Louisiana Transportation Research Center

Technical Assistance Report 19-01 TA-B

Variability of In-Line RAP Crushing vs. Pre-Screened Stockpiles

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TECHNICAL REPORT STANDARD PAGE

1. Title and Subtitle
Variability of In-Line RAP Crushing vs. Pre-Screened RAP Stockpiles

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4. Sponsoring Agency Name and Address
Louisiana Department of Transportation and Development
P.O. Box 94245
Baton Rouge, LA 70804-9245

5. Report No.
FHWA/LA.17/19-01TA-B

6. Report Date
November 2019

7. Performing Organization Code
LTRC Project Number: 19-01TA-B

8. Type of Report and Period Covered
Technical Assistance Final Report
8/19-10/19

9. No. of Pages
17

10. Supplementary Notes
Conducted in Cooperation with the U.S. Department of Transportation, Federal Highway Administration

11. Distribution Statement

12. Key Words
Reclaimed Asphalt Pavement; RAP; Variability; Properties

13. Abstract
The Louisiana Department of Transportation and Development (DOTD) allows contractors to utilize RAP in various asphalt mixtures throughout the state. The standard specifications for roads and bridges added the following statement regarding the storing of RAP, “Keep reclaimed asphalt pavement separate from other materials at the plant in such a manner that will allow for Department inspection and acceptance. Keep stockpiles uniform and free of soil, debris, foreign matter and other contaminants. Screen or crush RAP, prior to use, to pass a 1-inch sieve.” The wording of this statement has led contractors to stockpile RAP in two different manners; contractors crush and screen the RAP prior to stockpiling, or they store the RAP then crush and screen it on the cold feed line. LTRC was requested to evaluate the variability of RAP properties with respect to these storage methods.

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Introduction

When an asphalt roadway undergoes rehabilitation or reconstruction, the old pavement may be reclaimed for use in hot mix asphalt production. This material, commonly referred to as Reclaimed Asphalt Pavement (RAP), is one of the most recycled materials in the United States. DOTD's *Standard Specifications for Roads and Bridges* allows RAP to be used, but contractors must screen or crush RAP to pass a 1-inch sieve prior to use. Asphalt contractors meet this criterion via two different methods. They crush and screen the RAP prior to stockpiling or they store the RAP then crush and screen it on the cold feed line. LTRC personnel has obtained a RAP sample from two different asphalt contractors; Diamond B Construction crushes its RAP to size prior to stockpiling it, and Prairie Contractors stockpiles uncrushed RAP and crushes it down to size with an in-line crusher on the cold feed line. Testing and analysis of these samples was used to determine if these varying methods of storing the RAP has an influence on its properties.

Objective

The objective of this technical assistance was to evaluate the variability in RAP that is crushed and screened prior to being stockpiled versus the variability in RAP that is crushed and screened on the cold feed line.

Scope

LTRC personnel obtained a total of two RAP samples from two contractors. The samples were transferred to the LTRC asphalt laboratory and split in to three replicates from each source. Qualified technicians then ran a variety of asphalt mixture tests, which included the following:

- Standard Method of Test for Mechanical Analysis of Extracted Aggregate (AASHTO T 30)
- Standard Method of Test for Specific Gravity and Absorption of Fine Aggregate (AASHTO T 84)
- Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate (AASHTO T 85)
- Standard Method of Test for Theoretical Maximum Specific Gravity (ASHTO T 209)
- Standard Method of Test for Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method (AASHTO T 308)
- Standard Test Method for Automated Extraction of Asphalt Binder from Asphalt Mixtures (ASTM D8159)

Methodology

A suite of tests was conducted to determine the level of variance in the RAP samples.

- Sieve analysis of Fine and Coarse Aggregates, AASHTO T 30, was used to compare the gradations of the two RAP samples.
- Standard Method of Test for Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method, AASHTO T 308, was used to determine the asphalt binder content of the RAP samples.
- Standard Test Method for Automated Extraction of Asphalt Binder from Asphalt Mixtures (ASTM D8159) was performed to calculate the asphalt binder content.
- Mixture Maximum Specific Gravity (G_{mm}) was determined according to AASHTO T 209. Specific Gravity and Absorption of Fine & Coarse Aggregate (G_{sb}) was determined according to AASHTO T 84 and AASHTO T 85. The variability of the aforementioned properties was compared using the standard deviation of the three replicates tested.

Discussion of Results

Sieve Analysis of Fine and Coarse Aggregates

Prior to sieve analysis, an infraTest asphalt analyzer (ASTM D8159) was used to extract the asphalt binder from the aggregate for each of the RAP samples. In addition to the infraTest extractions, the Ignition Method (AASHTO T 308) for extraction was also conducted on each of the RAP samples.

After extraction, a sieve analysis was conducted in accordance with AASHTO T 30. The sieve analysis results for the In-Line RAP samples are shown in Figure 1 and results for the Pre-Screened RAP samples are shown in Figure 2. The gradation results from the infraTest asphalt analyzer samples are labelled 'Extraction' while results from the Ignition method are labelled 'Burn.'

Figure 1 displays the average percent passing for the burn and extracted In-Line RAP samples. The chart shows that the two samples are similarly graded.

Figure 1. In-Line RAP Gradation

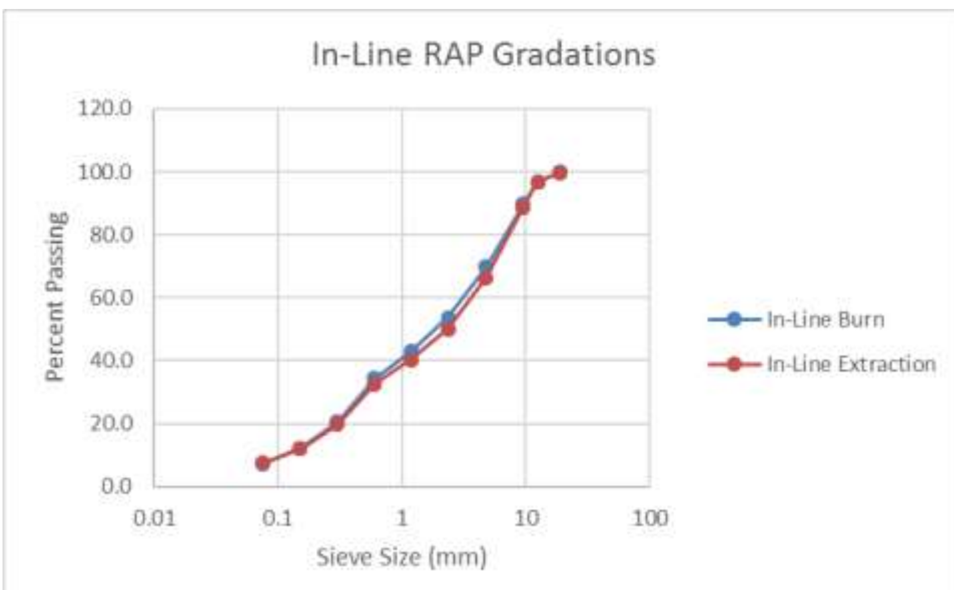
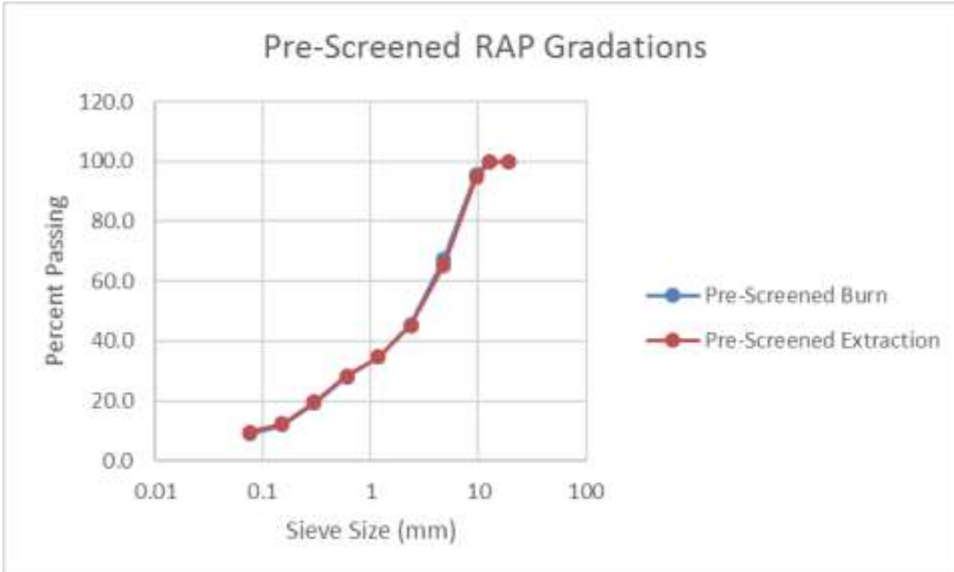


Figure 2 displays the average percent passing for the burn and extracted Pre-Screened RAP samples. The chart shows that the two samples are similarly graded.

Figure 2. Pre-Screened RAP Gradation



The standard deviation of the three test samples was determined for each sieve size to determine if there was significant variability. The standard deviations can be seen in Table 1 below and the coefficient of variance is reported in Table 2. It can be seen that the In-Line resulted in a lower average variability for the gradations. It should also be noted that the extracted Pre-Screened sample had higher standard deviations on sieve sizes 2.36 mm and 1.18 mm; these deviations fall outside of the ±3 and ±2 tolerance allowed in the asphalt specifications. Additionally, the coefficient of variance is lower for the In-Line data.

Table 1. Standard Deviation of Percent Passing

Mixture	Method	Sieve Opening (mm)										
		19	12.5	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075	Avg
Burn	**In-Line**	0.00	0.75	1.07	0.72	0.71	0.66	0.51	0.21	0.12	0.17	0.49
	Pre-Screened	0.00	0.21	0.71	1.66	1.61	1.25	0.93	0.51	0.25	0.17	0.73
Extraction	**In-Line**	0.40	0.98	1.24	1.42	0.81	0.49	0.44	0.35	0.23	0.18	0.65
	Pre-Screened	0.00	0.17	0.87	2.76	3.36	2.77	1.59	0.81	0.44	0.35	1.31

Table 2. Coefficient of Variance of Percent Passing

Mixture	Method	Sieve Opening (mm)										
		19	**12.5**	**9.5**	**4.75**	**2.36**	**1.18**	**0.6**	**0.3**	**0.15**	**0.075**	**Avg**
Burn	**In-Line**	0.00	0.78	1.19	1.03	1.32	1.52	1.49	1.01	0.94	2.44	1.17
	Pre-Screened	0.00	0.21	0.74	2.47	3.52	3.60	3.32	2.67	2.09	1.95	2.06
Extraction	**In-Line**	0.41	1.02	1.40	2.14	1.62	1.23	1.34	1.76	1.92	2.33	1.52
	Pre-Screened	0.00	0.17	0.91	4.23	7.46	8.01	5.58	4.11	3.49	3.61	3.76

Quantitative Extraction of Asphalt Binder from HMA

The asphalt binder content (%AC) was determined according to AASHTO T 308 in addition to ASTM D8159. The results are presented in Table 3 below. The standard deviation for both Pre-Screened samples is higher than AASHTO allowable standard deviation of 0.069. The standard deviation for the burned In-Line sample is within the AASHTO limit, while the extracted In-Line sample is slightly above the allowed tolerance. Additionally, the In-Line coefficient of variance is lower than the Pre-Screened for each method of asphalt extraction.

Table 3. Asphalt Content of RAP Samples

Mixture	Method	Specimen	%AC
Burn	**In-Line**	**1**	**7.63**
		2	**7.62**
		3	**7.60**
		Avg	**7.62**
		Stdev	**0.02**
		CV (%)	**0.20**
	Pre-Screened	**1**	**5.78**
		2	**5.96**
		3	**5.91**
		Avg	**5.88**

Mixture	Method	Specimen	%AC
		Stdev	**0.09**
		CV (%)	**1.58**
Extraction	In-Line	**1**	**5.21**
		2	**5.15**
		3	**5.29**
		Avg	**5.22**
		Stdev	**0.07**
		CV (%)	**1.35**
	Pre-Screened	**1**	**4.93**
		2	**5.16**
		3	**4.92**
		Avg	**5.00**
		Stdev	**0.14**
		CV (%)	**2.71**

Theoretical Maximum Specific Gravity (G_{mm})

The Maximum Specific Gravity was determined for each sample set according to AASHTO T 209. The results can be seen in Table 4 below. The pre-screened sample set has a lower standard deviation and coefficient of variance; however, the standard deviation for both sample sets is below the limit of 0.0051 allowed by AASTHO.

Table 4. Maximum Specific Gravity Results

Mixture	1	2	3	Avg	Stdev	CV (%)
In-Line	2.436	2.433	2.431	2.433	0.003	0.10
Pre-Screened	2.412	2.411	2.413	2.412	0.001	0.04

Bulk Specific Gravity (G_{sb})

The Bulk Specific Gravity for the fine and coarse aggregates was determined according to AASHTO T 84 and T 85. The results can be seen in Table 5 below. The standard deviation for the In-Line set is lower than Pre-Screened set. The standard deviation for the coarse sample set and the fine In-Line sample is below the limit of 0.011 allowed by AASTHO. The In-Line data also has a lower coefficient of variance for each aggregate type.

Table 5. Bulk Specific Gravity Results

Agg. Type	Mixture	1	2	3	Avg	Stdev	CV (%)
Coarse	In-Line	2.485	2.489	2.495	2.490	0.005	0.20
	Pre-Screened	2.449	2.455	2.435	2.446	0.010	0.42
Fine	In-Line	2.508	2.519	2.512	2.513	0.006	0.23
	Pre-Screened	2.474	2.472	2.441	2.463	0.018	0.75

Conclusions

Two RAP samples were obtained to determine if crushing and pre-screening prior to storage or crushing RAP with an in-line crusher has an influence on its properties. Based on the findings LTRC has determined the following:

- Sieve analysis showed that the In-Line crushed RAP gradations had lower standard deviations than the pre-screened RAP gradations. The extracted Pre-Screened standard deviation for sieve sizes 2.36 mm and 1.18 mm were outside of the tolerance allowed in the asphalt specifications.
- The standard deviation of the asphalt content for the burn and extraction In-Line crushed samples was lower than that of the pre-screened samples. The standard deviation was above the limit allowed by AASHTO for all samples except the burned In-Line sample.
- The standard deviation of the maximum specific gravity was lower for the pre-screened samples. The standard deviation for both sample sets was below the AASHTO limit.
- The standard deviation of the bulk specific gravity was lower for the In-Line samples for both the coarse and fine aggregate types. The standard deviation of the fine aggregate Pre-Screened sample was above the AASHTO tolerance.

Recommendations

Based on the findings, LTRC does not recommend changes be made to the specification to require or disallow either methodology.

This public document is published at a total cost of $250
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