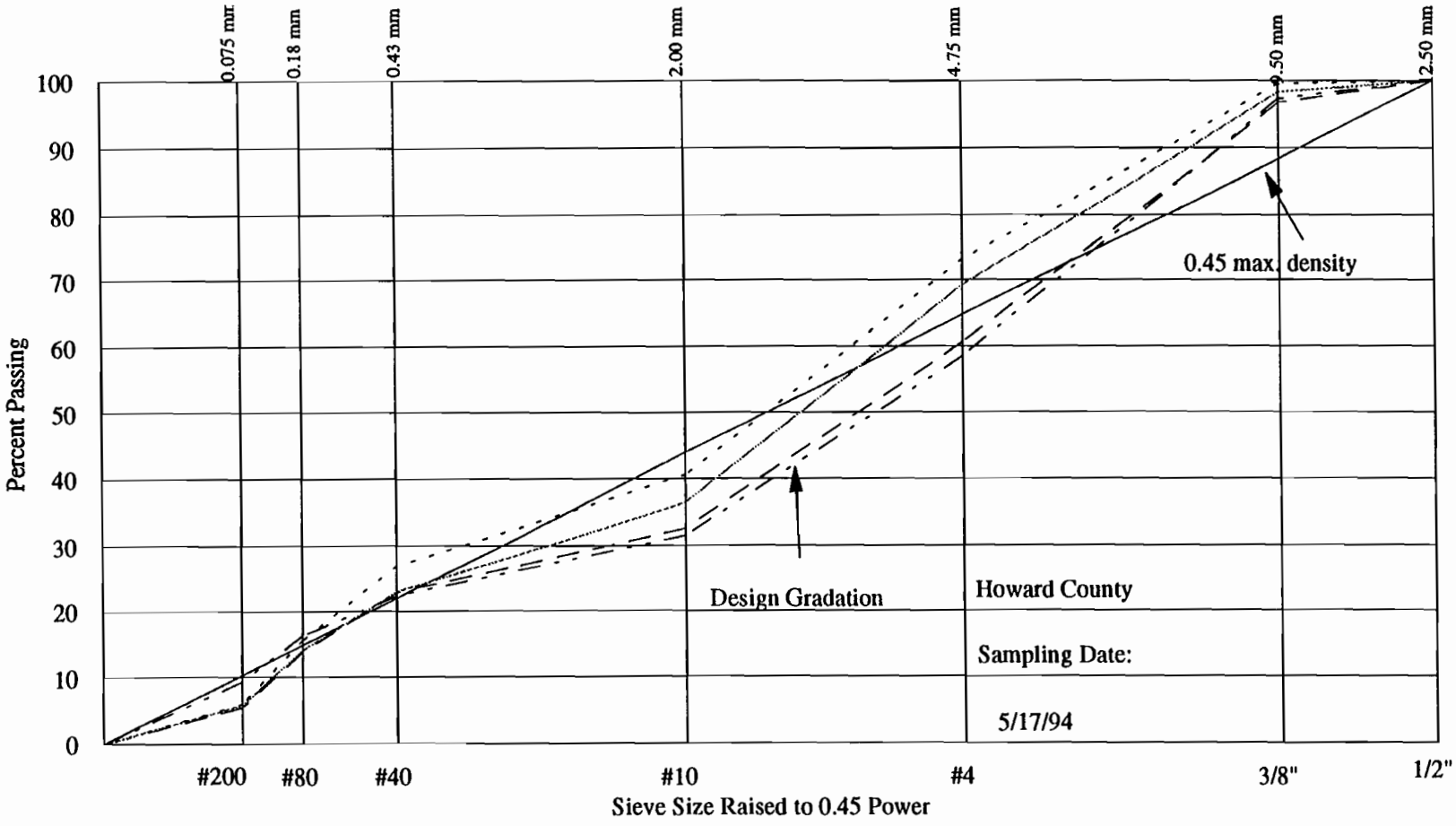


Figure B.2. Daily Gradations from Extraction for the Project in Howard County.

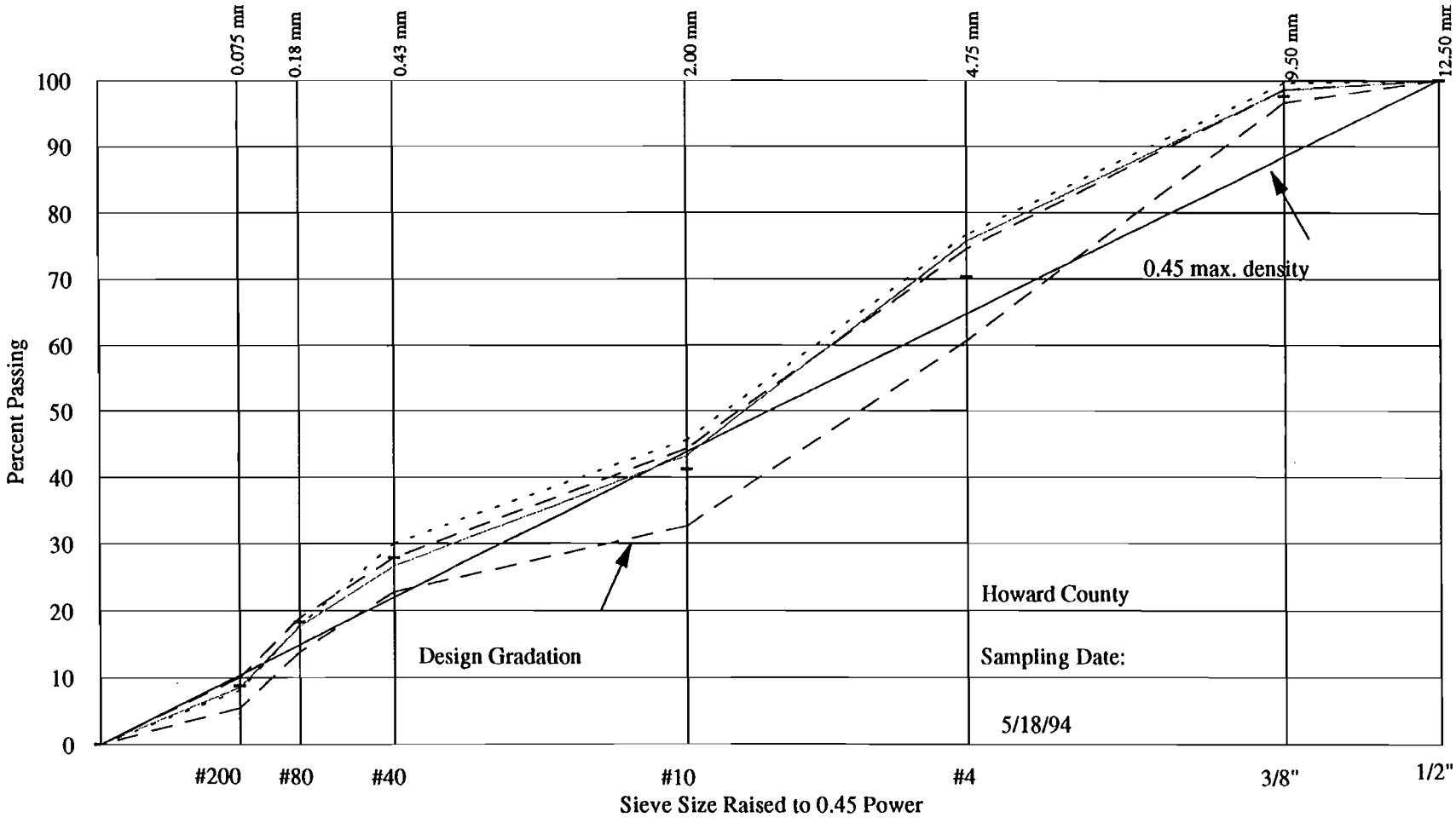


Figure B.3. Daily Gradations from Extraction for the Projet in Howard County.

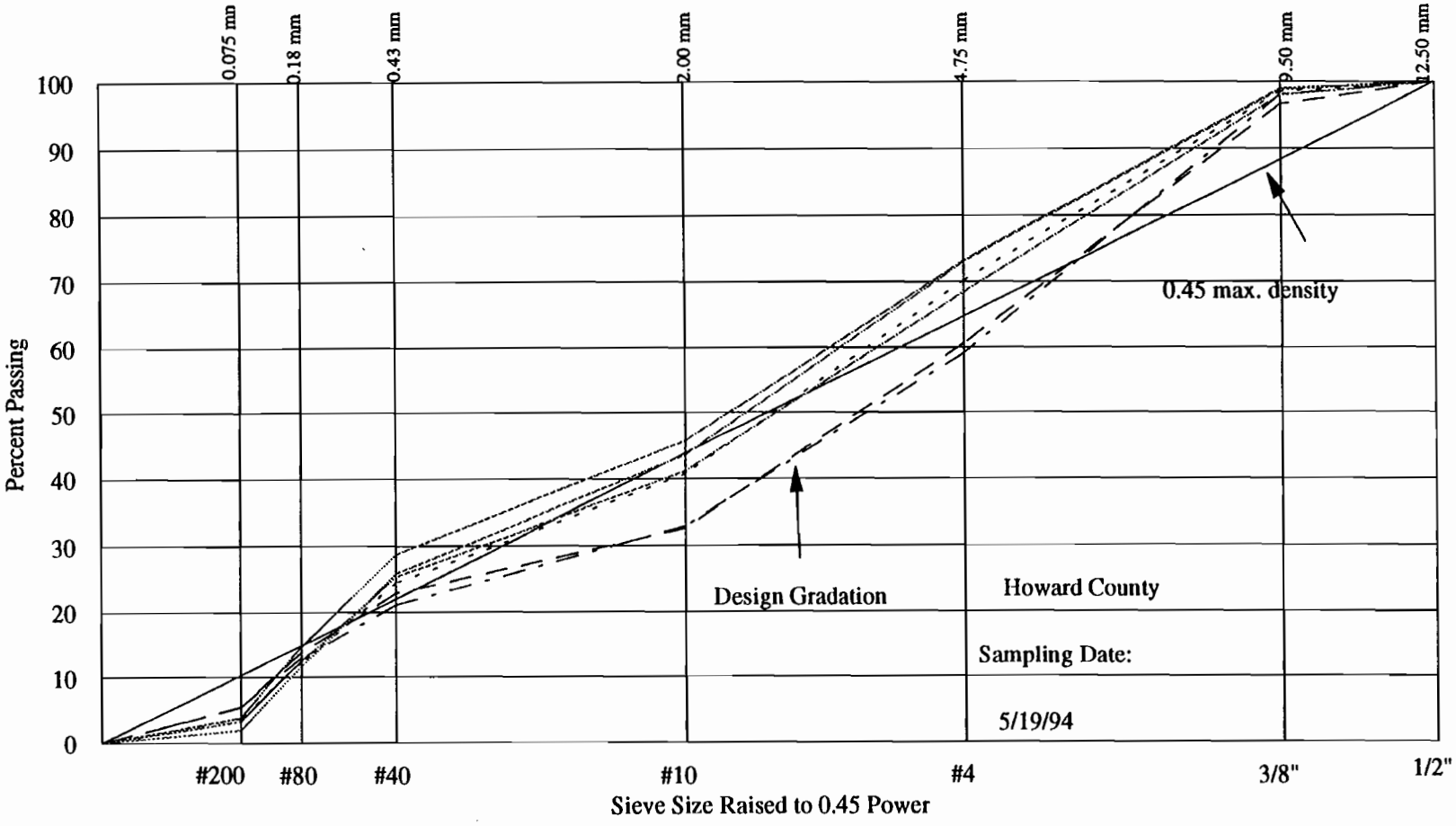


Figure B.4. Daily Gradations from Extraction for the Project in Howard County.

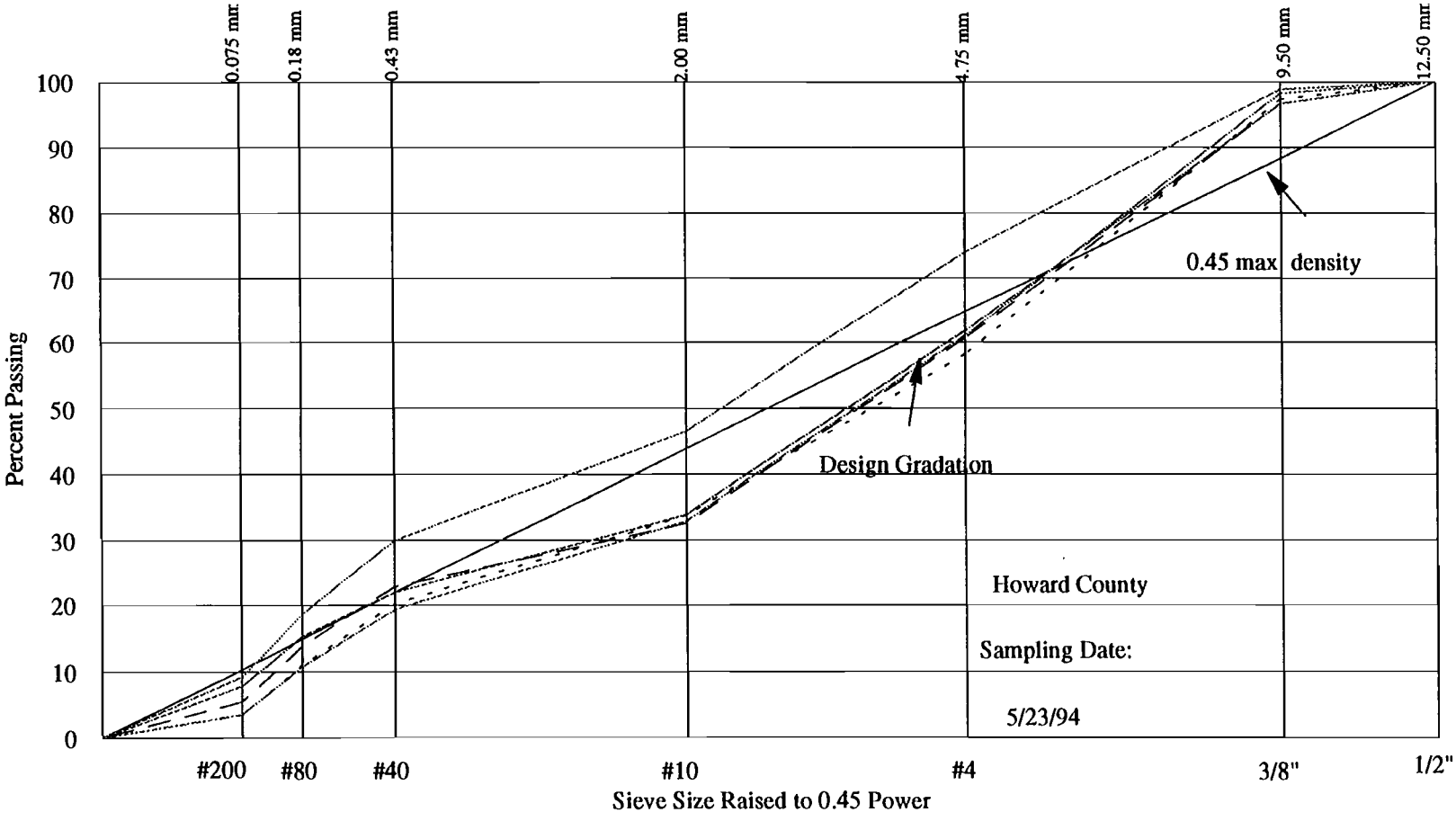


Figure B.5. Daily Gradations from Extraction for the Project in Howard County.

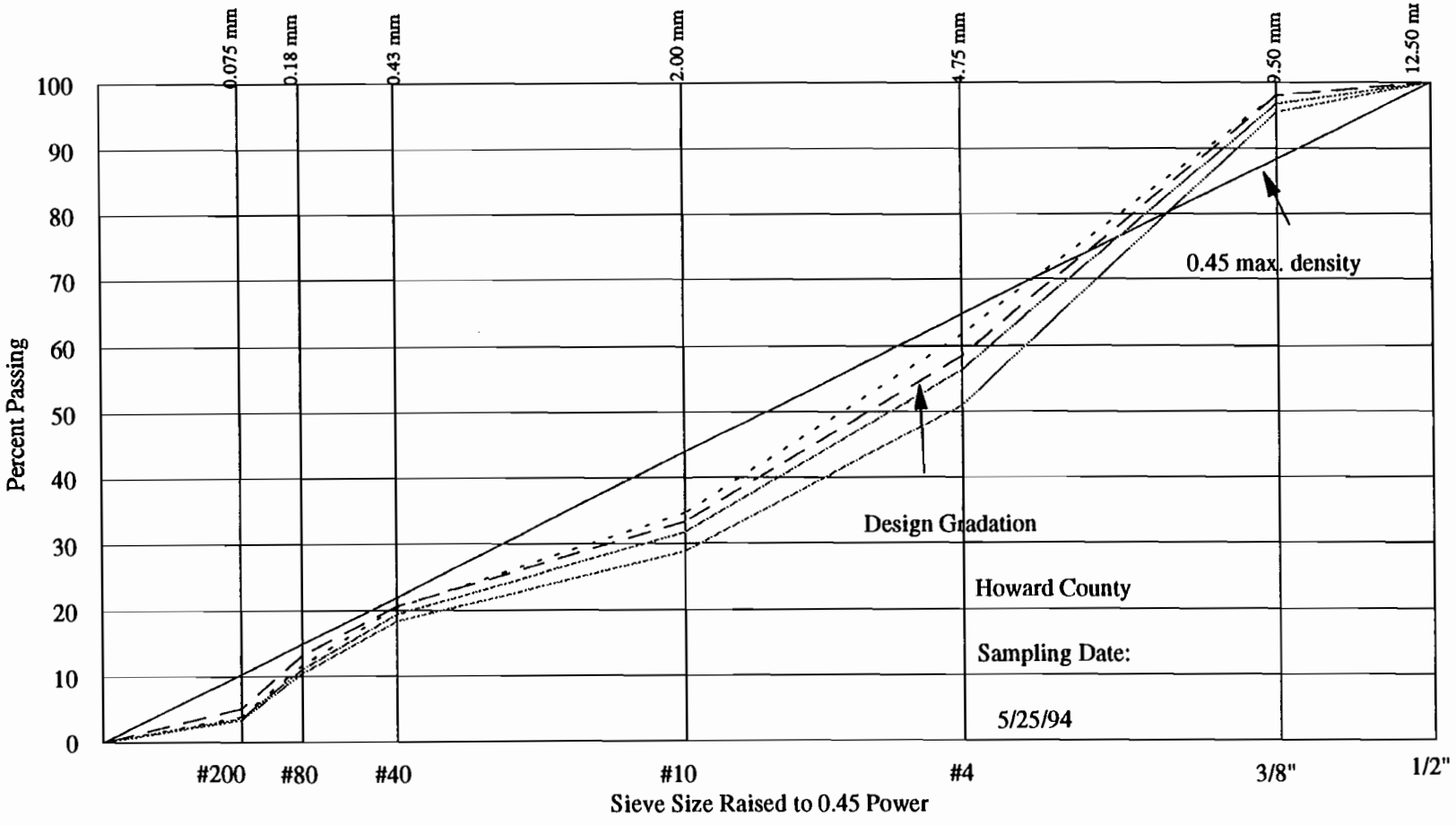


Figure B.6. Daily Gradations from Extraction for the Project in Howard County.

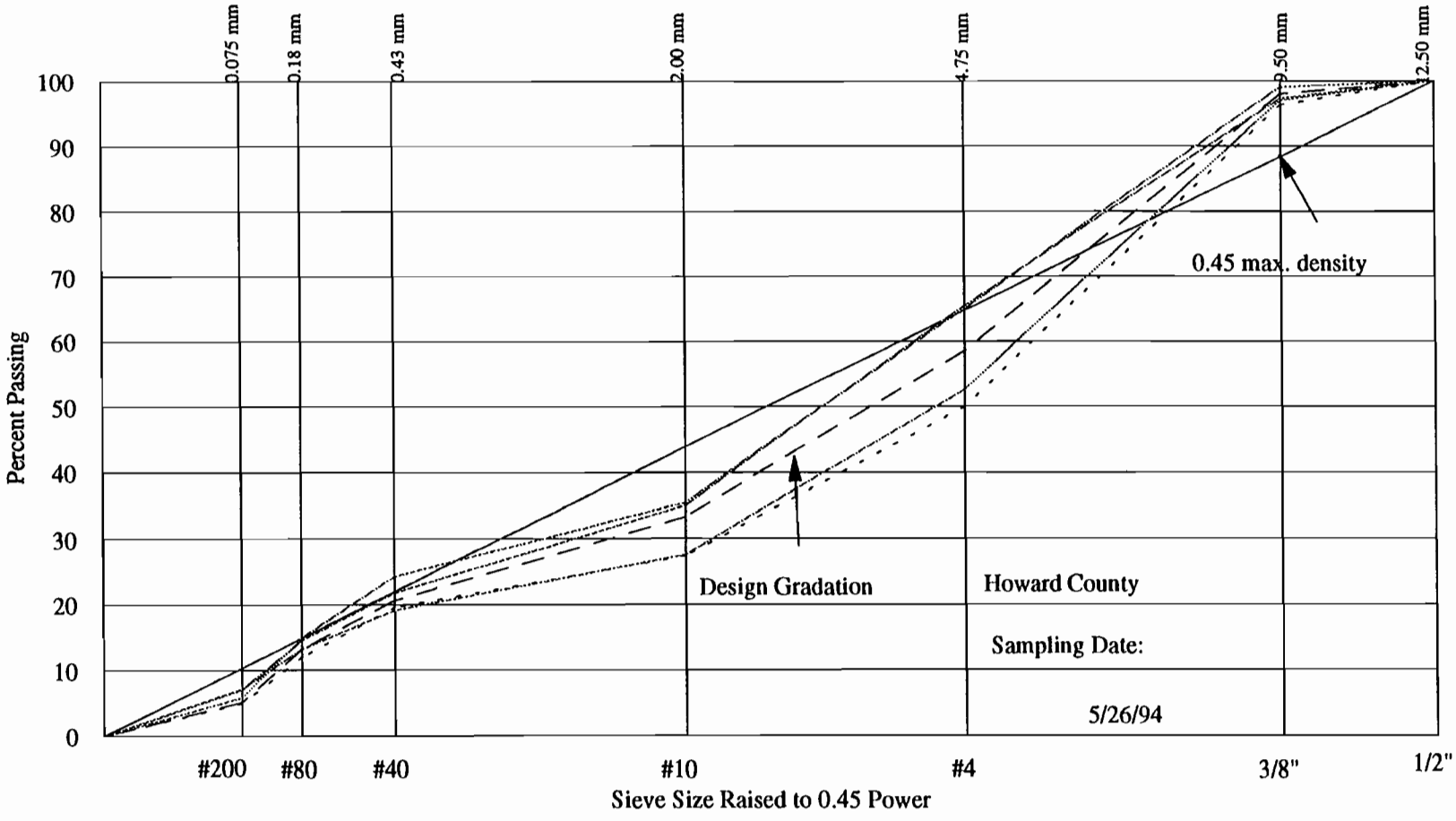


Figure B.7. Daily Gradations from Extraction for the Project in Howard County.

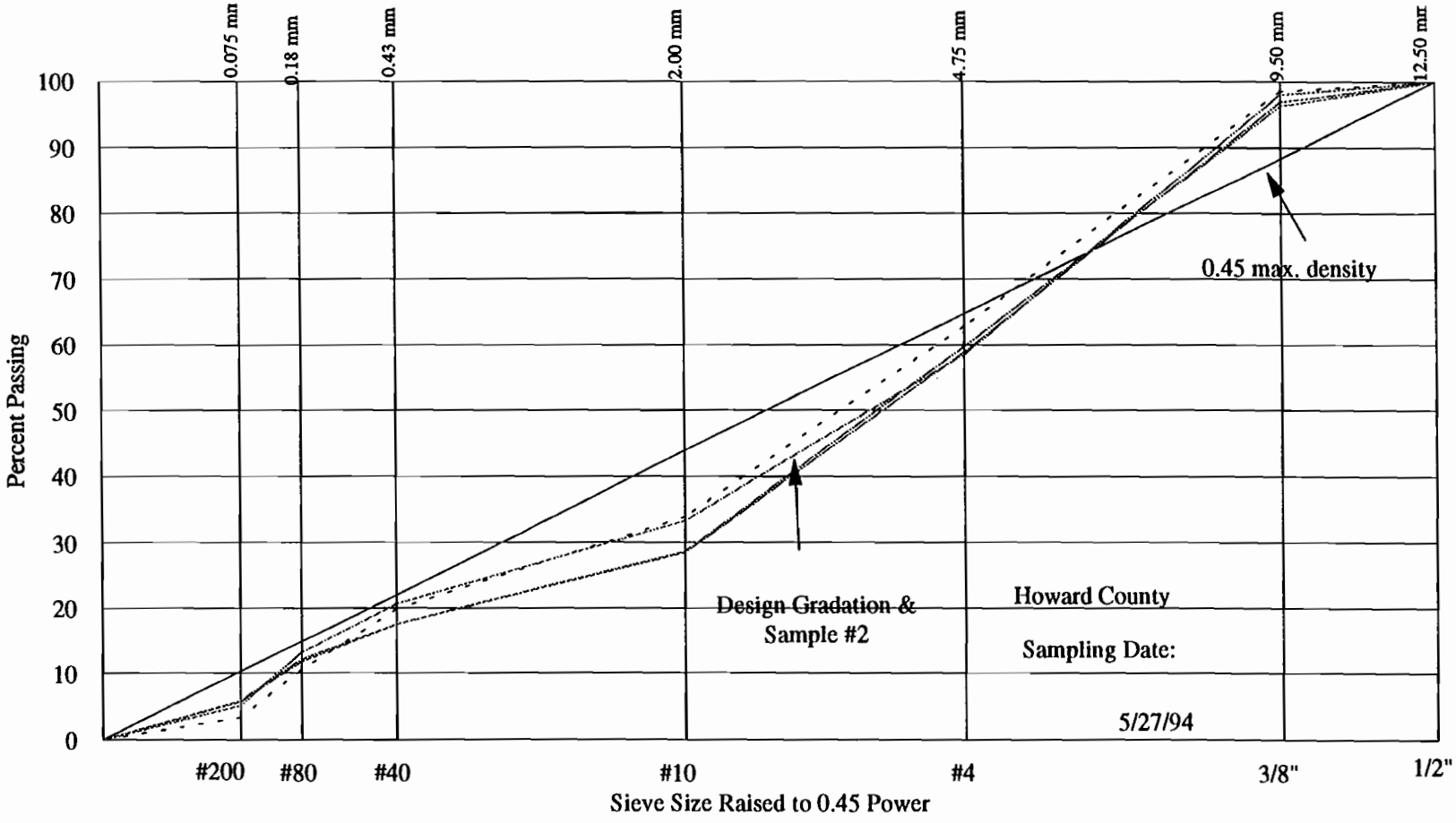


Figure B.8. Daily Gradations from Extraction for the Project in Howard County.

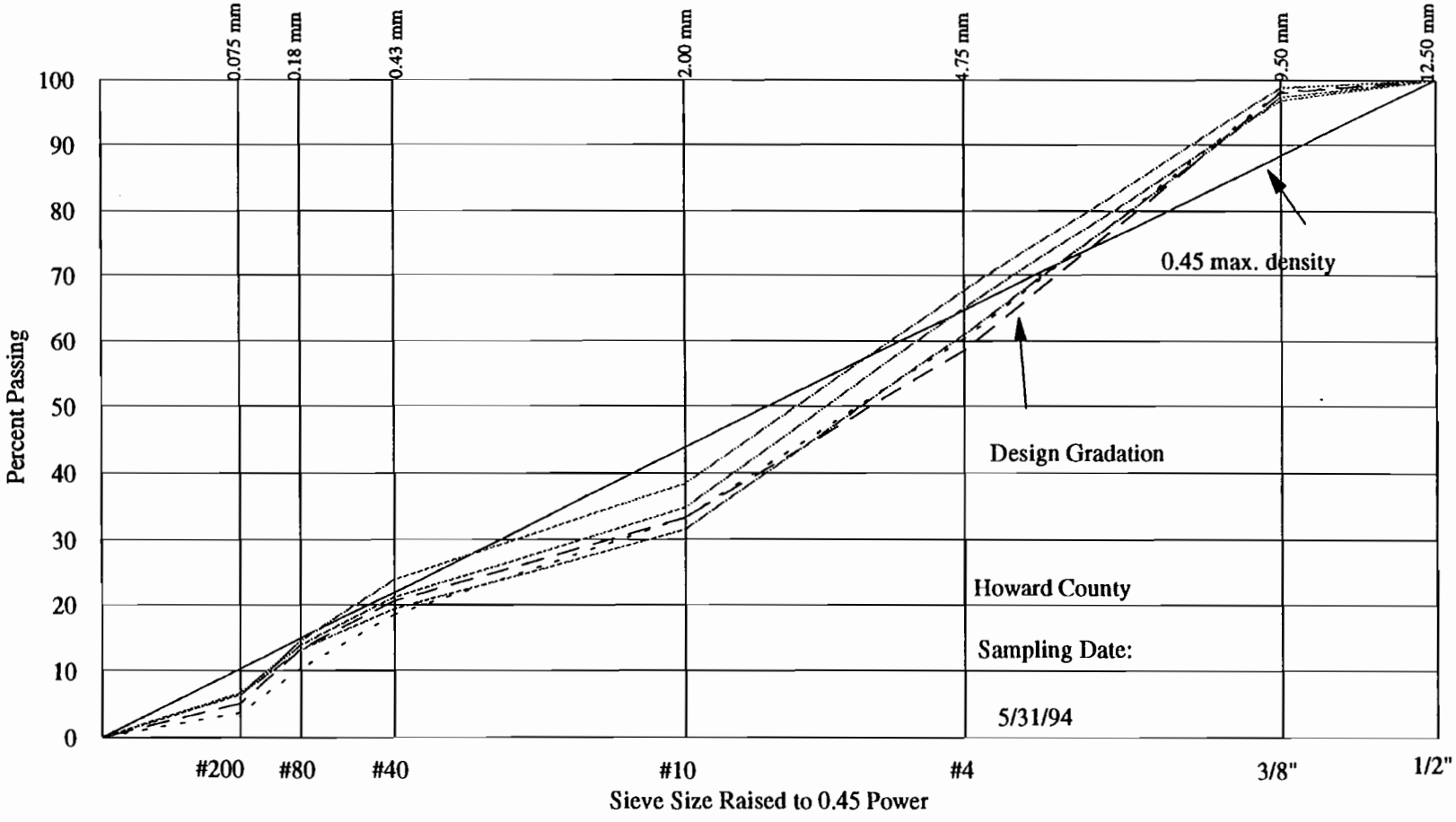


Figure B.9. Daily Gradations from Extraction for the Project in Howard County.

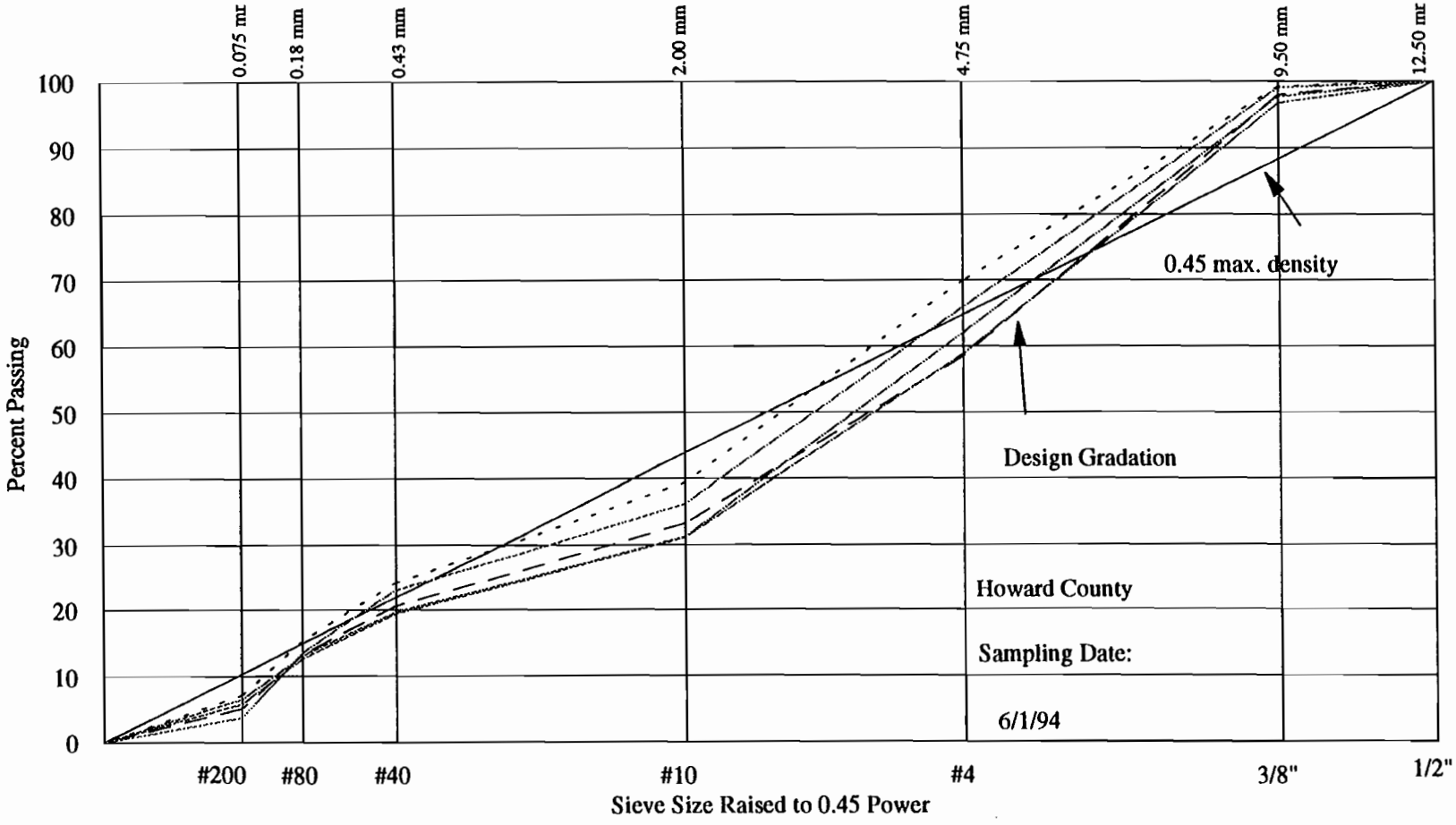


Figure B.10. Daily Gradations from Extraction for the Project in Howard County.

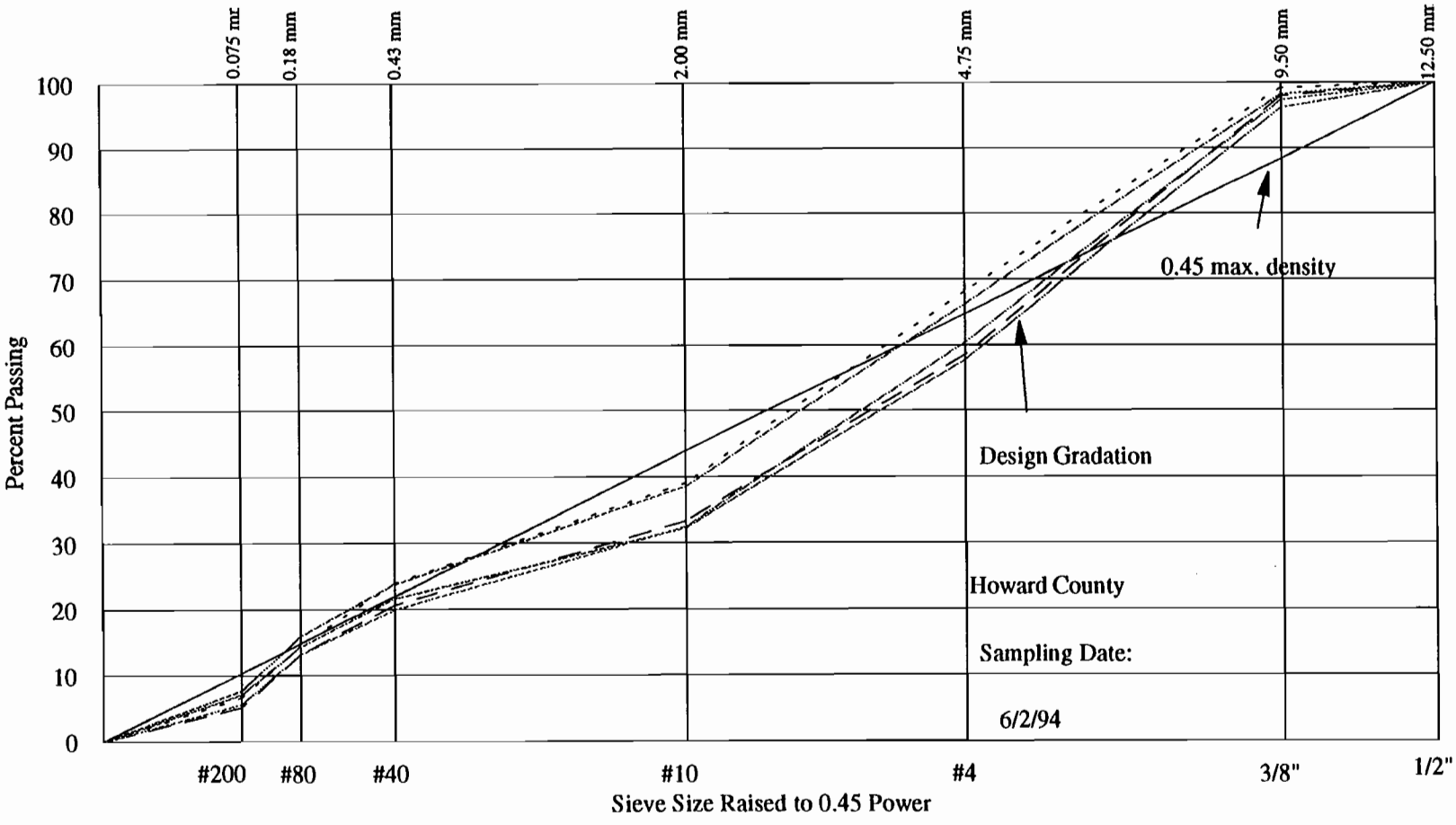


Figure B.11. Daily Gradations from Extraction for the Project in Howard County.

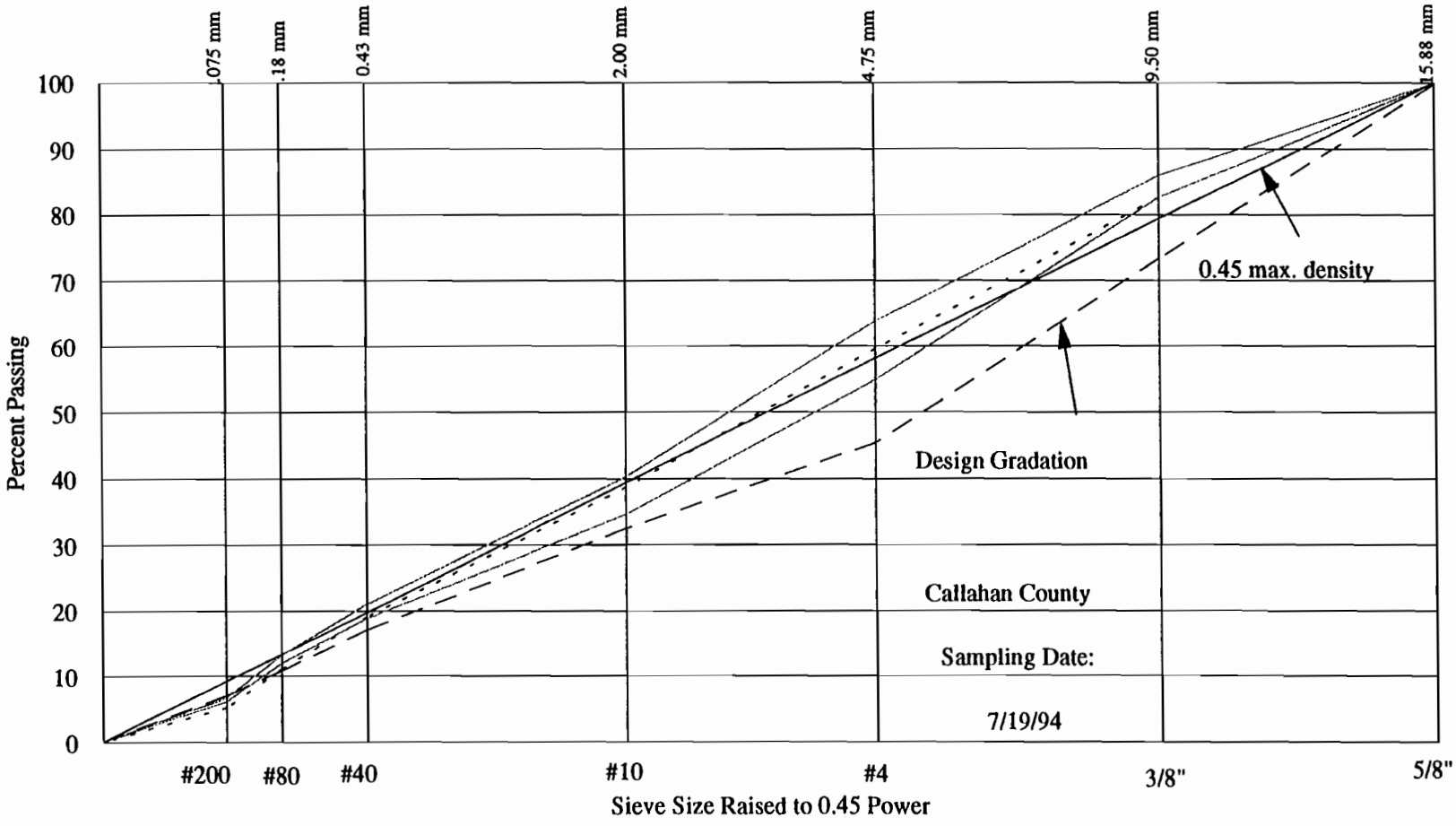


Figure B.12. Daily Gradations from Extraction for Callahan County.

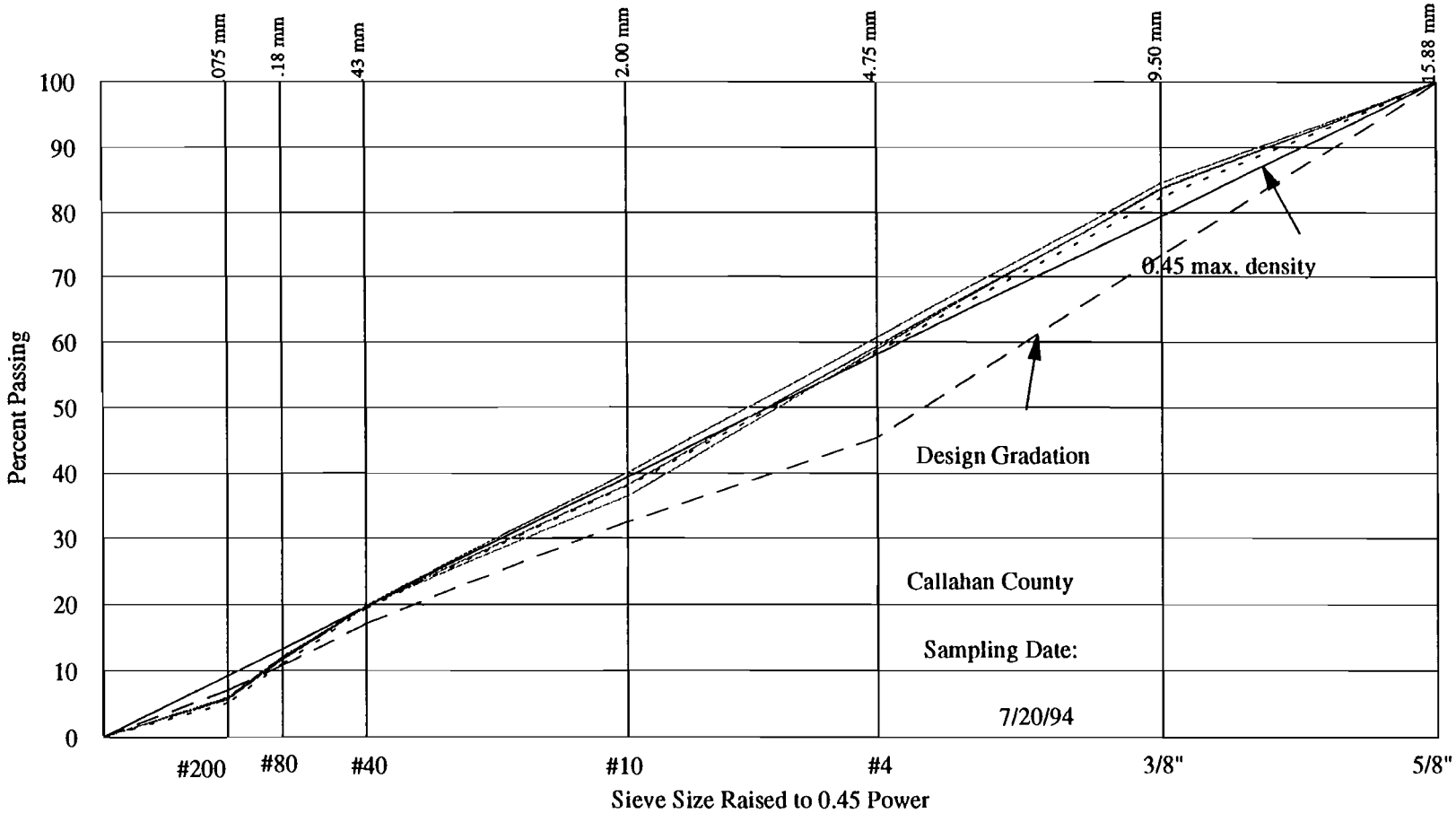


Figure B.13. Daily Gradation from Extraction for Callahan County.

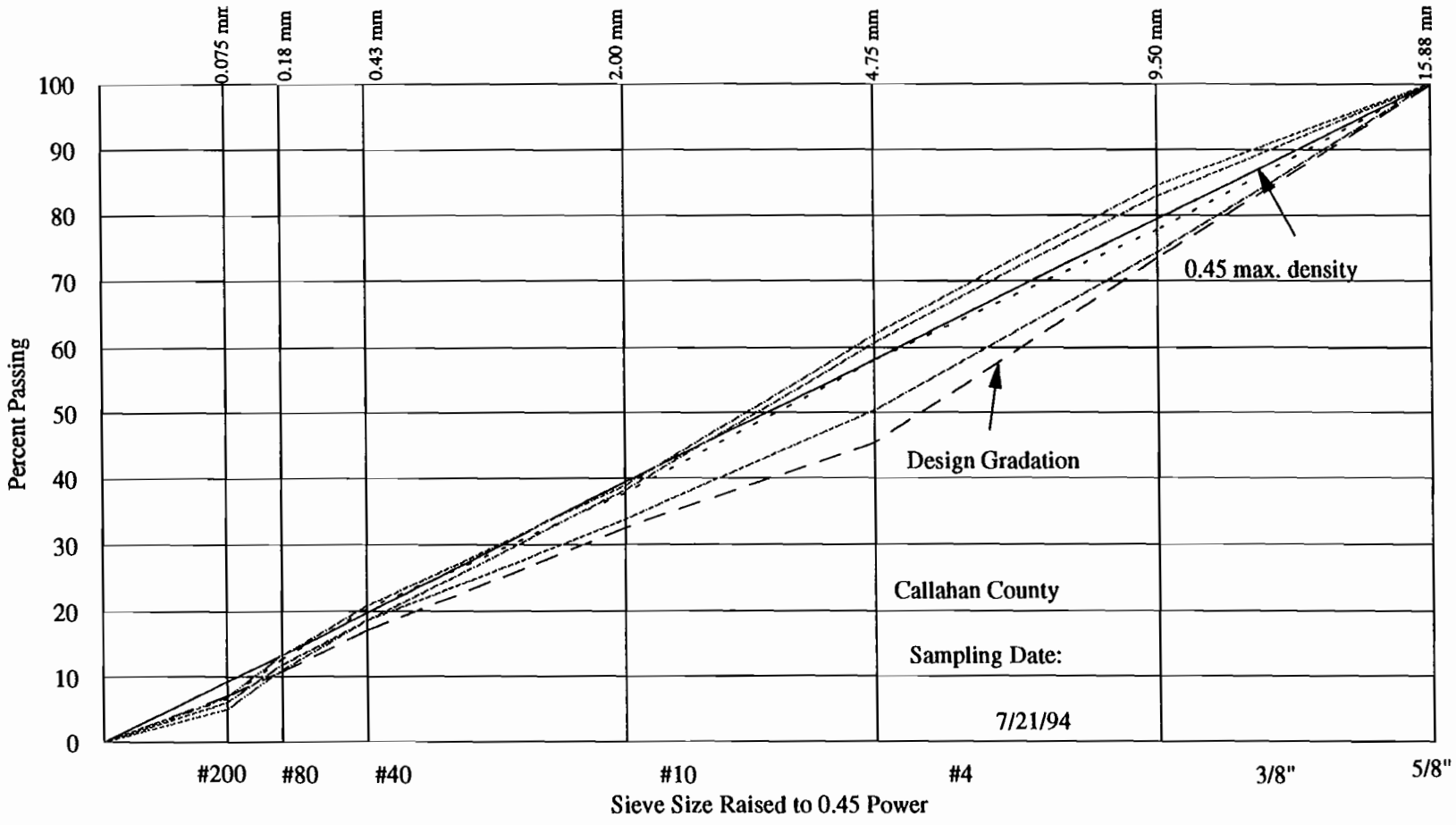


Figure B.14. Daily Gradations from Extraction for the Project in Callahan County.

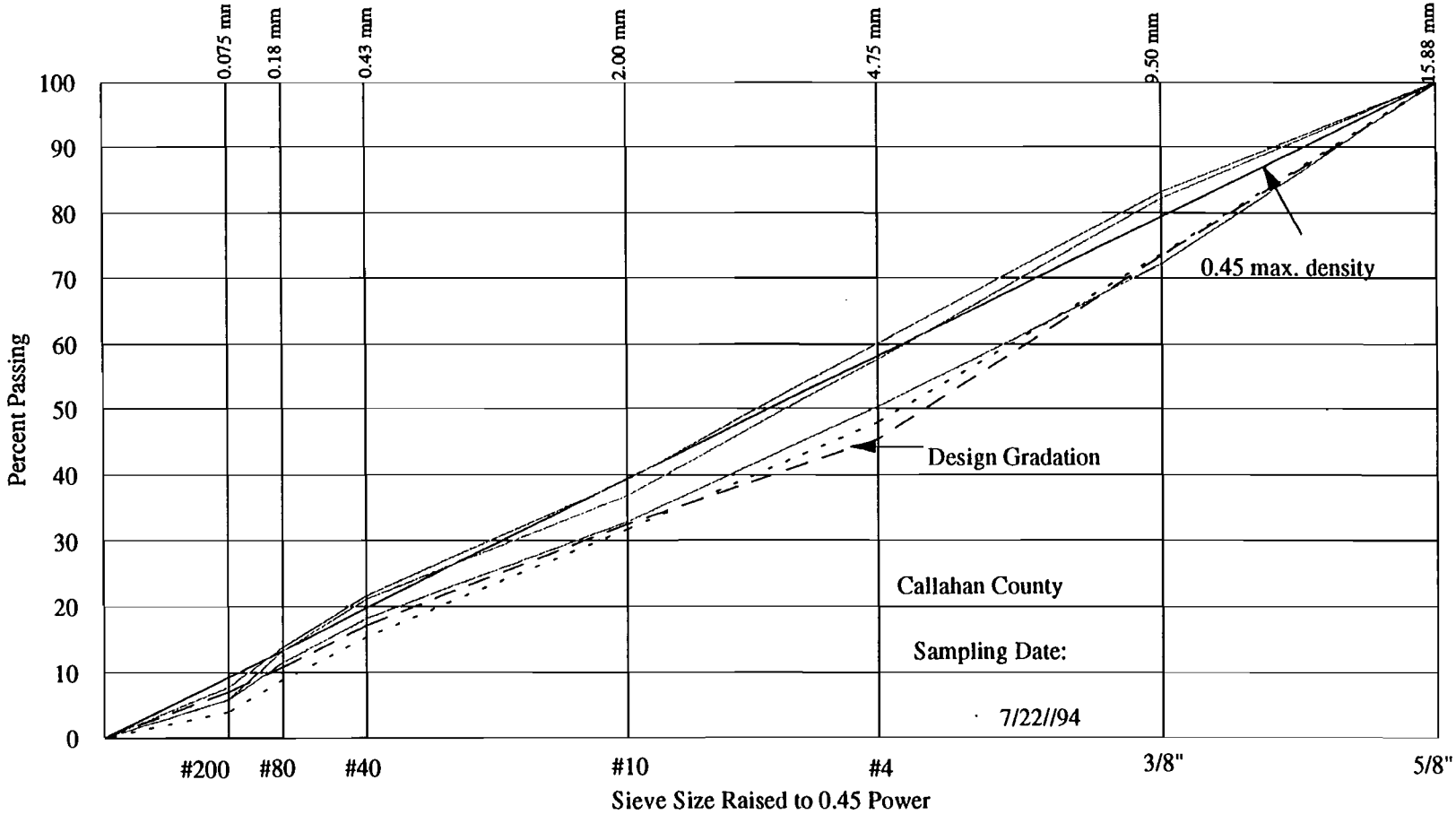


Figure B.15. Daily Gradations from Extraction for the Project in Callahan County.

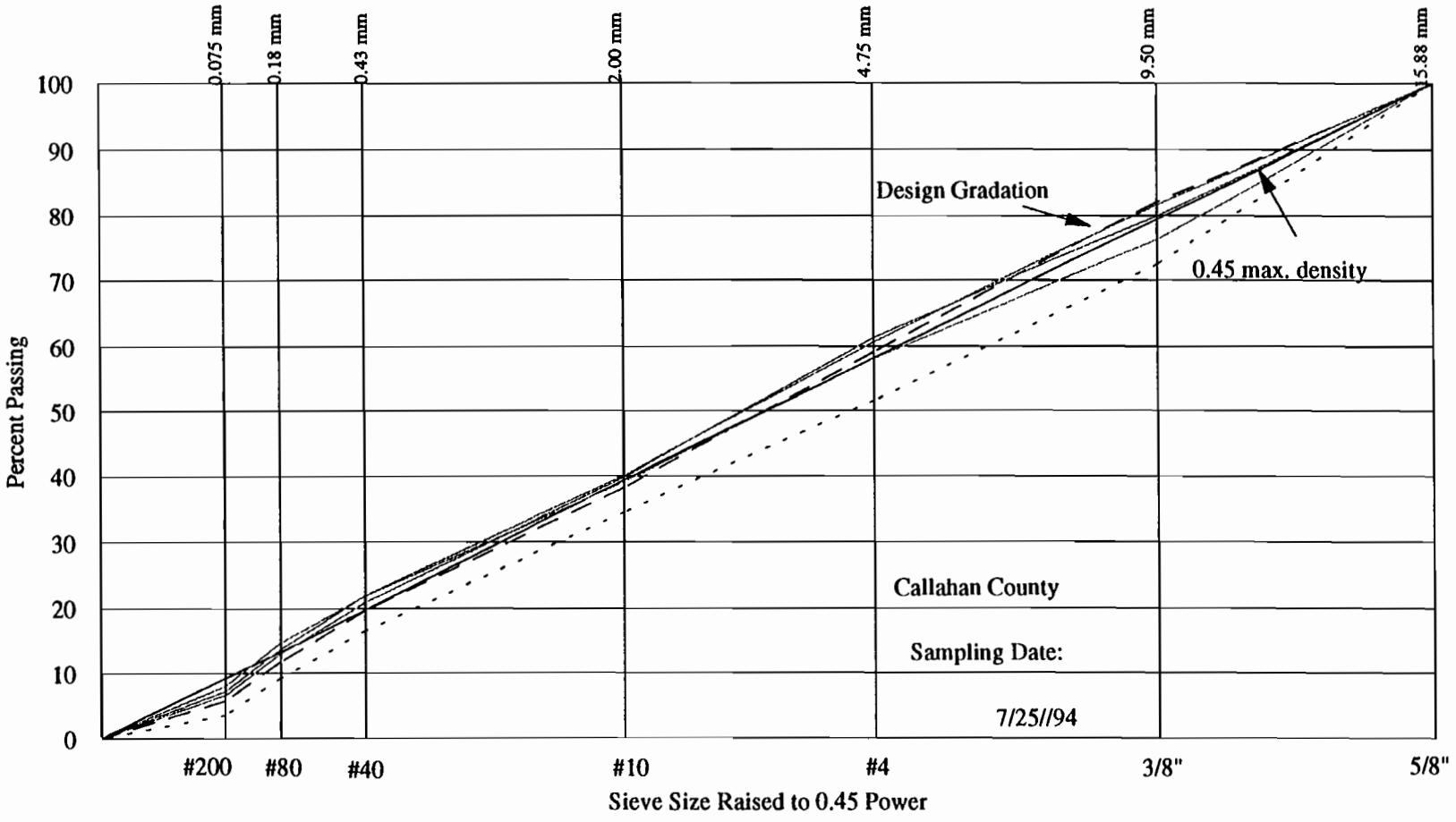


Figure B.16. Daily Gradations from Extraction for the Project in Callahan County.

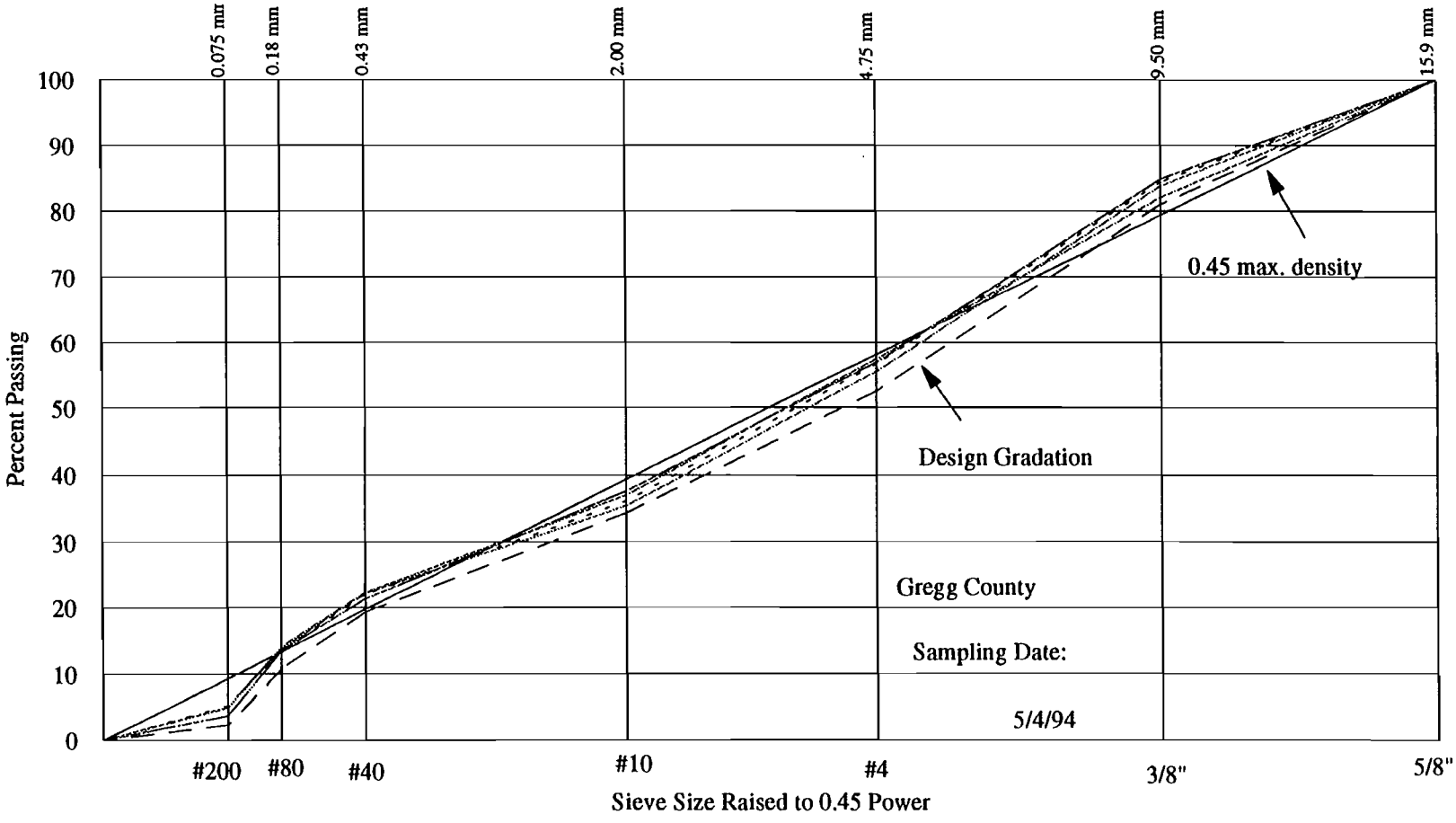


Figure B.17. Daily Gradations from Extraction for the Project in Gregg County.

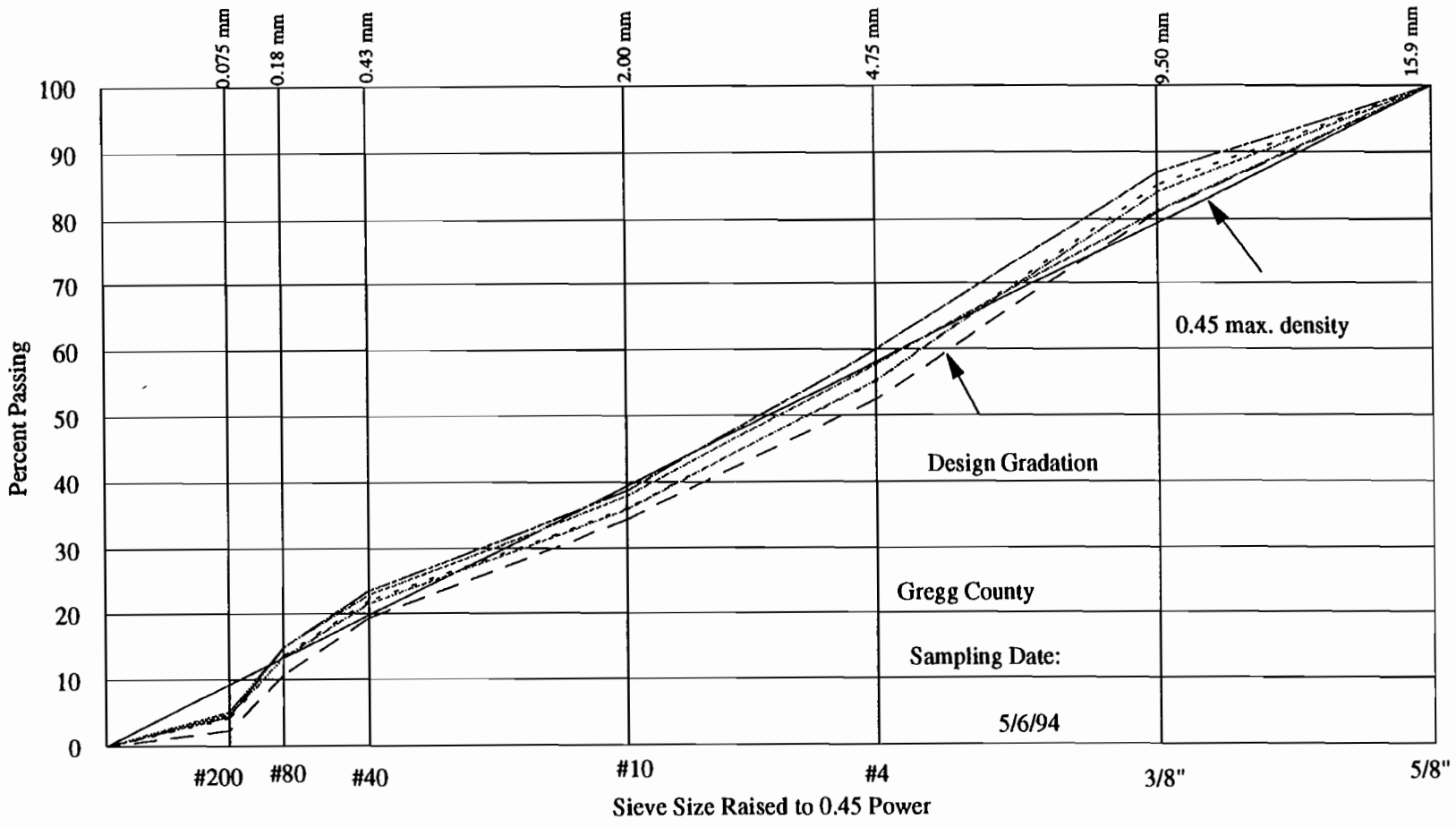


Figure B.18. Daily Gradations from Extraction for the Project in Gregg County.

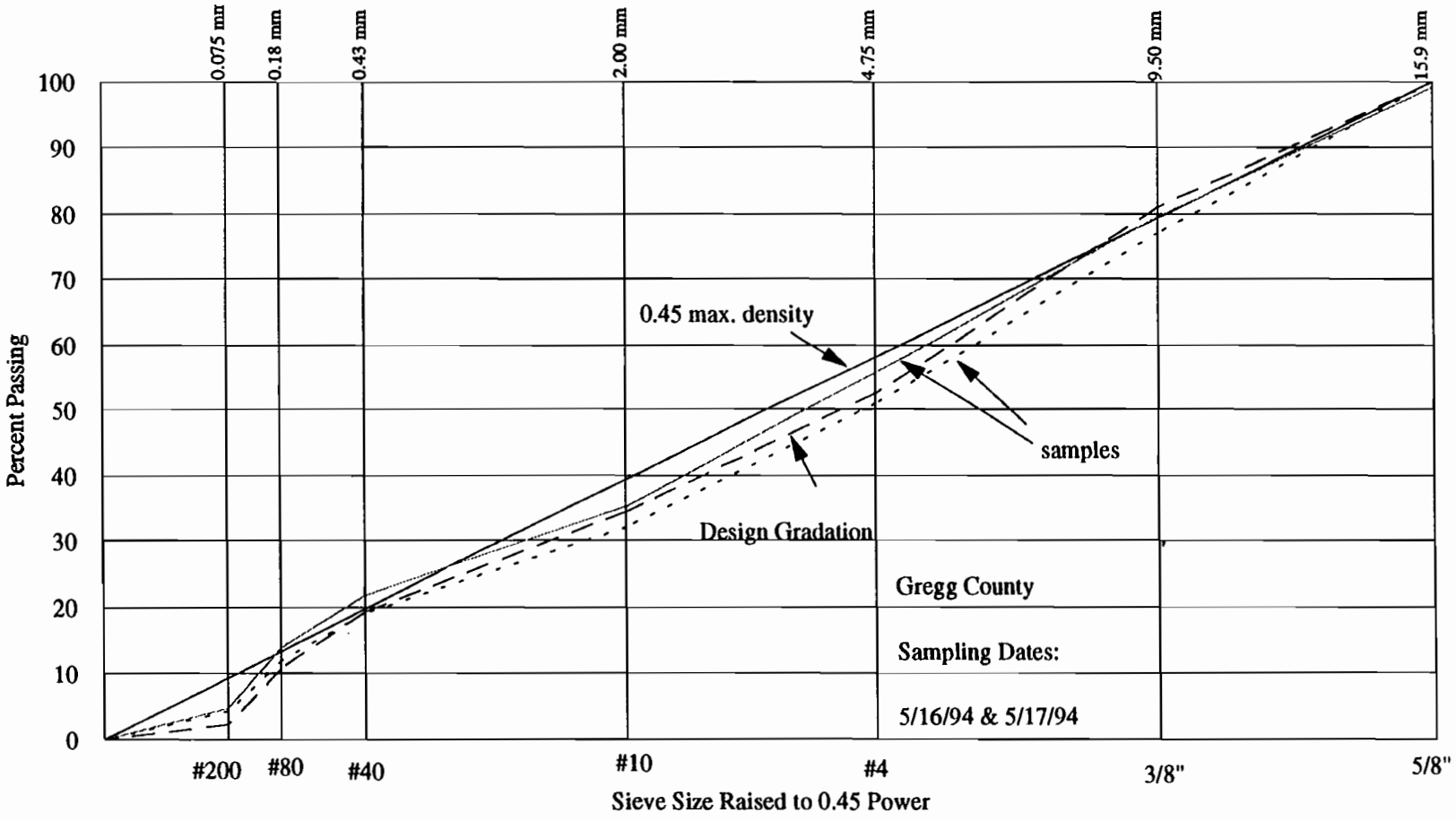


Figure B.19. Daily Gradations from Extraction for the Project in Gregg County.

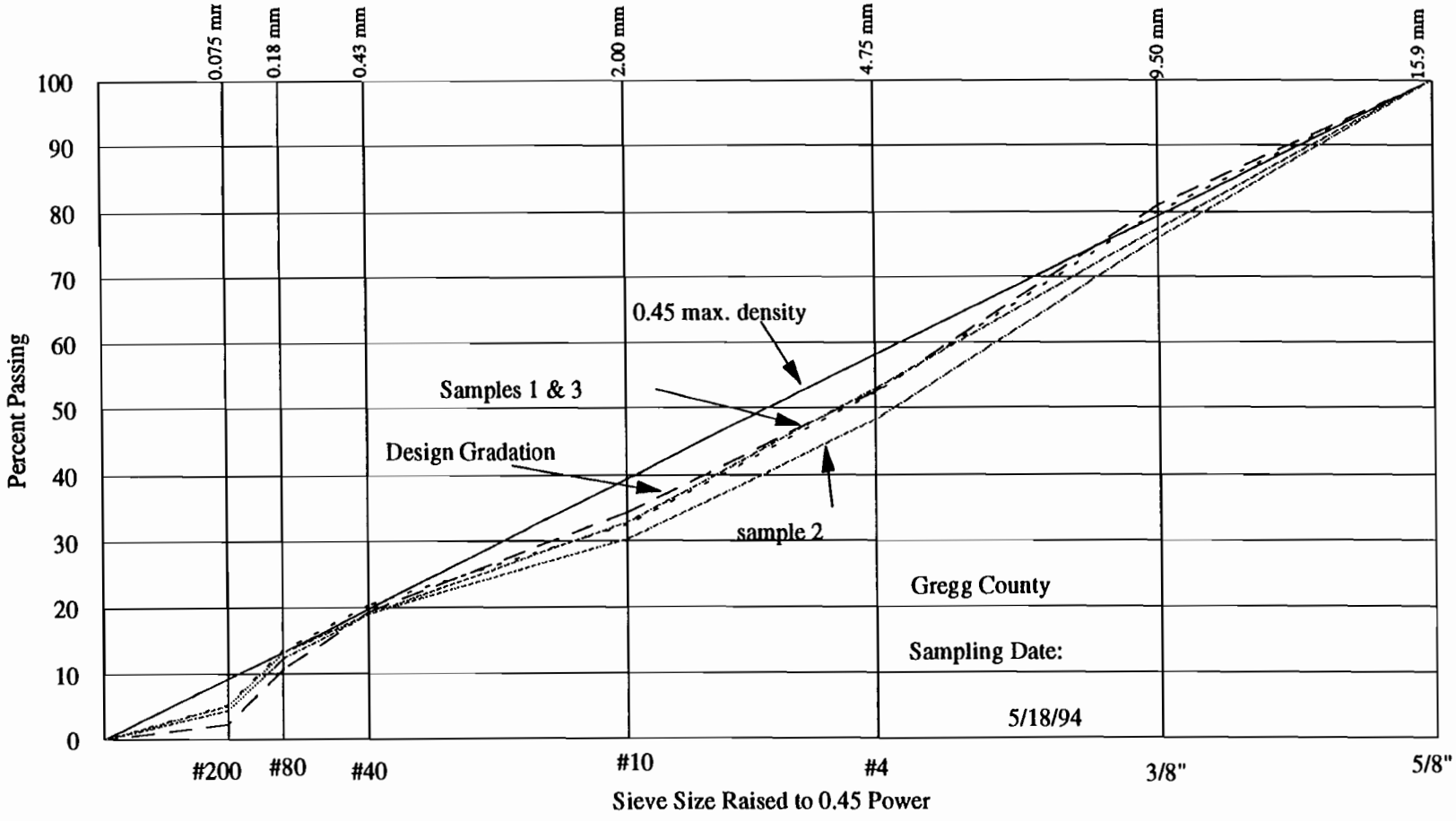


Figure B.20. Daily Gradations from Extraction for the Project in Gregg County.

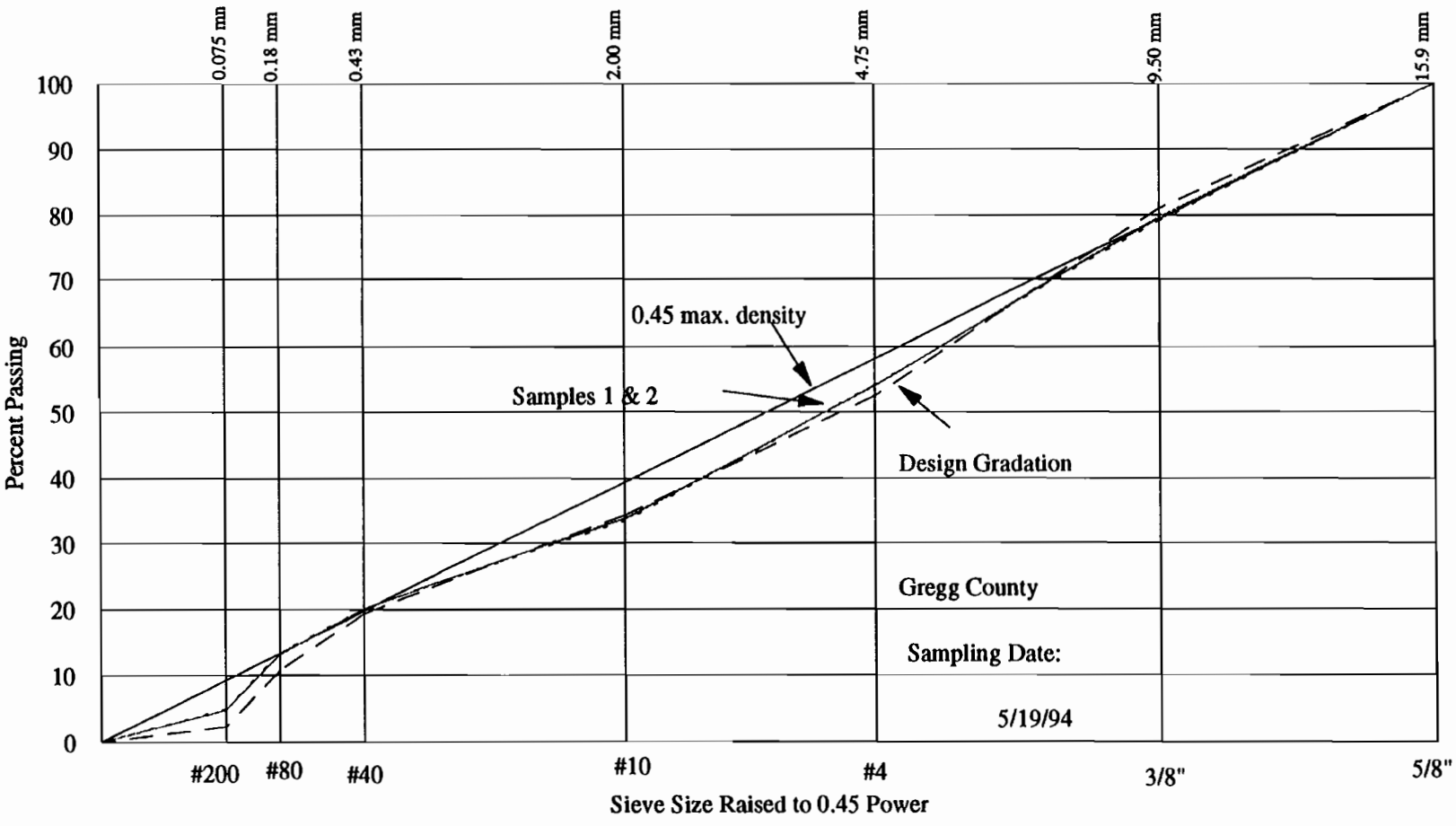


Figure B.21. Daily Gradations from Extraction for the Project in Gregg County.

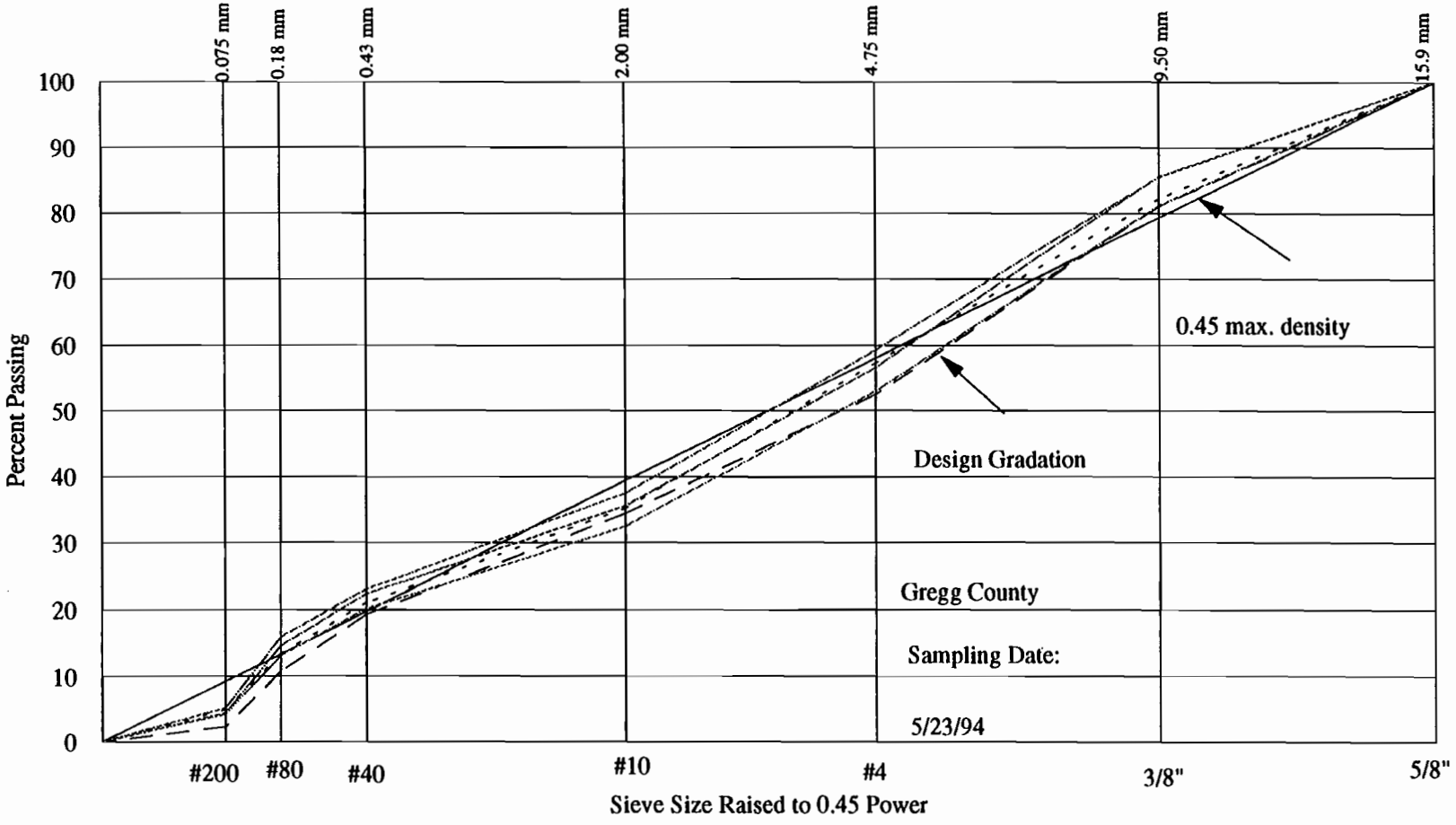


Figure B.22. Daily Gradations from Extraction for the Project in Gregg County.

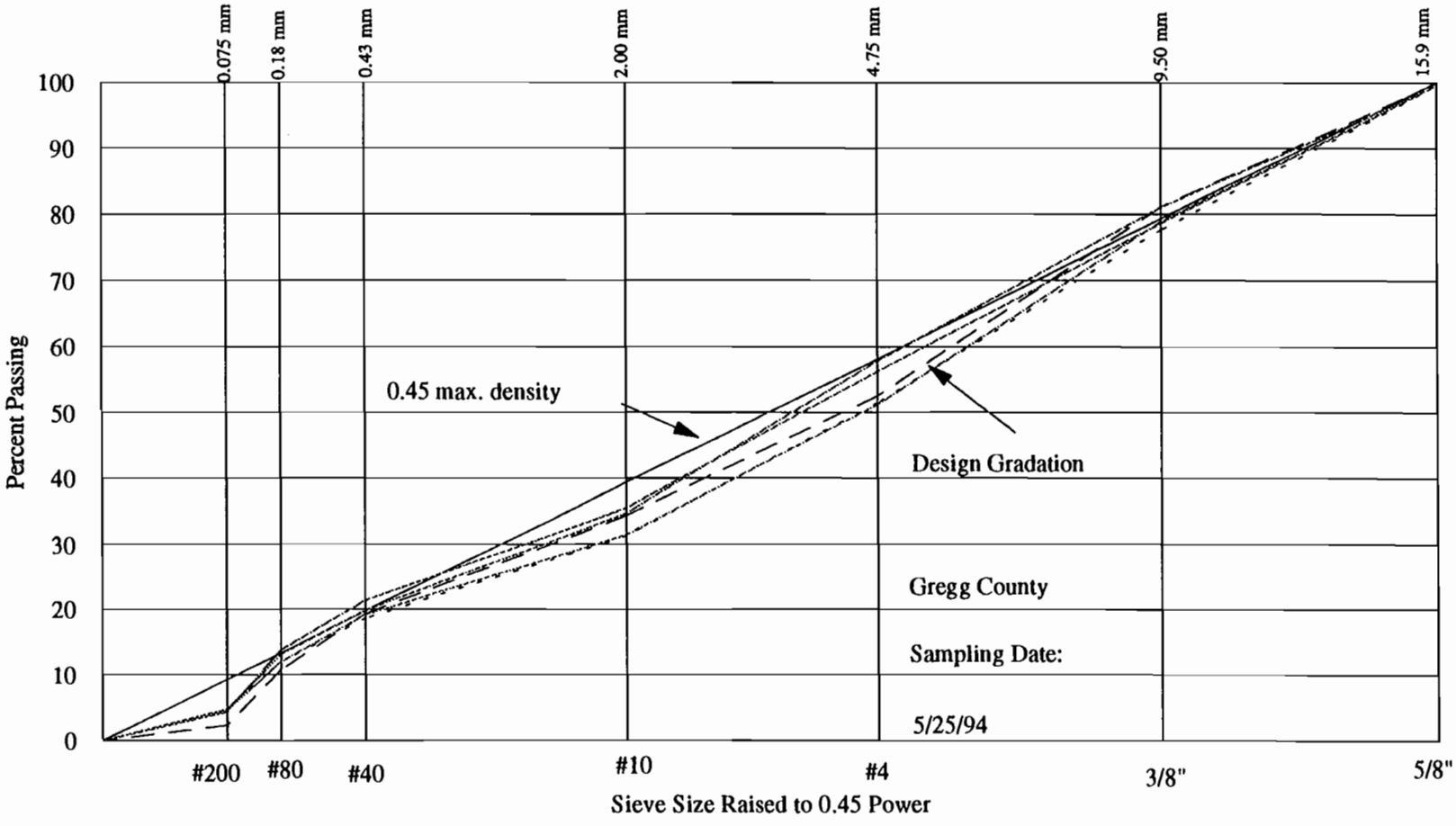


Figure B.23. Daily Gradations from Extraction for the Project in Gregg County.

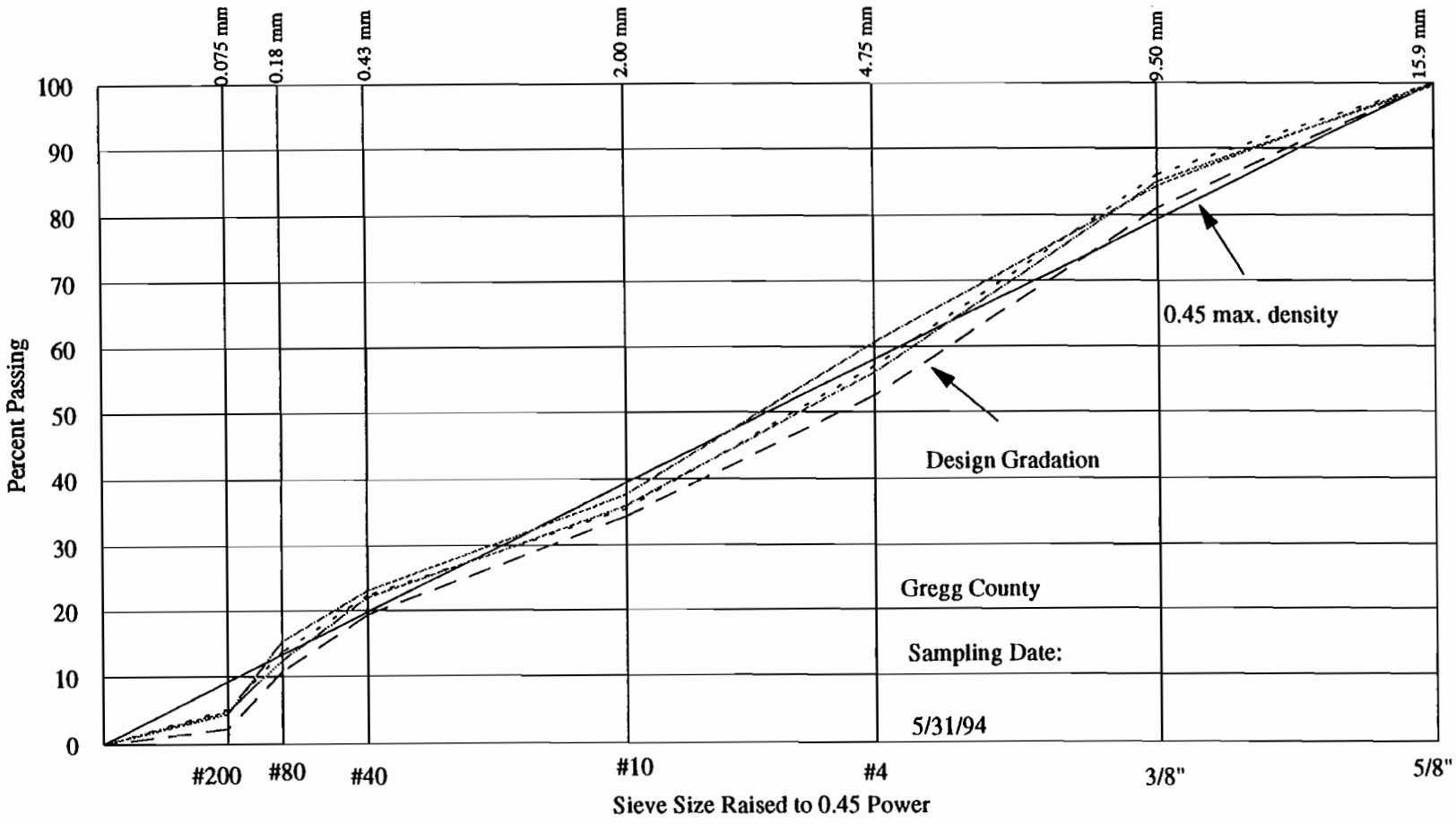


Figure B.24. Daily Gradations from Extraction for the Project in Gregg County.

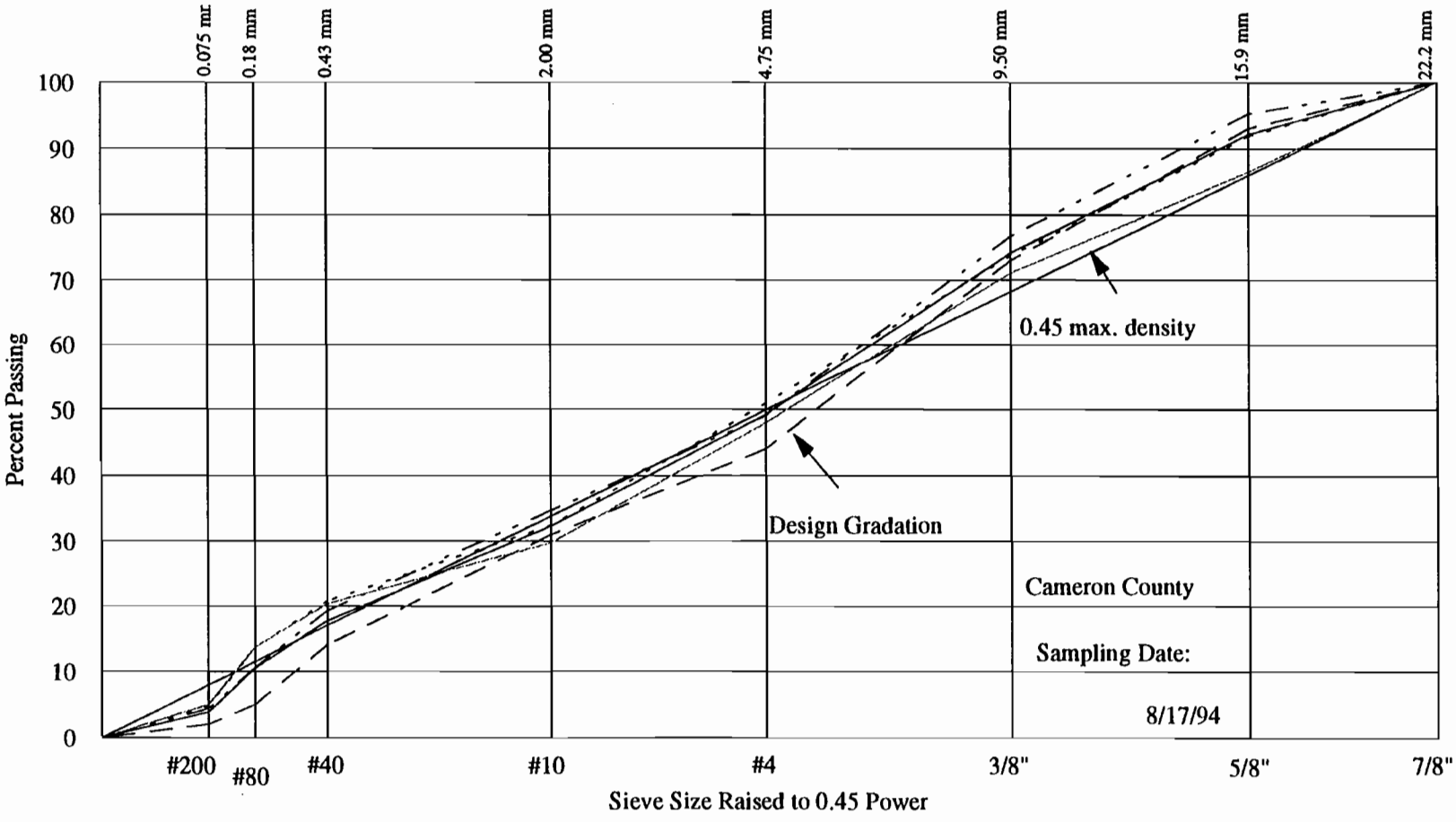


Figure B.25. Daily Gradations from Extraction for the Project in Cameron County.

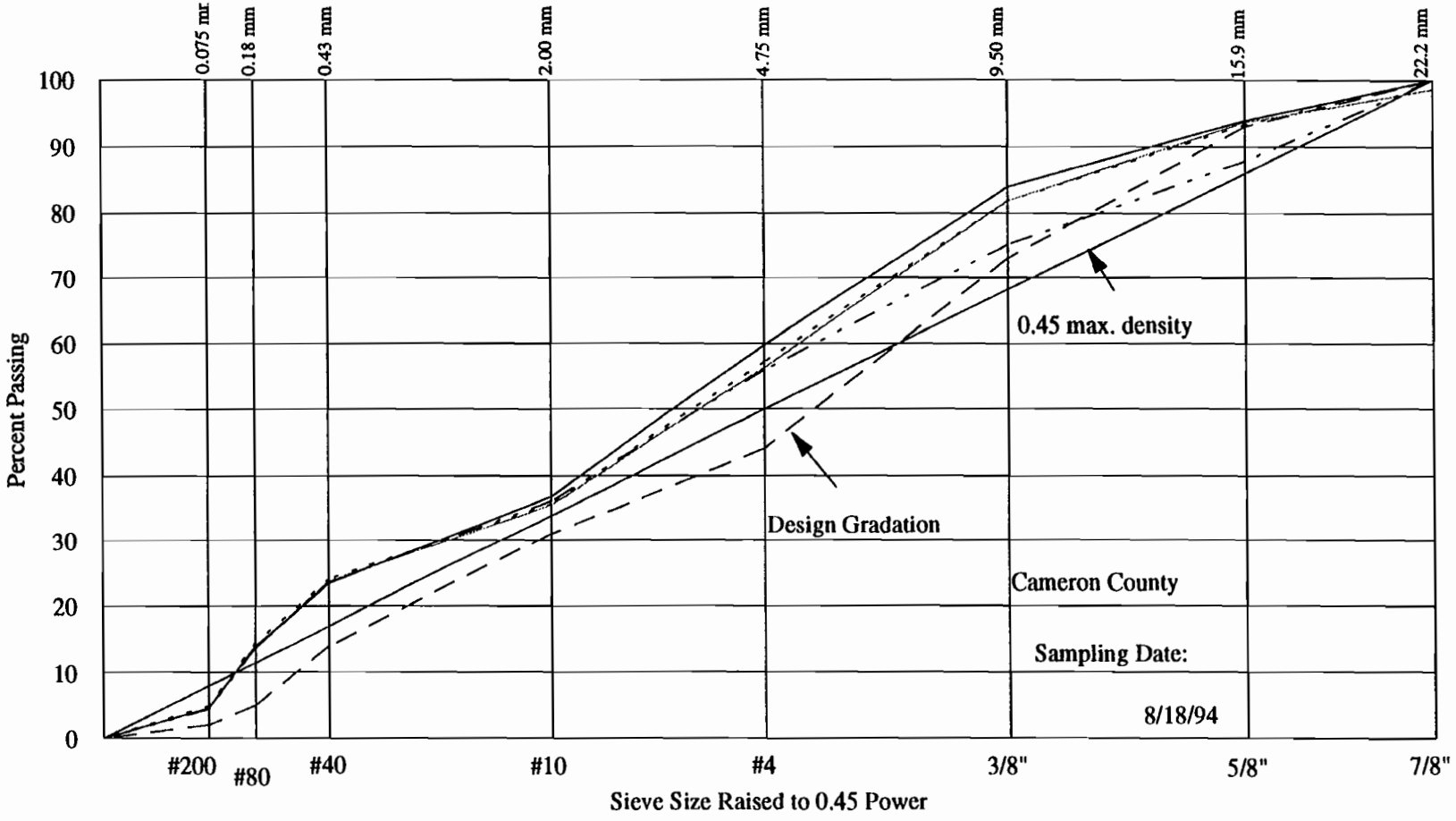


Figure B.26. Daily Gradations from Extraction for the Project in Cameron County.

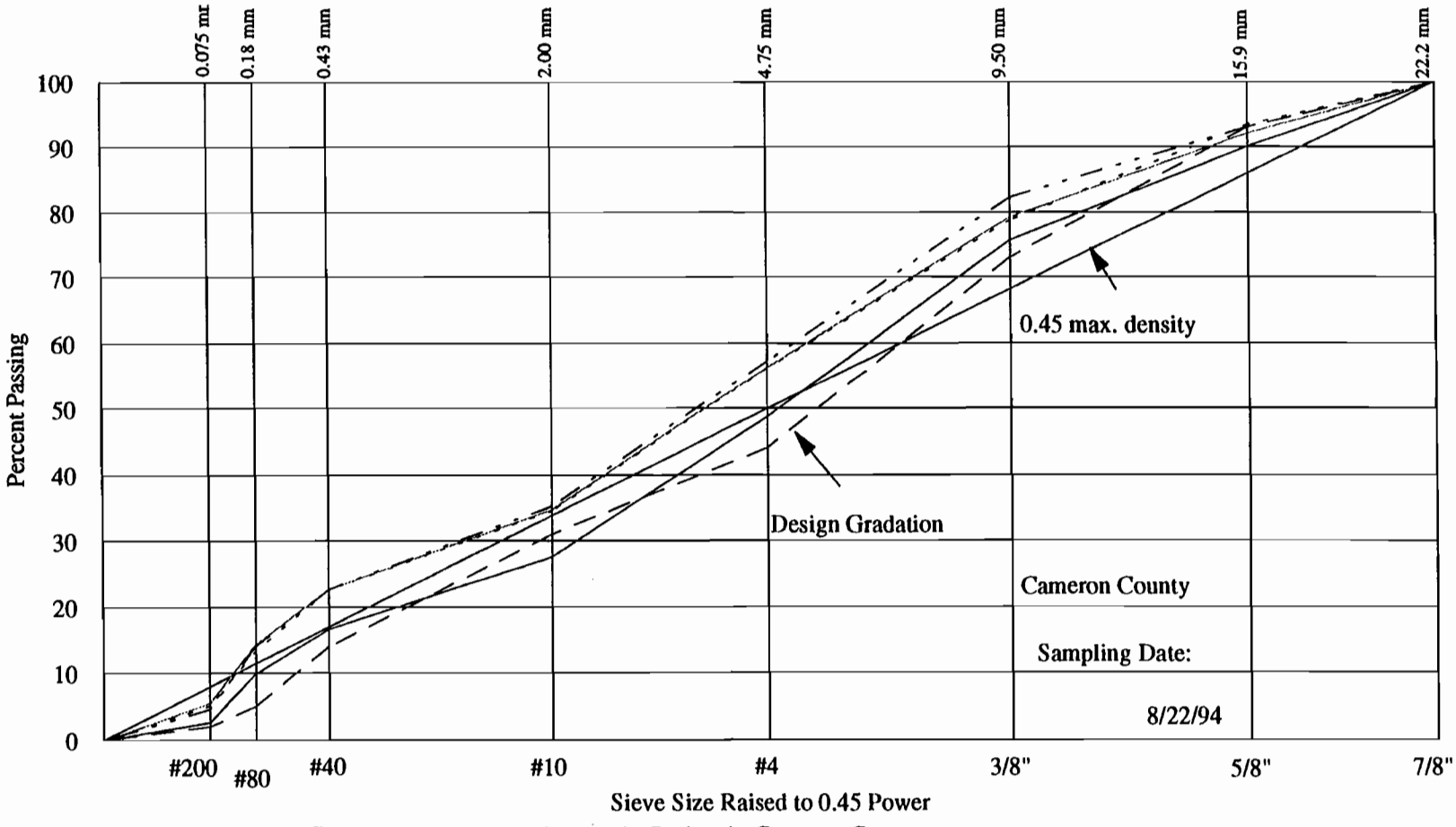


Figure B.27. Daily Gradations from Extraction for the Project in Cameron County.

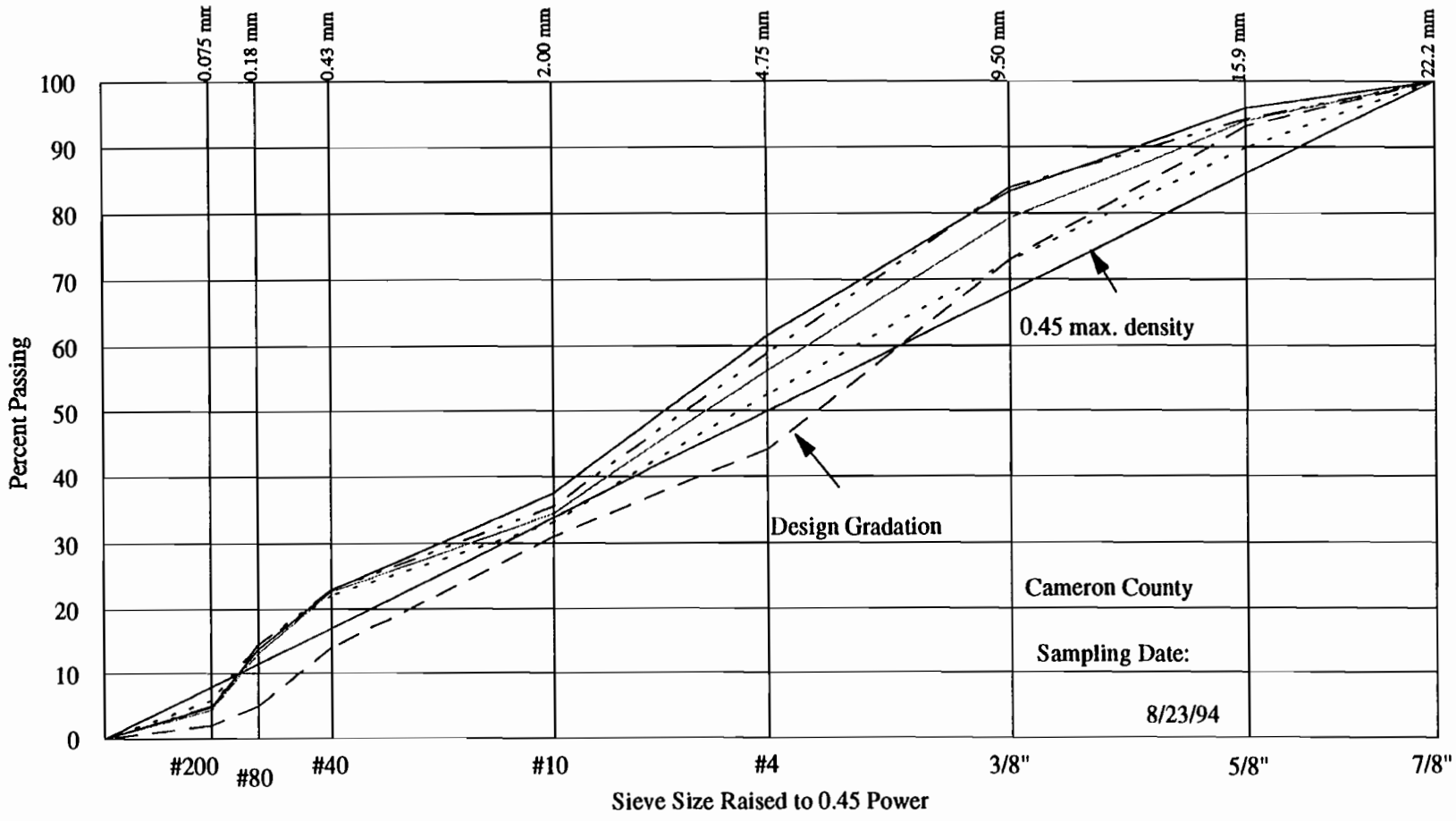


Figure B.28. Daily Gradations from Extraction for the Project in Cameron County.

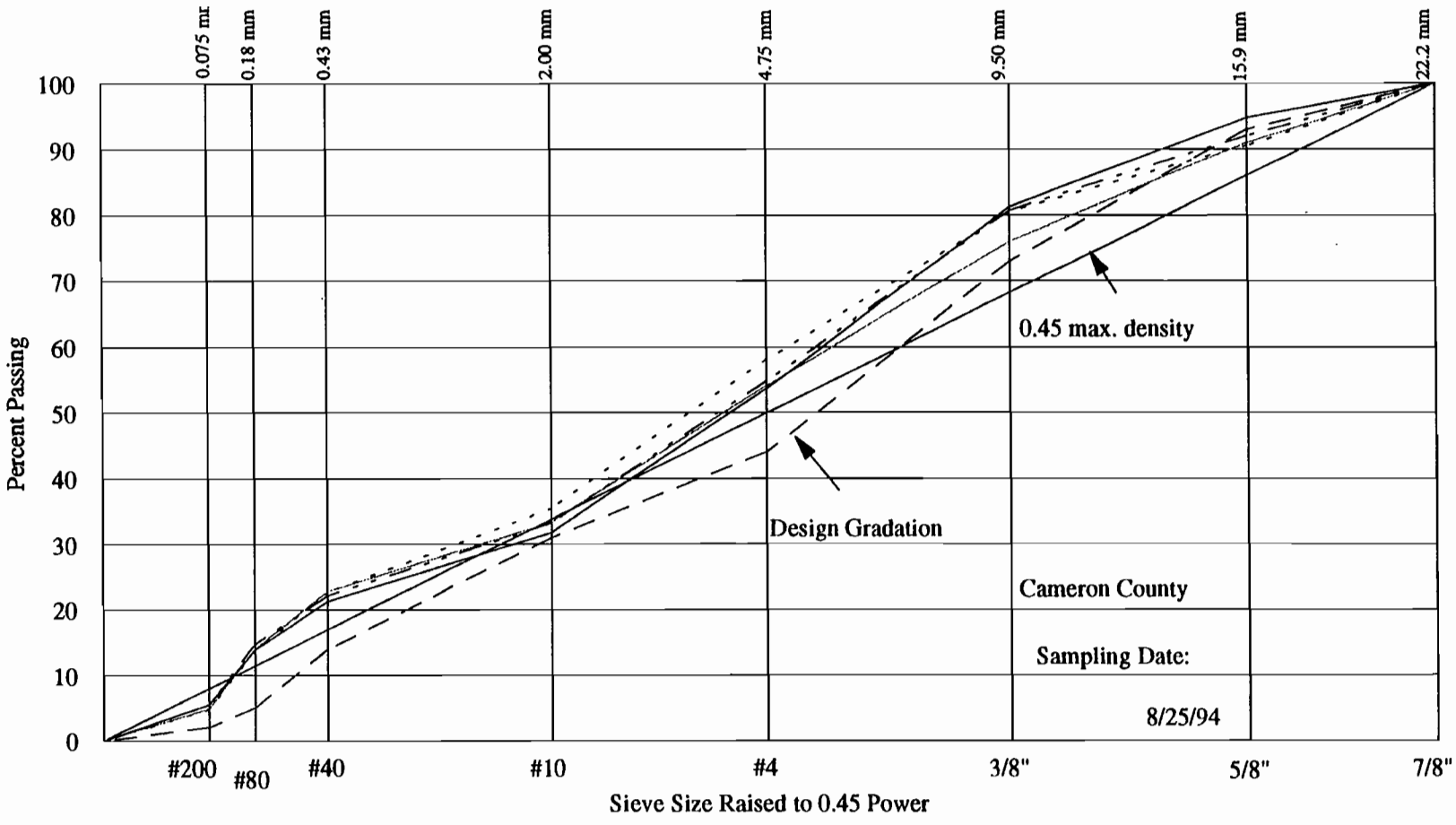


Figure B.29. Daily Gradations from Extraction for the Project in Cameron County.

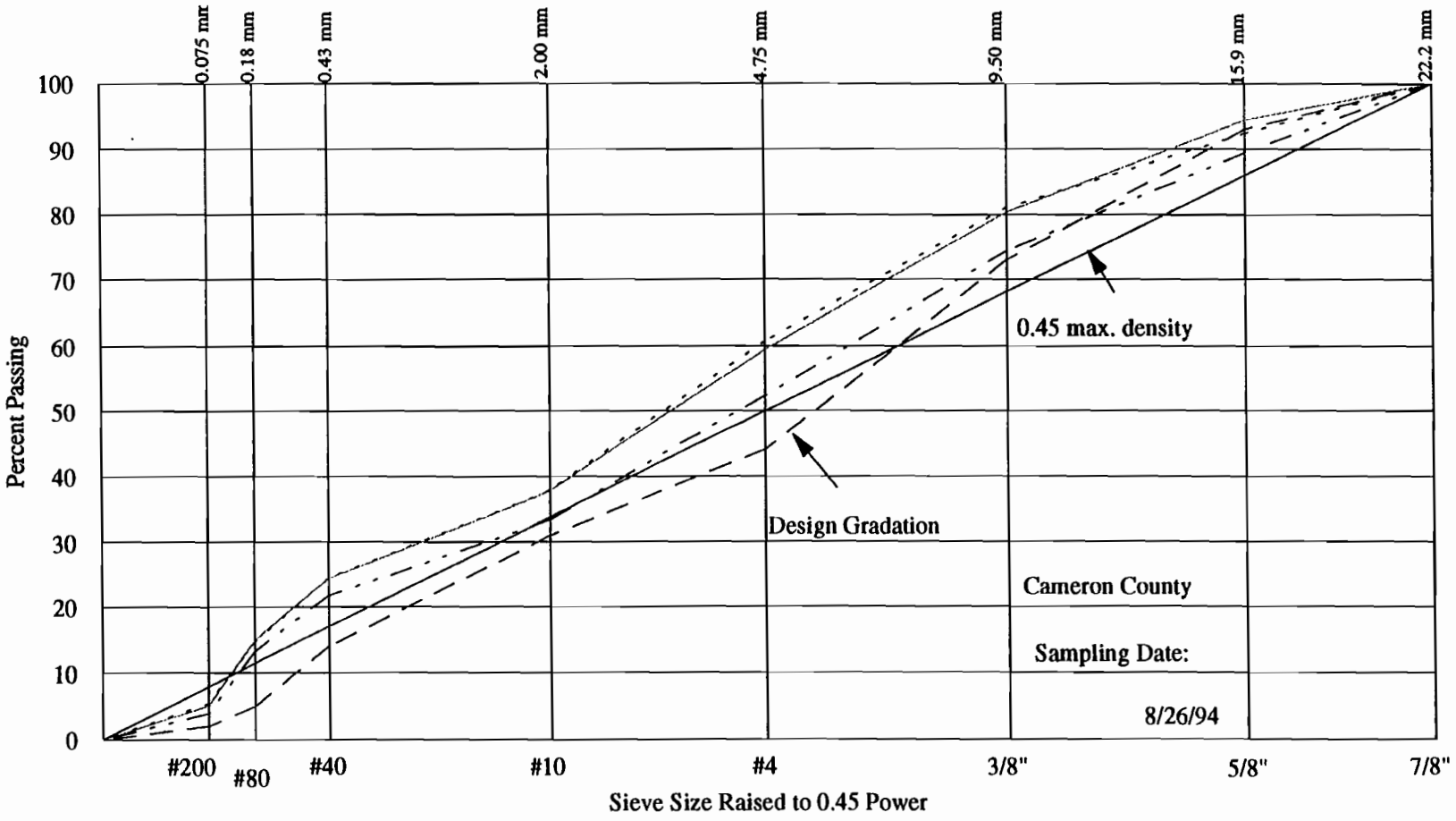


Figure B.30. Daily Gradations from Extraction for the Project in Cameron County.

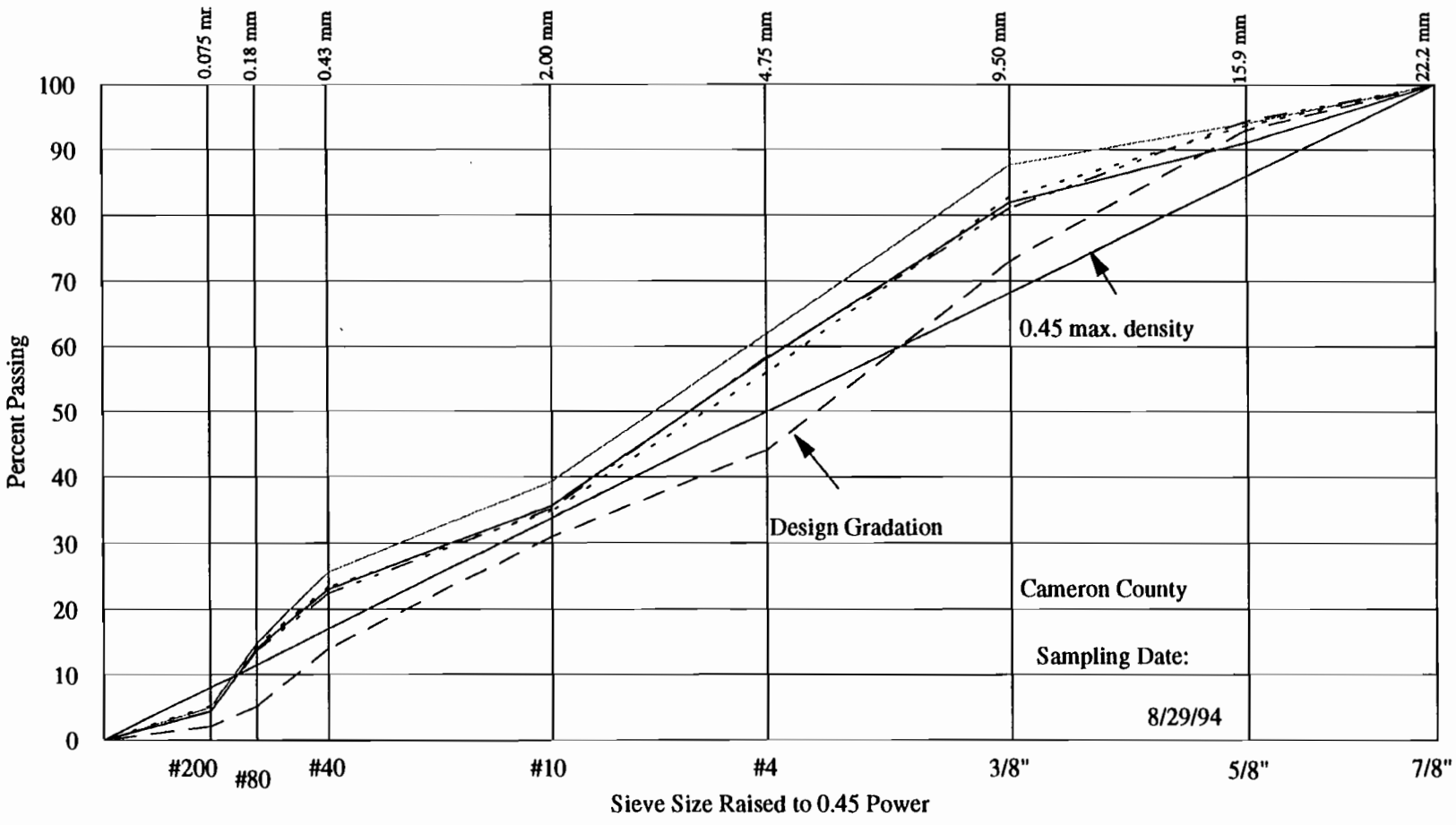


Figure B.31. Daily Gradations from Extraction for the Project in Cameron County.

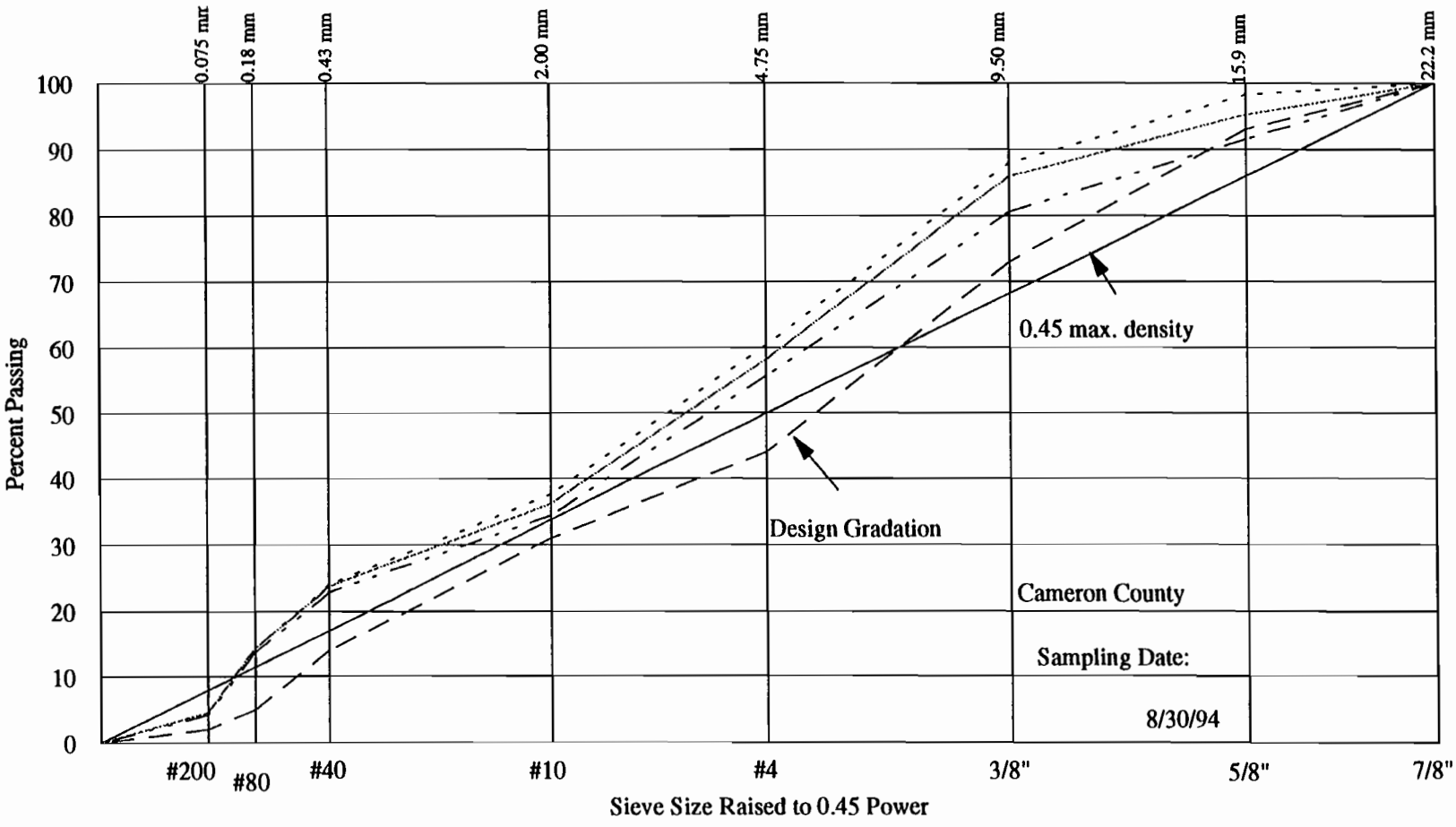


Figure B.32. Daily Gradations from Extraction for the Project in Cameron County.

APPENDIX C

DAILY ASPHALT CONTENT VARIATIONS AND CORRESPONDING PAY ADJUSTMENT FACTORS

Table C.1. Daily Asphalt Content and Variation from Target AC and Corresponding Pay Factors for the Project in Howard County.

Project CPM 0005-05-081	Type D (Surface) with RAP
Highw IH 20	Amount of RAP (%) 50
Count Howard	Dedicated Stockpile

			Extraction Results					Nuclear Gauge Measurements				
Date	RAP % AC	Design % AC	Extract AC	Diff. in AC	Abs. Diff.	Dev(1) in AC	Pay Factor	Nuclear AC	Diff. in AC	Abs. Diff.	Dev(2) in AC	Pay Factor
5/16/94	6.6	5.6	6.4	0.8	0.8	0.40	0.90	5.6	0.0	0.0	0.05	1.05
		5.6	5.9	0.3	0.3			5.7	0.1	0.1		
		5.6	5.3	-0.3	0.3							
5/17/94	7.1	5.6	5.8	0.2	0.2							
		5.6	5.1	-0.5	0.5	0.50	0.80	5.6	0.0	0.0	0.08	1.05
		5.6	4.8	-0.8	0.8							
5/18/94	6.8	5.6	5.2	-0.4	0.4							
		5.6	5.9	0.3	0.3			5.9	0.3	0.3	0.35	0.95
		5.6	5.4	-0.2	0.2	0.25	1.00	5.2	-0.4	0.4		
		5.6	5.5	-0.1	0.1							
5/19/94	5.1	5.6	5.3	-0.3	0.3							
		5.6	5.2	-0.4	0.4							
		5.6	5.1	-0.5	0.5	0.45	0.85					
		5.6	5.1	-0.5	0.5							
		5.6	5.2	-0.4	0.4							
5/20/94		5.6	5.2	-0.4	0.4			5.7	0.1	0.1	0.10	1.05
5/23/94	6.1	5.6	5.0	-0.6	0.6	0.45	0.85					
		5.6	4.8	-0.8	0.8							
		5.6	6.0	0.4	0.4							
		5.6	5.6	0.0	0.0							
5/24/94	6.5	4.8	4.3	-0.5	0.5	0.38	0.90					
		4.8	4.8	0.0	0.0							
5/25/94	6.1	4.8	4.4	-0.4	0.4			4.5	-0.3	0.3	0.65	0.70
		4.8	4.2	-0.6	0.6			3.8	-1.0	1.0		
5/26/94	5.0	4.8	4.1	-0.7	0.7	0.43	0.85	4.3	-0.5	0.5	0.40	0.90
		4.8	4.3	-0.5	0.5			4.5	-0.3	0.3		
5/27/94	6.2	4.8	4.9	0.1	0.1			4.6	-0.2	0.2	0.30	1.00
		4.8	4.4	-0.4	0.4			4.4	-0.4	0.4		
		4.8	5.0	0.2	0.2	0.45	0.85					
		4.8	5.9	1.1	1.1							
5/31/94	5.8	4.8	4.4	-0.4	0.4			4.8	0.0	0.0	0.00	1.05
		4.8	4.7	-0.1	0.1			4.8	0.0	0.0		
		4.8	5.4	0.6	0.6	0.43	0.85					
		4.8	5.3	0.5	0.5							
6/1/94	6.9	4.8	5.1	0.3	0.3							
		4.8	4.5	-0.3	0.3							
		4.8	4.7	-0.1	0.1	0.45	0.85					
		4.8	5.3	0.5	0.5							
6/2/94	6.3	4.8	4.8	0.0	0.0			5.0	0.2	0.2	0.20	1.02
		4.8	6.0	1.2	1.2			4.6	-0.2	0.2		
		4.8	5.1	0.3	0.3							
		4.8	4.6	-0.2	0.2							
Mean	**6.21**			**-0.09**	**0.41**	**0.42**	**0.87**	**4.94**	**-0.16**	**0.25**	**0.24**	**0.97**
Std. Dev	**0.66**			**0.49**	**0.27**	**0.07**	**0.05**	**0.62**	**0.32**	**0.26**	**0.21**	**0.12**

(1): Deviation is calculated as the mean absolute deviation (i.e. sum of absolute values of deviations from target value for four consecutive measurements, representing four sublots, divided by four (Reference 4). asphalt contents from extractions were used in calculating these deviations.

(2): As in note (1) above except that only daily nulcear density measurements were used to calculate the daily deviation from target asphalt content (in some cases only one measurement is used).

Table C.2. Daily Asphalt Content and Variation from Target AC and Corresponding Pay Factors for the Project in Callahan County.

Project	**CPM 0006-07-060**	Type C (Surface) with RAP	
Highway	**IH 20**	Amount of RAP (%) 35	
County	**Callahan**	Dedicated Stockpile	

Date	RAP % AC	Design % AC	Extracted AC	Difference in AC	Absolute Difference	Deviation* in AC	Pay Factor
7/19/94	5.6	5.8	5.4	-0.4	0.4	0.48	0.80
		5.8	5.7	-0.1	0.1		
		5.8	5.1	-0.7	0.7		
7/20/94	5.8	5.8	5.1	-0.7	0.7		
		5.8	5.4	-0.4	0.4	0.38	0.90
		5.8	5.2	-0.6	0.6		
7/21/94	6.2	5.8	5.3	-0.5	0.5		
		5.8	5.8	0.0	0.0		
		5.8	5.8	0.0	0.0	0.50	0.80
7/22/94	7.3	5.8	4.7	-1.1	1.1		
		5.8	5.2	-0.6	0.6		
		5.8	5.5	-0.3	0.3		
		5.8	4.8	-1.0	1.0	0.35	0.95
7/25/94	6.6	5.6	5.5	-0.1	0.1		
		5.6	5.4	-0.2	0.2		
		5.6	5.7	0.1	0.1		
		5.6	5.8	0.2	0.2		
Mean	**6.30**			**-0.38**	**0.41**	**0.43**	**0.86**
Std. Dev	**0.64**			**0.38**	**0.34**	**0.07**	**0.07**

NOTE: Deviation is calculated as the mean absolute deviation (i.e. sum of absolute values of deviations from target value for four consecutive measurements, representing four sublots, divided by four)- Refer to TxDOT specification 3007.

Table C.3. Daily Asphalt Content and Variation from Target AC and Corresponding Pay Factors for the Project in Gregg County.

Project	**IM 20-6(71) 580**	Type C (Base) with RAP	
Highway	**IH 20**	Amount of RAP (%)	35
County	**Gregg**	Dedicated Stockpile	

Date	RAP % AC	Design % AC	Extracted AC	Difference in AC	Absolute Difference	Deviation* in AC	Pay Factor
5/4/94	2.9	3.7	4.1	0.4	0.4	0.40	0.90
		3.7	4.0	0.3	0.3		
		3.7	4.2	0.5	0.5		
		3.7	4.1	0.4	0.4		
		3.7	4.1	0.4	0.4	0.40	0.90
5/6/94	6.0	3.7	4.2	0.5	0.5		
		3.7	4.1	0.4	0.4		
		3.7	4.0	0.3	0.3		
		3.7	4.5	0.8	0.8	0.65	0.70
		3.7	4.3	0.6	0.6		
5/16/94		3.7	4.2	0.5	0.5		
5/17/94		3.7	4.4	0.7	0.7		
5/18/94		3.7	4.0	0.3	0.3	0.38	0.90
		3.7	4.0	0.3	0.3		
		3.7	4.1	0.4	0.4		
5/19/94		3.7	4.2	0.5	0.5		
		3.7	4.1	0.4	0.4	0.65	0.7
5/23/94		3.7	4.2	0.5	0.5		
		3.7	4.7	1.0	1.0		
		3.7	4.4	0.7	0.7		
5/25/94		3.7	4.2	0.5	0.5	0.63	0.7
		3.7	4.2	0.5	0.5		
		3.7	4.4	0.7	0.7		
	5.7	3.7	4.5	0.8	0.8		
5/31/94		3.7	4.2	0.5	0.5		
6/7/94		3.7	4.1	0.4	0.4		
6/8/94		3.7	4.0	0.3	0.3		
Mean				**0.50**	**0.50**	**0.52**	**0.80**
Std. Dev				**0.18**	**0.18**	**0.14**	**0.11**

NOTE: Deviation is calculated as the mean absolute deviation (i.e. sum of absolute values of deviations from target value for four consecutive measurements, representing four sublots, divided by four)- Refer to TxDOT specification 3007.

Table C.4. Daily Asphalt Content and Variation from Target AC and Corresponding Pay Factors for the Project in Cameron County.

Project	**NH 94 (21) M**	Type B (Base) with RAP
Highway	**SH 100**	Amount of RAP (%) 40
County	**Cameron**	Dedicated Stockpile

			Extraction Results					Nuclear Gauge Measurements				
Date	RAP % AC	Design % AC	Extract AC	Diff. in AC	Abs. Diff.	Dev.(1) in AC	Pay Factor	Nuclear AC	Diff. in AC	Abs. Diff.	Dev.(2) in AC	Pay Factor
8/17/94	5.8	4.7	4.2	-0.5	0.5	0.45	0.85	3.9	-0.8	0.8	0.43	0.85
		4.7	4.0	-0.7	0.7			4.4	-0.3	0.3		
		4.7	4.5	-0.2	0.2			4.9	0.2	0.2		
		4.7	4.3	-0.4	0.4							
8/18/94	5.8	4.7	5.1	0.4	0.4	0.18	1.05	4.1	-0.6	0.6	0.40	0.90
		4.7	4.7	0.0	0.0			4.5	-0.2	0.2		
		4.7	4.7	0.0	0.0			4.3	-0.4	0.4		
		4.7	5.0	0.3	0.3							
8/22/94	6.1	4.7	4.6	-0.1	0.1	0.13	1.05	4.3	-0.4	0.4	0.57	0.75
		4.7	4.5	-0.2	0.2			4.4	-0.3	0.3		
		4.7	4.5	-0.2	0.2			3.7	-1.0	1.0		
		4.7	4.7	0.0	0.0							
8/23/94	6.2	4.7	3.8	-0.9	0.9	0.35	0.95	4.4	-0.3	0.3	0.30	1.00
		4.7	5.0	0.3	0.3			4.4	-0.3	0.3		
		4.7	4.8	0.1	0.1			4.4	-0.3	0.3		
		4.7	4.6	-0.1	0.1							
8/25/94	6.1	4.7	4.6	-0.1	0.1	0.10	1.05	3.9	-0.8	0.8	0.53	0.75
		4.7	4.7	0.0	0.0			4.2	-0.5	0.5		
		4.7	4.6	-0.1	0.1			4.4	-0.3	0.3		
		4.7	4.5	-0.2	0.2							
8/26/94	6.4	4.7	5.0	0.3	0.3	0.27	1.00	4.4	-0.3	0.3	0.33	0.95
		4.7	4.9	0.2	0.2			4.3	-0.4	0.4		
		4.7	4.4	-0.3	0.3			4.4	-0.3	0.3		
		4.7										
8/29/94	6.0	4.7	5.8	1.1	1.1	0.38	0.90	4.5	-0.2	0.2	0.13	1.05
		4.7	4.8	0.1	0.1			4.7	0.0	0.0		
		4.7	4.8	0.1	0.1			4.5	-0.2	0.2		
		4.7	4.5	-0.2	0.2							
8/30/94	6.1	4.7	4.9	0.2	0.2	0.20	1.02					
		4.7	4.9	0.2	0.2							
		4.7	4.9	0.2	0.2							
		4.7										
Mean	**6.06**			**-0.02**	**0.26**	**0.26**	**0.98**	**4.33**	**-0.37**	**0.39**	**0.39**	**0.89**
Std Dev	**0.19**			**0.36**	**0.26**	**0.13**	**0.08**	**0.27**	**0.27**	**0.24**	**0.15**	**0.12**

(1): Deviation is calculated as the mean absolute deviation (i.e. sum of absolute values of deviations from target value for four consecutive measurements, representing four sublots, divided by four (Referance 1). However, asphalt contents from extractions were used in calculating these deviations.

(2): As in note (1) above except that three daily nulcear density measurements were used to calculate the daily deviation from taget asphalt content.

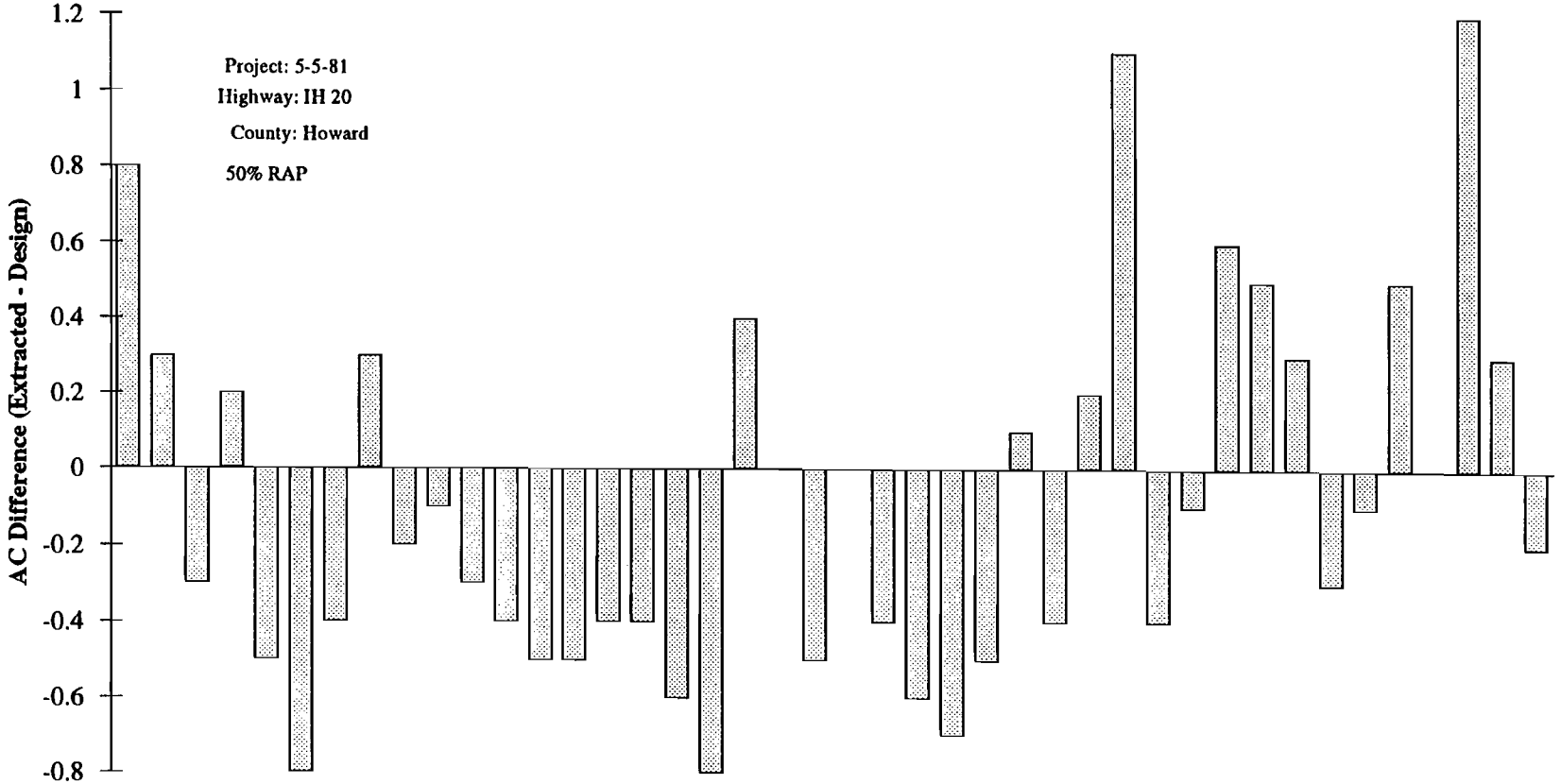


Figure C.1. The difference between Extracted and Design Asphalt Conents fot the Project in Howard County

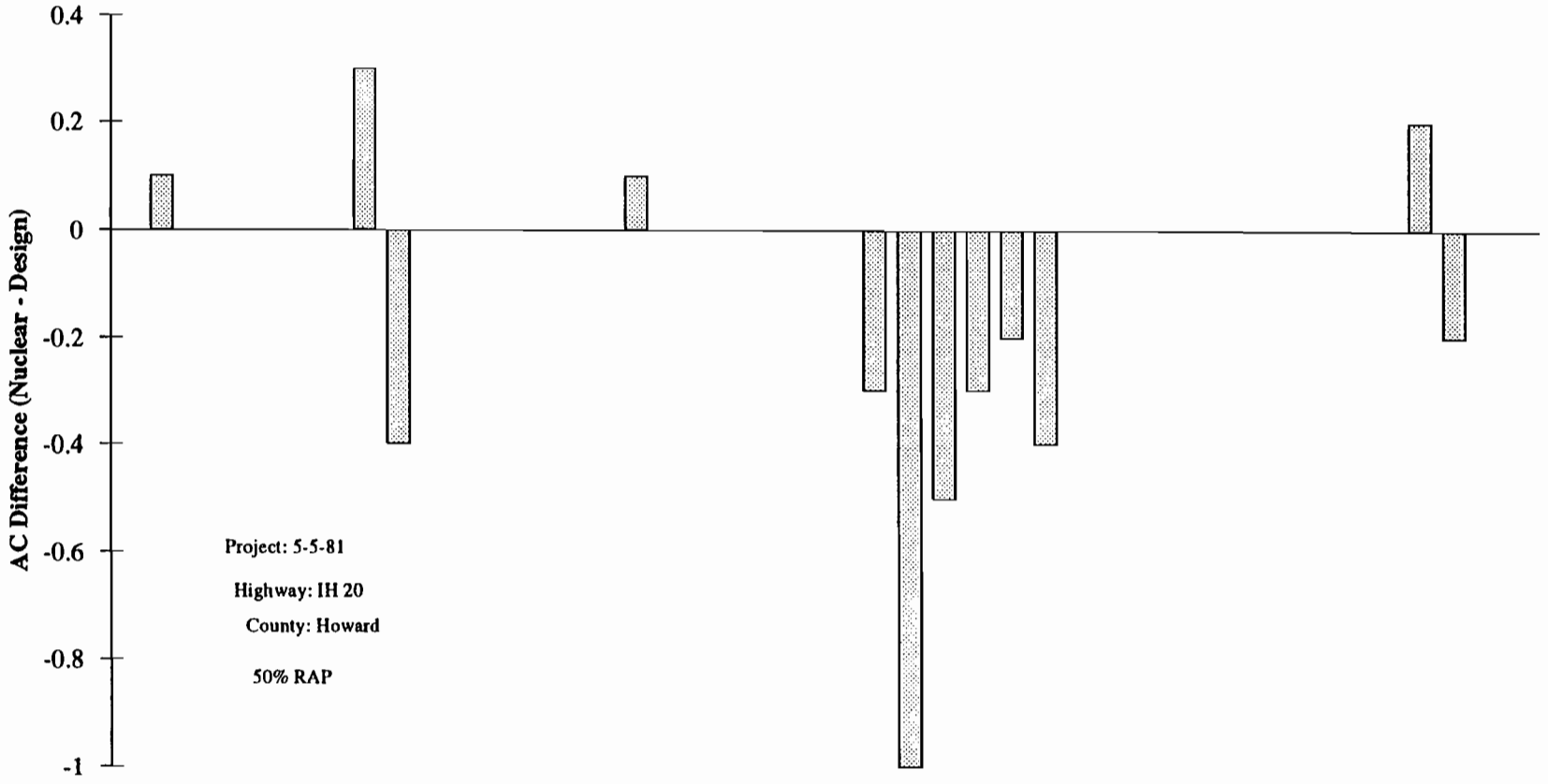


Figure C.2. The difference between Nuclear Gauge and Design Asphalt Conents fot the Project in Howard County

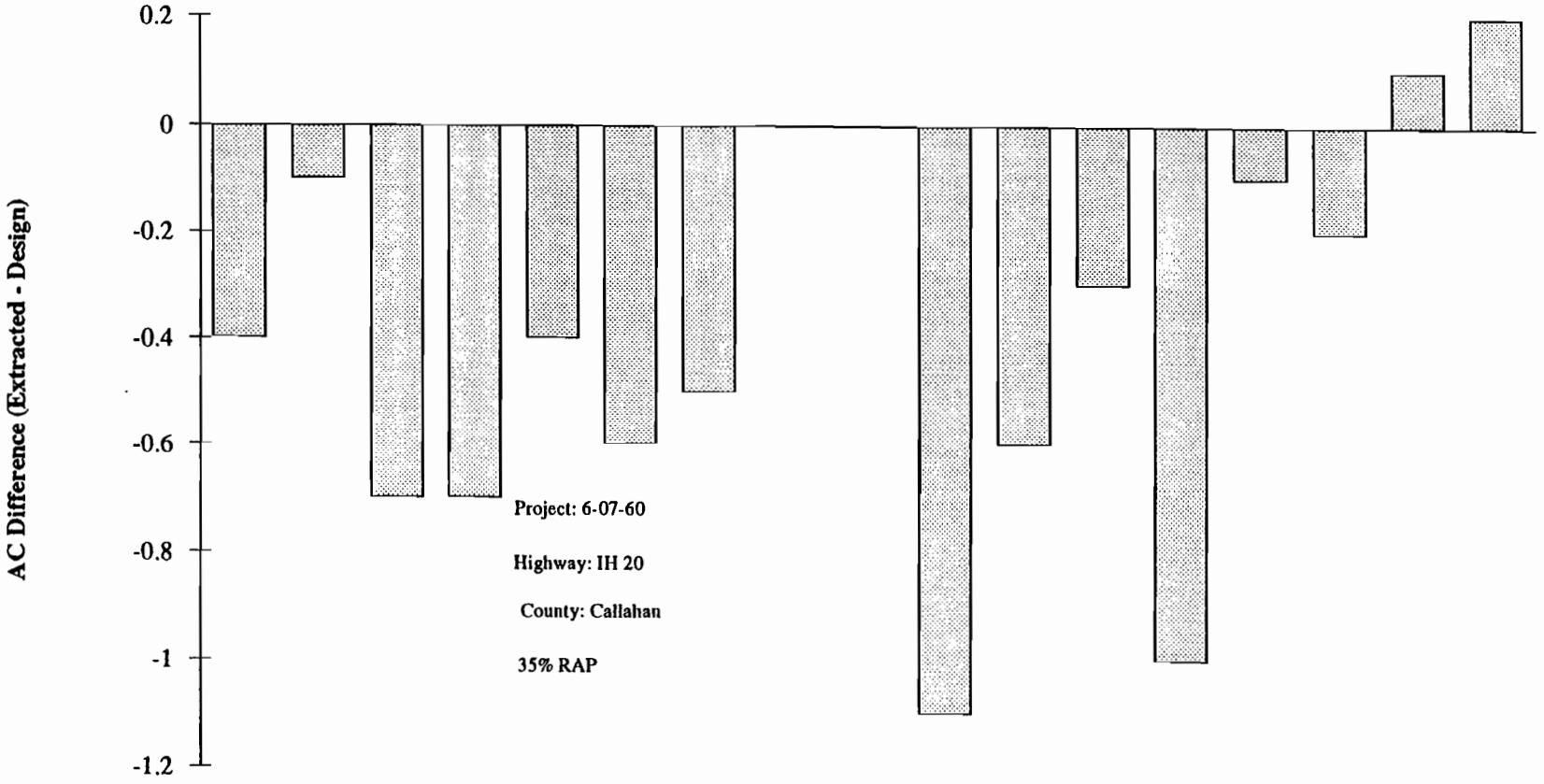


Figure C.3. The difference between Extracted and Design Asphalt Conents fot the Project in Callahan County

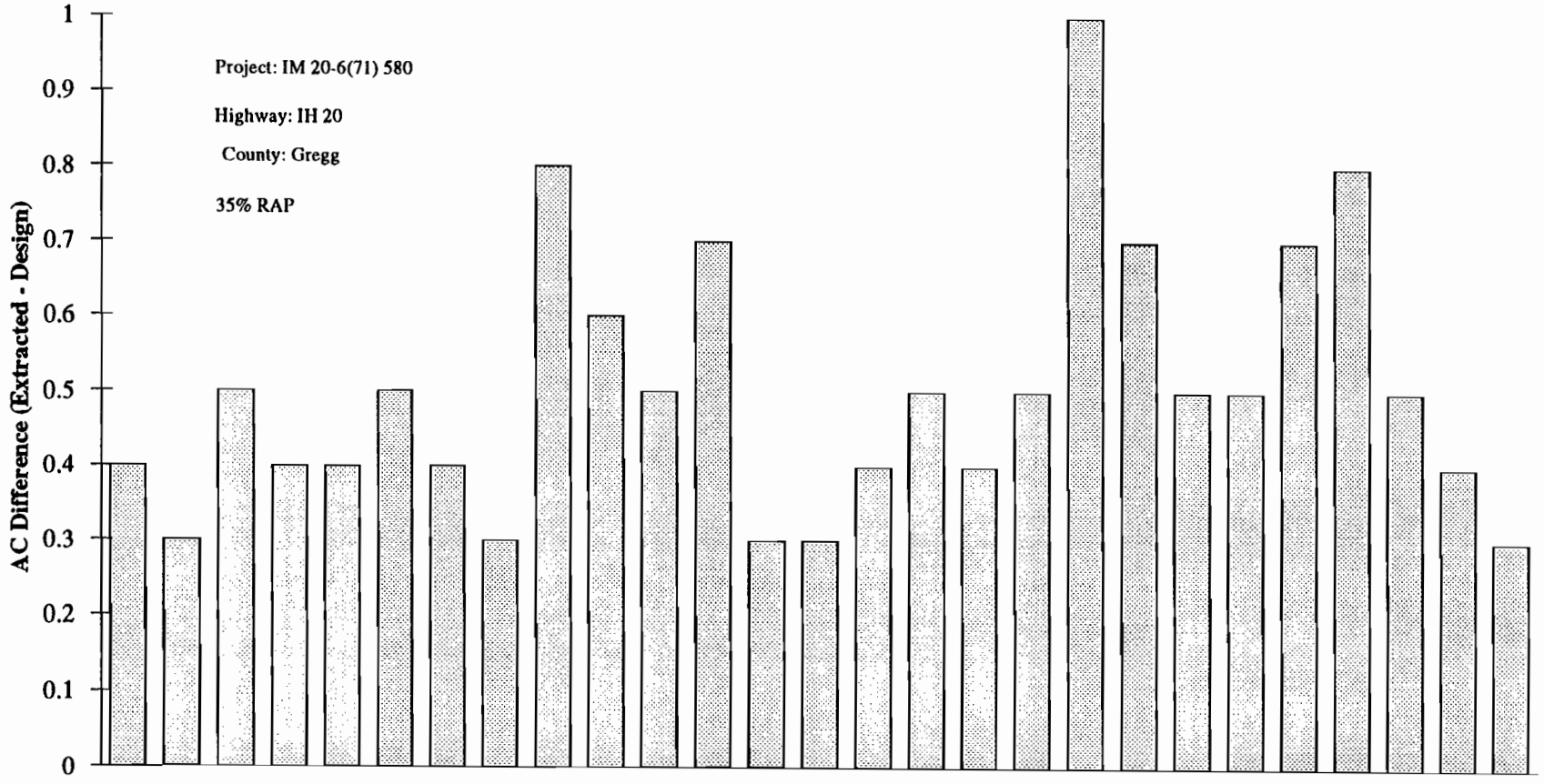


Figure C.4. The difference between Extracted and Design Asphalt Conents fot the Project in Gregg County

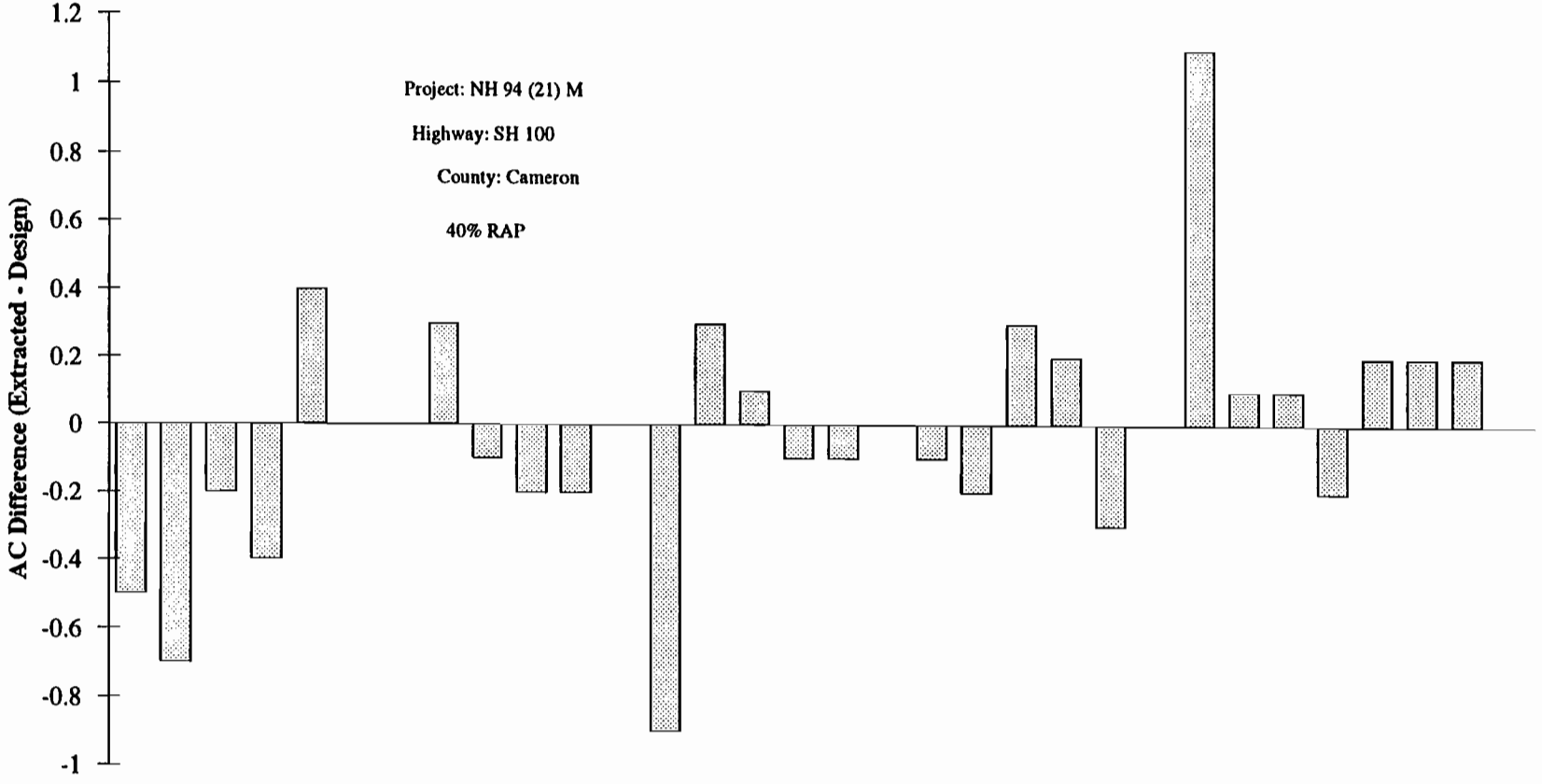


Figure C.5. The difference between Extracted and Design Asphalt Conents for Cameron County Project.

APPENDIX D

HVEEM STABILITIES AND AIR VOIDS

Table D.1. Stabilitiy and Air Void Values and Corresponding Pay Factors for the Project in Howard County.

Project	**CPM 0005-05-081**
Highway	**IH 20**
County	**Howard**

Aggregate Source	Transit Materials Inc., Midland, TX
Asphalt Source	Fina AC-10, Big Springs, TX

Type D (Surface) with RAP	**Amount of RAP (%) 50**	**Dedicated Stockpile**

Date	Specimen	Stability, M&T Division	Avg. Stability, M&T Division	Stability, Dist Lab	Avg. Stability, Dist. Lab	Lab Dens	Avg Lab Air Void	Road Dens (1)	Avg Road Air Void (2)	Pay Factor (3)
5/16/94	1-1	37		49		95.3				
	1-2	31	34	48	47	93.1	5.2			
	1-3	35		43		95.9				
5/16/94	2-1	42								
	2-2	51	48							
	2-3	52								
5/17/94	3-1	43		39		96.6		94.2		
	3-2	47	43	44	41	96.6	3.5	92.6	6.4	1.02
	3-3	38		41		96.3		93.9		
5/17/94	4-1	48								
	4-2	43	49							
	4-3	55								
5/18/94	5-1	30		29		96.0				
	5-2	37	36	43	34	95.6	4.2			
	5-3	42		30						
5/18/94	6-1	25		35		96.7				
	6-2	34	30		37	96.0	3.8			
	6-3	30		38		96.0				
5/19/94	7-1			47		97.7		94.7		
	7-2			35	43	98.0	2.1	92.1	7.7	1.00
	7-3			46		98.0		91.7	(7.1)	
5/19/94	8-1	31		34		96.8		90.9		
	8-2	31	33	31	32	96.4	.3.3	94.5		
	8-3	38		32		96.9		92.2		
5/23/94	9-1	37		37		97.3		95.7		
	9-2	39	38	38	35	96.9	3.0	93.0	7.8	1.00
	9-3	37		31		96.7		91.0	(7.4)	
5/23/94	10-1	41		46		97.7		88.9		
	10-2	35	40	52	50	97.1	2.5			
	10-3	45		51		97.8				
5/26/94	11-1	52		43		94.7		91.1		
	11-2	46	49	50	47	94.6	5.0	91.4	8.7	1.00
	11-3	50		48		95.6		92.5	(8.6)	
5/26/94	12-1	41		48		95.6		90.1		
	12-2	40	40	46	48	95.8	4.3			
	12-3	40		51		95.8				

Table D.1. Stabilitiy and Air Void Values and Corresponding Pay Factors for the Project in Howard County (cont'd).

5/26/94	12-1	39								
	12-2	46	42							
	12-3	42								
5/27/94	13-1	44		40		96.9				
	13-2	37	41	38	39	97.0	3.4			
	13-3	41		40		96.0			(9.6)	0.90
5/27/94	14-1	43								
	14-2	42	42							
	14-3	41								
5/31/94	15-1	45		48						
	15-2	44	42	44	45					
	15-3	36		44					(9.6)	0.90
5/31/94	16-1	38				95.2				
	16-2	44	41			95.5	4.7			
	16-3	41				95.1				
5/31/94	17-1	39				95.0				
	17-2	40	39			94.9	5.1			
	17-3	38				94.8				
6/1/96	18-1	49		39		95.5				
	18-2	42	44	46	44	94.7	5.1			
	18-3	40		46		94.6				
6/1/94	19-1	37				95.4				
	19-2	35	37			95.8	4.4			
	19-3	38				95.6				
6/2/94	20-1	46				92.7				
	20-2	43	45			92.3	7.9			
	20-3	47				91.3			(8.8)	1.00
6/2/94	21-1	44				94.7				
	21-2	38	41			95.0	5.0			
	21-3	41				95.4				
6/2/94	22-1	46				91.6				
	22-2	49	47			94.4	7.9			
	22-3	46				90.3				

(1) Road densities are based on average of four nuclear density measurement readings.

(2) Air voids are calculated as the average of four consecutive measurements (nuclear).
The numbers in parentheses indicate the average air void for three cores.
Not all air voids were available for all days.

(3) Pay factors are calculated based on Table 3.3. However, it is important to realize that the air void results are just average of three or four daily measurements (not following Spec 3007).

Table D.2. Stabilitiy and Air Void Values and Corresponding Pay Factors for the Project in Callahan County.

Project	**CPM 0006-07-060**
Highway	**IH 20**
County	**Callahan**

Aggregate Source	Vulcan Materials, Limestone
Asphalt Source	Coastal AC-10

Type C (Surface) with RAP Amount of RAP (%) 35 Dedicated Stockpile

Date	Specimen	Stability, M&T Division	Avg. Stability, M&T Division	Stability, Dist Lab	Avg. Stability, Dist. Lab	Lab Dens	Avg Lab Air Void	Road Dens	Avg Road Air Void	Pay Factor
7/15/94	1-1			35						
	1-2			31	32					
	1-3			31						
7/15/94	2-1			54						
	2-2			55	57					
	2-3			61						
7/15/94	3-1			64						
	3-2			65	61					
	3-3			54						
7/19/94	4-1			46		96.8				
	4-2			61	56	96.8	3.0			
	4-3			62		97.5				
7/19/94	5-1			41		96.9				
	5-2			44	43	97.0	3.1			
	5-3			43		96.8				
7/20/94		29								
		28	28							
		28								
7/20/94		29								
		25	26							
		25								
7/20/94		44								
		47	43							
		39								
7/21/94	6-1	26		33		97.2				
	6-2	25	23	38	36	97.1	2.8			
	6-3	19		37		97.4				
7/21/94	7-1	25		33						
	7-2	26	25	26	28					
	7-3	25		25						
7/21/94		40								
		35	39							
		43								
7/22/94	8-1	41		59						
	8-2	43	42	61	61					
	8-3	41		62						

Table D.2. Stabilitiy and Air Void Values and Corresponding Pay Factors for the Project in Callahn County (Cont'd).

Project	**CPM 0006-07-060**
Highway	**IH 20**
County	**Callahan**

Aggregate Source	Vulcan Materials, Limestone
Asphalt Source	Coastal AC-10

Type C (Surface) with RAP **Amount of RAP (%) 35** **Dedicated Stockpile**

Date	Specimen	Stability, M&T Division	Avg. Stability, M&T Division	Stability, Dist Lab	Avg. Stability, Dist. Lab	Lab Dens	Avg Lab Air Void	Road Dens	Avg Road Air Void	Pay Factor
7/22/94		36								
		39	37							
		37								
7/22/94		41								
		55	49							
		52								
7/25/94	9-1	40		43		96.9				
	9-2	42		40	41	96.7	3.1			
	9-3	41		40		97.0				
7/25/94		31								
		30								
		30								
7/25/94		34								
		32								
		33								

Road air voids were not available for this project.

Table D.3. Stabilitiy and Air Void Values and Corresponding Pay Factors for the Project in Gregg County.

Project	**IM 20-6(71) 580**
Highway	**IH 20**
County	**Gregg**

Aggregate Source	G-H PERCH & C.X.I.
Asphalt Source	AC-10, Lion Oil, Eldorado, AR

Type C (Base) with RAP **Amount of RAP (%) 40** **Dedicated Stockpile**

Date	Specimen	Stability, M&T Division	Avg. Stability, M&T Division	Lab Dens	Avg Lab Air Void	Road Dens	Avg Road Air Void (1)	Pay Factor (2)
5/4/94	1-1	45		96.5				
	1-2	46	45	96.9	3.2		9.0	1.00
	1-3	45		96.9				
5/4/94	2-1	49						
	2-2	53	51					
	2-3	52						
5/6/94	2-1	52		97.2				
	2-2	52	53	97.8	2.6		9.0	1.00
	2-3	54		97.3				
5/16/94	3-1	45		97.0				
	3-2	55	50	97.0	3.0		8.5	1.00
	3-3	51		96.9				
5/23/94	4-1	49		96.7				
	4-2	53	50	97.1	3.4			
	4-3	49		96.1				
5/23/94	5-1	47						
	5-2	48	49					
	5-3	51						
5/25/94	6-1	51		96.7				
	6-2	50	50	96.8	3.2			
	6-3	49		97.0				
5/25/94	7-1	37						
	7-2	41	38					
	7-3	36						
5/31/94	8-1	52		97.4				
	8-2	54	52	97.5	2.6		7.2	1.00
	8-3	49		97.4				
5/31/94	9-1	33						
	9-2	43	39					
	9-3	42						

(1) Road air voids are based on the average of air voids of three cores.
Not all air voids were available for all days.

(2) Pay factors are cacluated based on table 3.3. However, it is important to realize that the air void results are just average values for three cores (not following TxDOT Spec 3007).

Table D.4. Stabilitiy and Air Void Values and Corresponding Pay Factors for the Project in Cameron County.

Project	**NH 94 (21) M**
Highway	**IH 20**
County	**Cameron**

Aggregate Source	Parker La Farge and Fordyce
Asphalt Source	Coastal AC-5

Type B (Base) with RAP **Amount of RAP (%) 40** **Dedicated Stockpile**

		Compacted at UT		Compacted at Plant						
Date	Specimen	Stability, M&T Division	Avg. Stability, M&T Division	Stability, M&T Division	Avg. Stability, M&T Division	Lab Dens	Avg Lab Air Void	Road Dens (1)	Avg Road Air Void (2)	Pay Factor (3)
8/17/94	1-1	45		46		98.8		92.5		
	1-2	40	41	44	47	98.1	1.6	91.1	7.9	1.00
	1-3	42		50		98.4		92.6		
8/17/94	1-1	49								
	1-2	40	43							
	1-3	45								
8/17/94	1-1	45								
	1-2	45	43							
	1-3	40								
8/17/94	1-1	23								
	1-2	21	21							
	1-3									
8/18/94	2-1	38		46						
	2-2	33	36	45	46		1.1		6.4	1.02
	2-3	38		46						
8/18/94	2-1	43								
	2-2	44	42							
	2-3	39								
8/18/94	2-1	41								
	2-2	32	37							
	2-3	41								
8/18/94	2-1	38								
	2-2	44	43							
	2-3	42								
8/19/94	3-1			47		98.7		92.3		
	3-2			47	45	99.0	1.1	93.2	7.0	1.00
	3-3			42		98.9		93.4		
8/22/94	4-1	46		41		99.0		94.5		
	4-2	45	43	46	43	99.1	1.1	93.9	5.5	1.05
	4-3	41		43		98.7		95.1		
8/22/94	4-1	41								
	4-2	41	38							
	4-3	35								
8/22/94	4-1	38								
	4-2	38	40							
	4-3	42								
8/22/94	4-1	40								
	4-2	45	46							
	4-3	46								

Table D.4. Stabilitiy and Air Void Values and Corresponding Pay Factors for the Project in Cameron County (Cont'd)

Project	**NH 94 (21) M**
Highway	**IH 20**
County	**Cameron**

Aggregate Source	Parker La Farge and Fordyce
Asphalt Source	Coastal AC-5

Type B (Base) with RAP **Amount of RAP (%) 40** **Dedicated Stockpile**

		Compacted at UT		Compacted at Plant						
Date	Specimen	Stability, M&T Division	Avg. Stability, M&T Division	Stability, M&T Division	Avg. Stability, M&T Division	Lab Dens	Avg Lab Air Void	Road Dens (1)	Avg Road Air Void (2)	Pay Factor (3)
8/24/94	6-1			51		98.2		94.7		
	6-2			40	44	98.3	1.7	94.0	5.7	1.05
	6-3			41		98.4		94.1		
8/24/94	7-1			31						
	7-2			32	33					
	7-3			36						
8/25/94	8-1	40		35		99.0		94.3		
	8-2	39	39	36	37	98.5	1.2	93.6	6.0	1.02
	8-3	37		40		99.0		94.2		
8/25/94	8-1	41								
	8-2	36	40							
	8-3	44								
8/25/94	8-1	37								
	8-2	43	40							
	8-3	39								
8/25/94	8-1	42								
	8-2	35	41							
	8-3	45								
8/26/94	9-1	'37		43		98.2		94.1		
	9-2	40	39	39	41	98.8	1.4	92.7	6.4	1.02
	9-3	38		41		98.7		94		
8/26/94	9-1	47								
	9-2	43	48							
	9-3	52								
8/26/94	9-1	44								
	9-2	41	40							
	9-3	39								
8/29/94	10-1	41		30		98.6		93.0		
	10-2	37	36	33	33	99.3	1.0	93.4	7.1	1.00
	10-3	35		36		99.1		92.2		
8/29/94	11-1	28		27						
	11-2	25	31	26	25					
	11-3	36		21						
8/29/94	11-1	37								
	11-2	43	37							
	11-3	31								
8/29/94	11-1	34								
	11-2	44	40							
	11-3	36								

Table D.4. Stabilitiy and Air Void Values and Corresponding Pay Factors for the Project in Cameron County (Cont'd).

Project	**NH 94 (21) M**
Highway	**IH 20**
County	**Cameron**

Aggregate Source	Parker La Farge and Fordyce
Asphalt Source	Coastal AC-5

Type B (Base) with RAP **Amount of RAP (%) 40** **Dedicated Stockpile**

		Compacted at UT		Compacted at Plant						
Date	Specimen	Stability, M&T Division	Avg. Stability, M&T Division	Stability, M&T Division	Avg. Stability, M&T Division	Lab Dens	Avg Lab Air Void	Road Dens (1)	Avg Road Air Void (2)	Pay Factor (3)
8/30/94	12-1	44								
	12-2	49	42							
	12-3	34								
8/30/94	12-1	34								
	12-2	35	34							
	12-3	33								
8/31/94	13-1			56		98.8		93.3		
	13-2			68	58	99.4	0.9	93.0	7.0	1.00
	13-3			49		99.0		92.6		

(1) Road densities are obtained from road cores.

(2) Air voids are calculated as the average values for three road cores. Not all air voids were available for all days.

(3) Pay factors are cacluated based on table 3.3. However, it is important to realize that the air void results are just average of three road cores for a day (not following TxDOT Spec 3007).

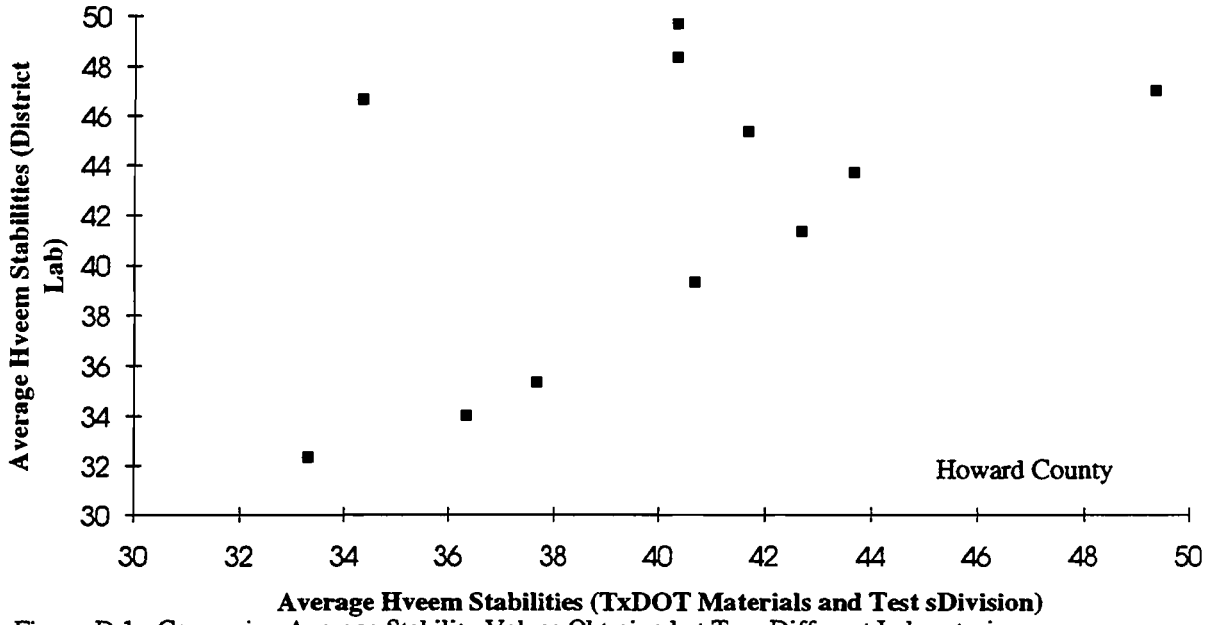


Figure D.1. Comparing Average Stability Values Obtrained at Two Different Laboratories.

APPENDIX E

PENETRATION AND VISCOSITIES FOR ASPHALT MATERIAL EXTRACTED FROM HMAC AND RAP

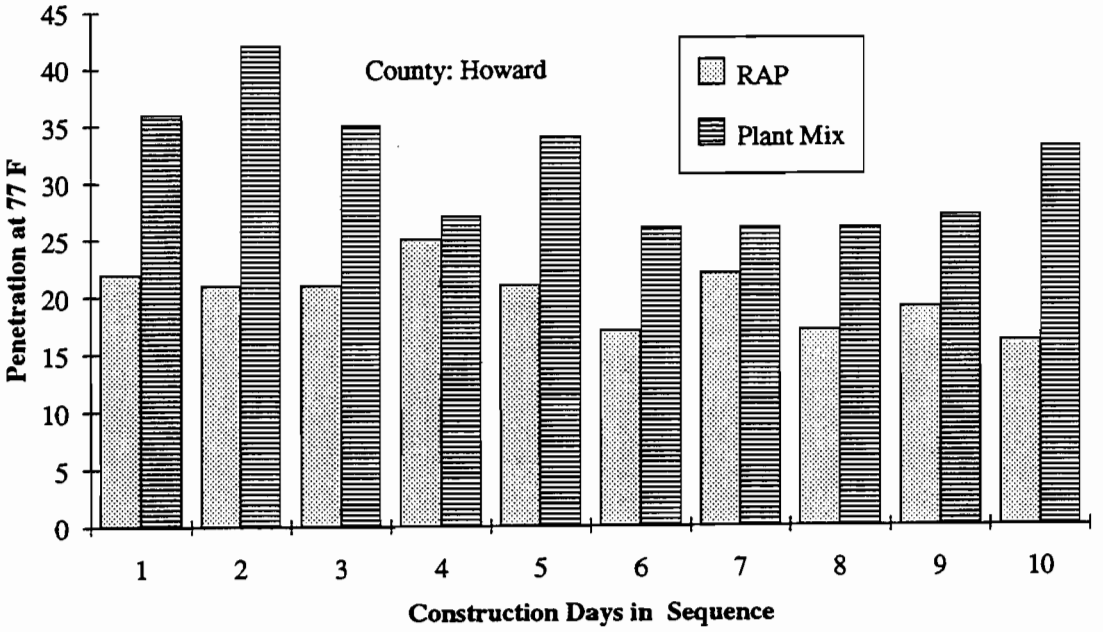
Table E.1. Daily Penetration and Viscosity Values for the Projects.

Project	Howard				Callahan				
Sample Date	Penetration at 77 F		Viscosity at 140 F, Poise		Sample Date	Penetration at 77 F		Viscosity at 140 F	
	RAP	Mix	RAP	Mix		RAP	Mix	RAP	Mix
5/16/94	22	36	10636	3620	7/19/94	17	34	N/P	4649
5/17/94	21	42	11389	1694	7/20/94	15	27	N/P	11716
5/18/94	21	35	10561	3444	7/21/94	13	24	N/P	12186
5/19/94	25	27	7436	5530	7/22/94	17	24	N/P	13053
5/23/94	21	34	11232	5486	7/25/94	16	27	N/P	11720
5/26/94	17	26	16852	9469					
5/27/94	22	26	10300	7517					
5/31/94	17	26	17255	7834					
6/1/94	19	27	9527	7114					
6/2/94	16	33	19434	3633					
Mean	20	31	12462	5534		16	27		10665
Std Dev.	2.8	5.6	3930.2	2440.3		1.7	4.1		3406.8
COV	0.14	0.18	0.32	0.44		0.11	0.15		0.32

Project	Gregg				Cameron				
Sample Date	Penetration at 77 F		Viscosity at 140 F		Sample Date	Penetration at 77 F		Viscosity at 140 F	
	RAP	Mix	RAP	Mix		RAP	Mix	RAP	Mix
5/4/94	15	30	19752	7020	8/9/94	15	27	N/P	12284
5/6/94	34	51	5845	2299	8/15/94	16	28	N/P	15150
5/23/94	N/A	41	N/A	5456	8/17/94	15	32	N/P	7718
5/25/94	N/A	36	N/A	7330	8/18/94	16	30	N/P	12259
5/29/94	26	37	24837	6323	8/22/94	13	30	N/P	12027
5/31/94	N/A	35	N/A	6622	8/23/94	14	28	N/P	13465
					8/25/94	16	31	N/P	12713
					8/26/94	13	28	N/P	14897
					8/29/94	14	28	N/P	15155
					8/30/94	13	31	N/P	8899
Mean		38		5842		15	29		12457
Std Dev		7.1		1851.7		1.3	1.7		2515.2
COV		0.19		0.32		0.09	0.06		0.20

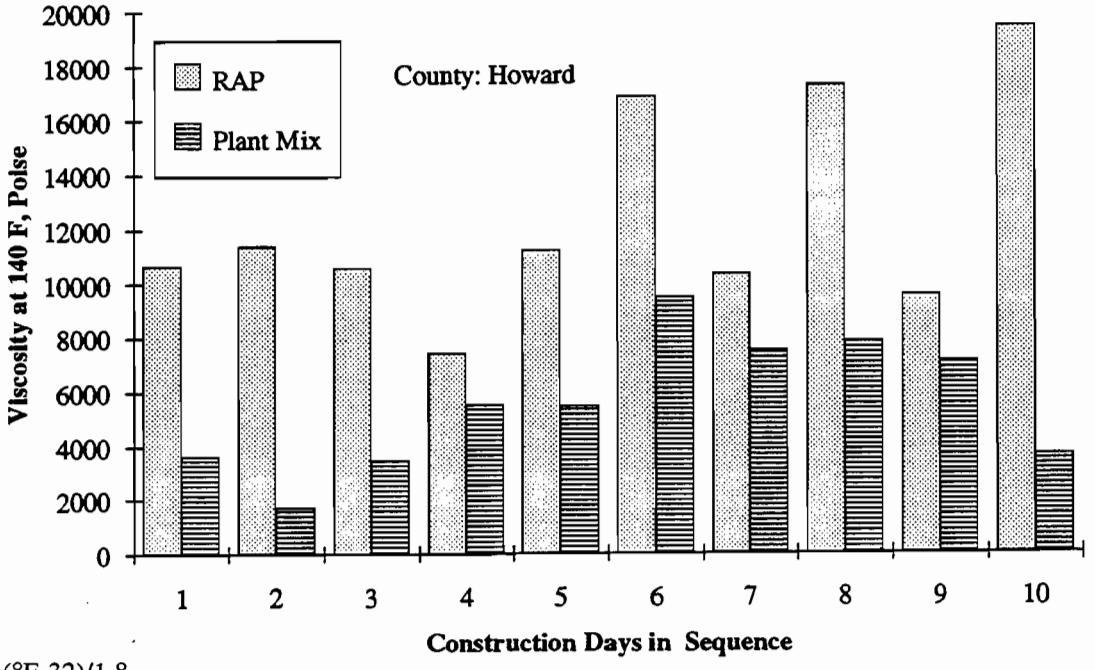
N/A Not Available

N/P Asphalt too stiff and not possible to test



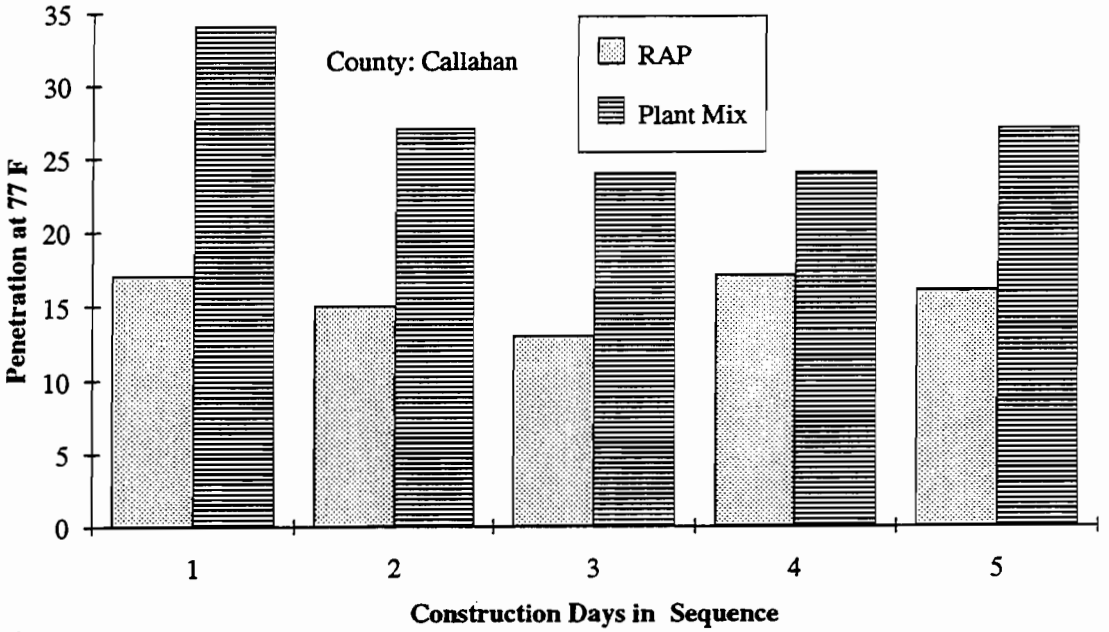
°F=(°F-32)/1.8

Figure E.1. Daily Penetrations for the Project in Howard County.



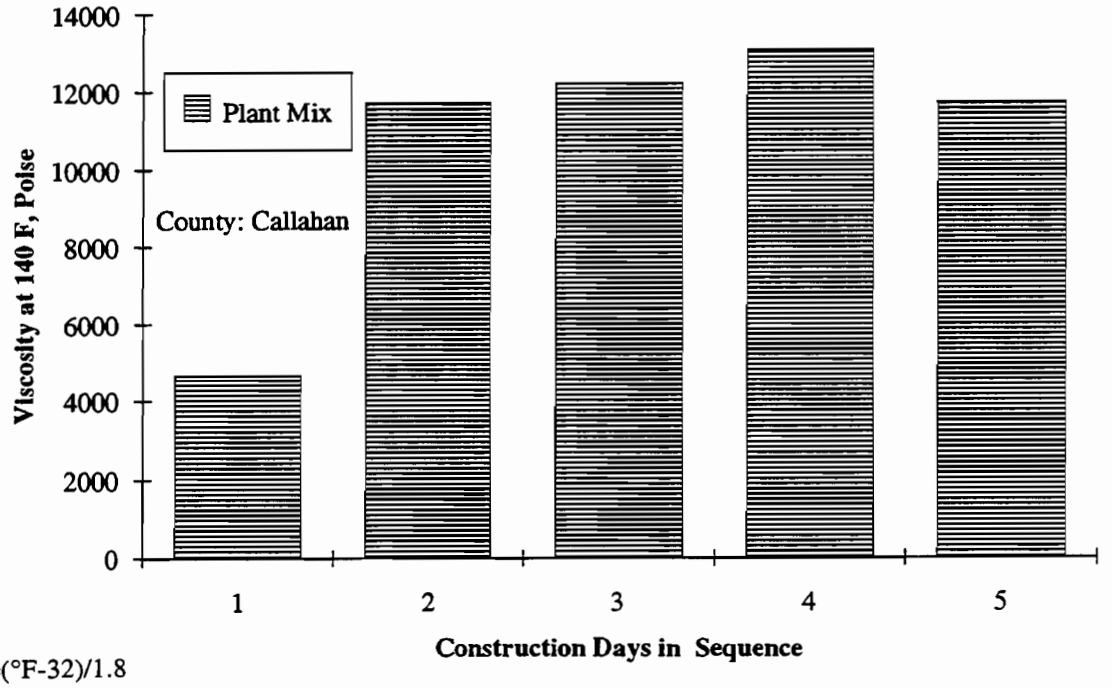
°F=(°F-32)/1.8

Figure E.2. Daily Viscosities for the Project in Howard County.



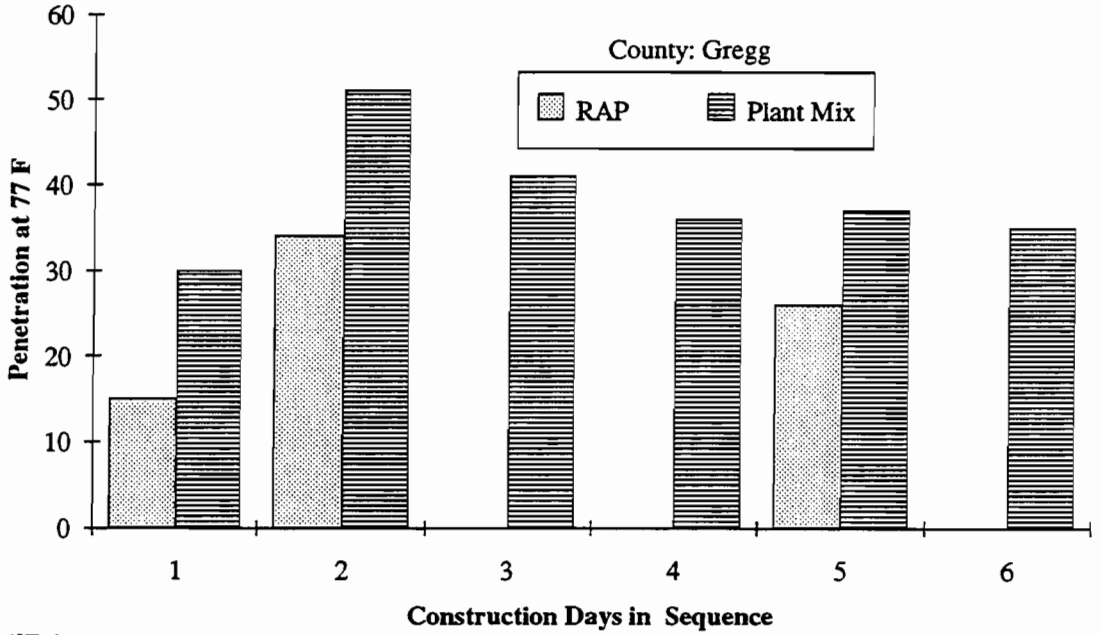
°F=(°F-32)/1.8

Figure E.3. Daily Penetrations for the Project in Callahan County.



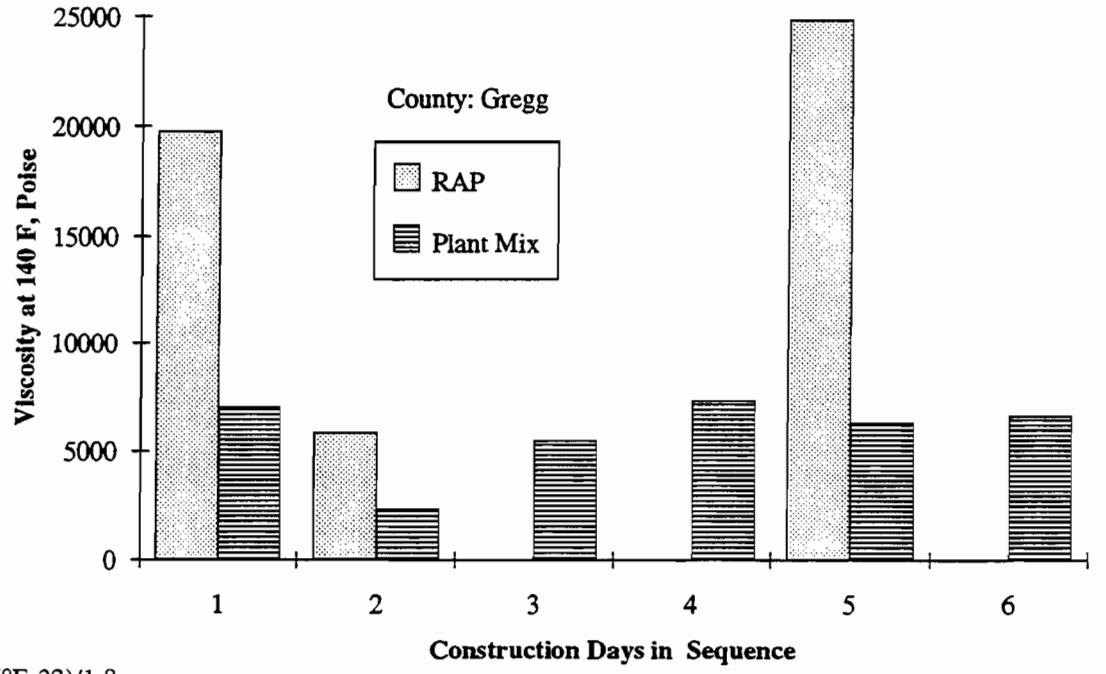
°F=(°F-32)/1.8

Figure E.4. Daily Viscosities for the Project in Callahan County.



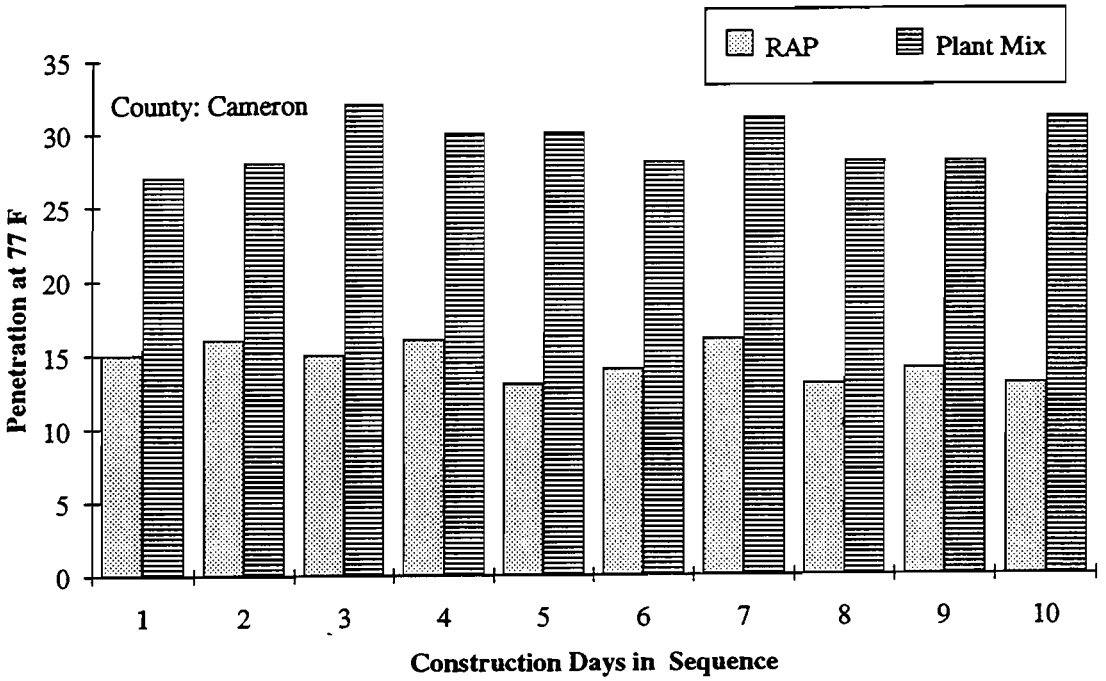
°F=(°F-32)/1.8

Figure E.5. Daily Penetrations for the Project in Gregg County.



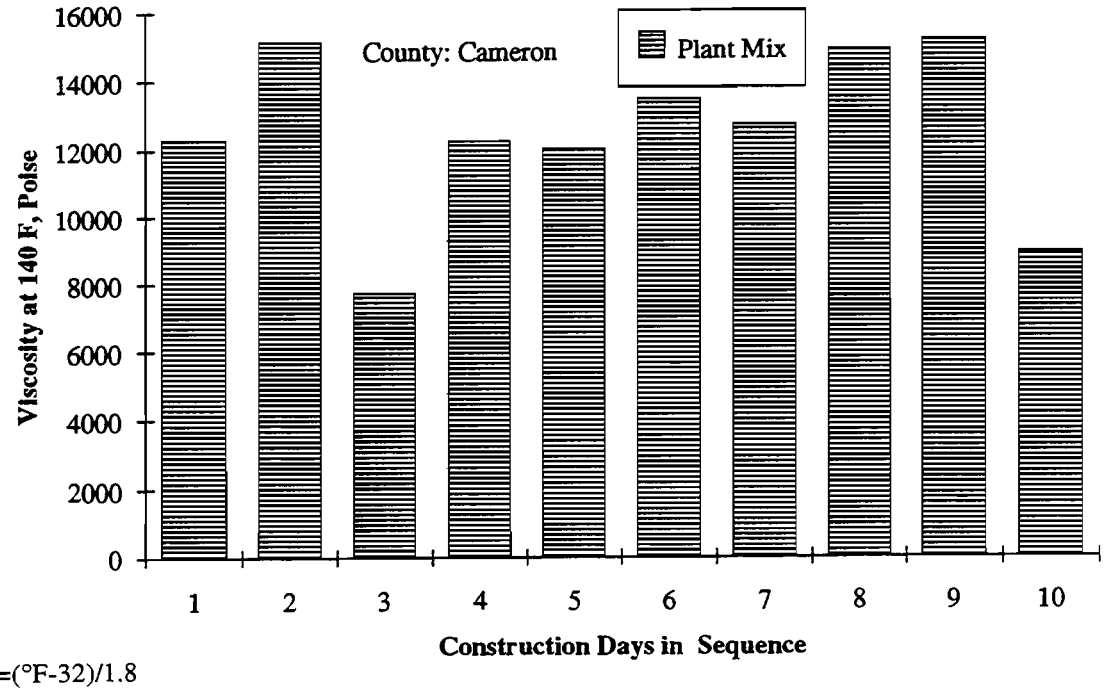
°F=(°F-32)/1.8

Figure E.6. Daily Viscosities for the Project in Gregg County.



°F=(°F-32)/1.8

Figure E.7. Daily Penetrations for the Project in Cameron County.



°F=(°F-32)/1.8

Figure E.8. Daily Viscosities for the Project in Cameron County.

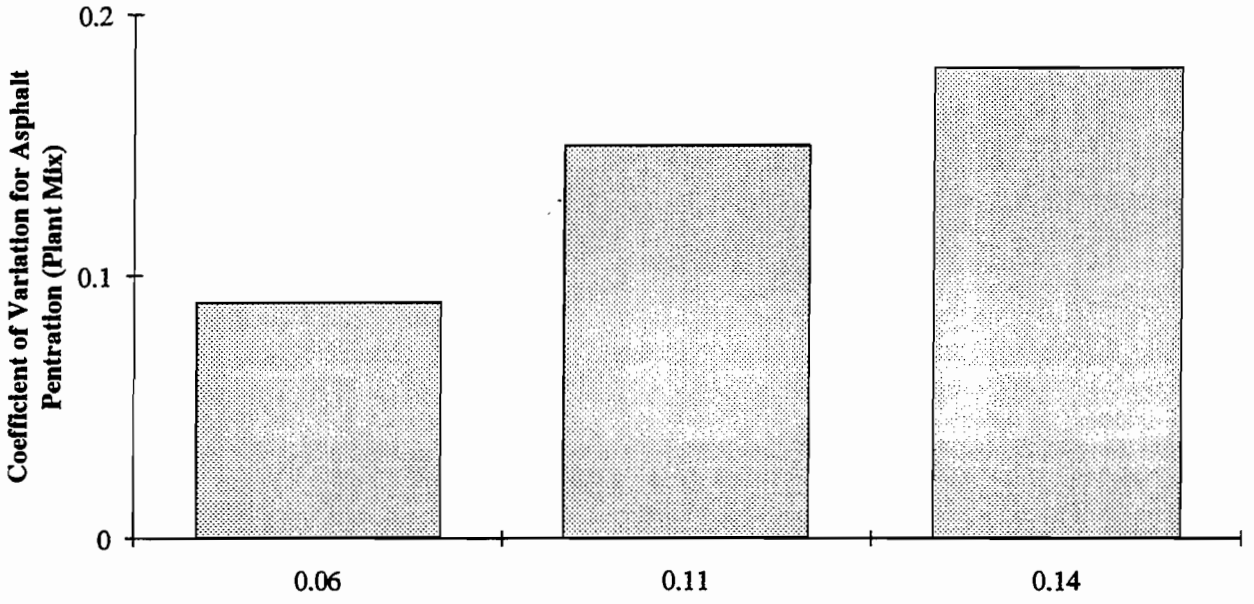


Figure E.9. Variability of Mix Asphalt Penetration versus that of the RAP.