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ADVANCED CHARACTERIZATION OF ASPHALT AND CONCRETE MATERIALS

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Preface

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This Geotechnical Special Publication contains 18 peer-reviewed papers that showcase recent developments and advancements in geotechnical and pavement engineering and that offer insights into future directions for geoengineering in the 21st century. Topics include: recycled asphalt and concrete pavements, warm mix asphalt, asphalt shingles, advanced hot mix asphalt, cement paste and concrete materials characterization.

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Mix Design for Full-Depth Reclaimed Asphalt Pavement with Cement as Stabilizer

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ABSTRACT: A rational rehabilitation design should base on the understanding and knowledge of the existing pavement distress/condition. The purpose of this research was to investigate the effects of reclaimed asphalt pavement (RAP) content and cement content on the strength of Full-Depth Reclamation (FDR) base. FDR for asphalt pavement with cement as the stabilizer was used as the base course. The full-factorial experimental design included: (1) five RAP contents, and (2) five cement contents. To ensure the reproducibility, there were three replicates for each specimen. The 7 days unconfined compressive strength (UCS) was used as the control parameters. The five RAP contents consisted of 0%, 25%, 50%, 75% and 100%. The five cement blending content included 0.5%, 1.0%, 1.5%, 2.0% and 2.5%. The test results indicate that the optimum design was 50% RAP and 2% cement.

KEYWORDS: Cement Stabilization; Full-depth Reclamation; Reclaimed Asphalt Pavement; Unconfined Compressive Strength; Factorial Analysis

INTRODUCTION

Given the necessity of preserving natural resources, HeBei Province of P. R. China, has utilized Full-Depth Reclamation (FDR), with different stabilizers, to rehab thousands of miles of deteriorated streets and roads. The following sections describe the research procedures associated with Full-Depth Reclamation (FDR) with cement as the stabilizer.

When asphalt surface layer and base course of the streets and roads are both seriously damaged/ deteriorated, FDR is one of the best rehabilitation strategies. The main objective of this study was to determine the optimum reclaimed asphalt pavement (RAP) and cement content. The primary tasks in this study included:

- According to particle size, RAP was divided into two classes: 10-30mm and 0-10mm. The Reclaimed Base Course Pavement (RBP) was divided into three classes: 0-5mm, 5-15mm and 15-30mm.
- The specimens were prepared with five different RAP contents (0%, 25%, 50%, 75% and 100%) and five different cement contents (0.5%, 1.0%, 1.5%, 2.0% and 2.5%).
- 7-day Unconfined Compressive Strength (UCS) was used as the evaluation criterion
- The factorial data analysis was carried out using the SPSS software.

MATERIALS CHARACTERIZATION

RAP and RBP were obtained from Shi-Huang highway renovation project. 10-25mm mineral raw gravels need to add to regenerative material, because the mechanical force made the pavement materials fragmentation in the milling planer process. So as to achieve good gradation, 0-5mm mineral finer should be blended with the RAP and RBP.

Testing RAP

At least 8 times of mixture samples were brought to laboratory. After drying the materials, the gradation results are presented in Table 1 and the gradation curve is shown in figure1.

The gradation results for RAP and RBP suggest that additional fine materials need to be added to meet gradation requirements.

Table1 Gradation Results for Recycled Road Material

Item	percentage passing sieve size（%）							
	31.5	26.5	19	9.5	4.75	2.36	0.6	0.075
RAP	100	98.8	94.6	73.8	45.4	18.5	6.4	1.3
RBP	100	95.9	91.2	64.3	39.7	25.9	11.3	3.7
grading limit for base	100	90-100	72-89	47-67	29-49	17-35	8-22	0-7

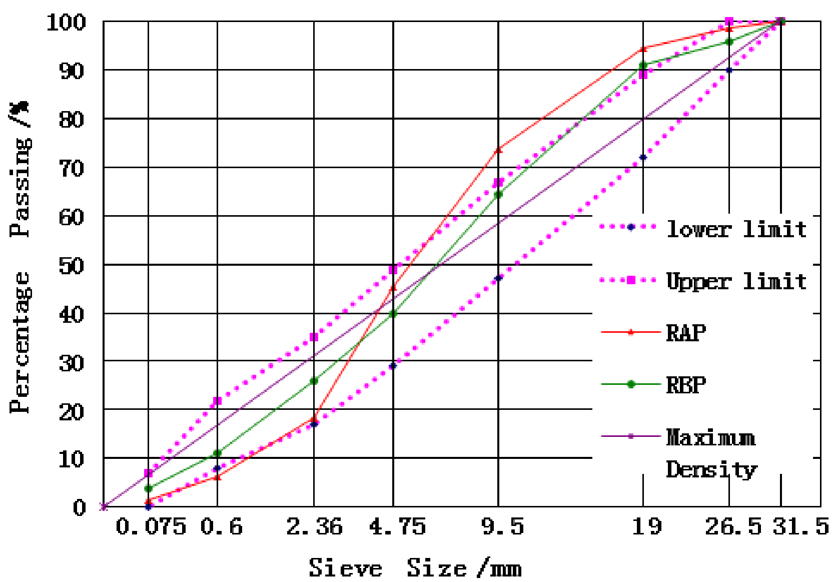

Figure 1 Gradation Curve for Recycled Materials

The asphalt extraction results from RAP are given as follows:

- asphalt-aggregate ratio 4.02%,
- penetration 3.2mm,
- ductility 92mm at 15℃,

- softening point at 62℃,
- viscosity 3421pa·s at 60℃.

The results indicated that reclaimed asphalt was significantly aged. It basically meets the technical requirements of 30# matrix asphalt. The effective calcium oxide and magnesium oxide content of RBP was 3.0%. EDTA titration method to determine the lime dose was close to zero. Crushing value of RBP was 13.4% and the apparent relative density was 2.69 g/cm^3.

Testing Cement

BoHai "god lion" brand cement used in this study was tested. Table 2 shows the engineering index test result. Relative indicators met the specification requirements.

Table 2 Engineering Index Test Results for Cement

Grade of Cement	Fineness/%	Standard Consistency	Setting Time （min）		28d-Compressive Strength /Mpa	28d-Flexural Strength /Mpa	Soundness
			Initial Setting	Final Setting			
P·S32.5	1.1	29.4	327	486	37.5	6.7	Conformity

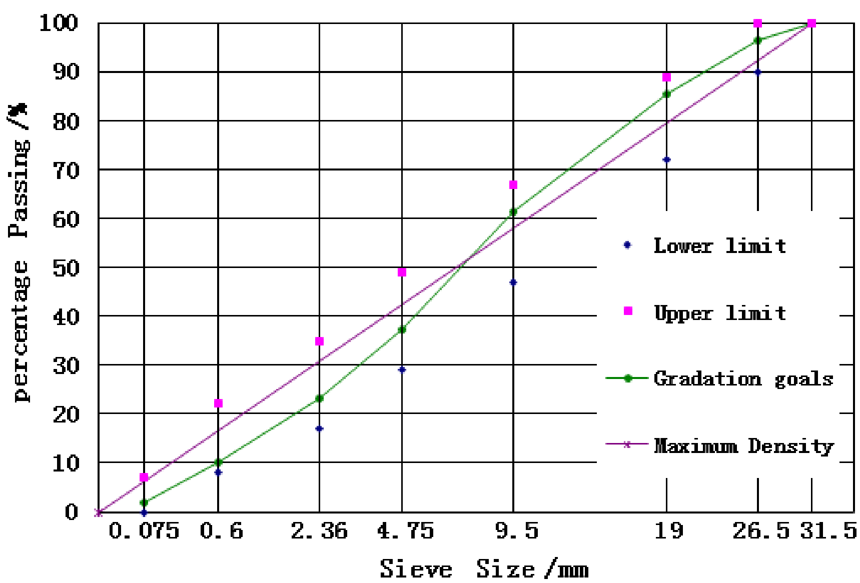

Figure 2 the Blending Target Curve with Regenerated Mixture

METHODOLOGY

The FDR methodology for combination of RAP and RBP using cement as stabilizer is presented. The design target proportions for RAP and RBP were selected as: (1) RAP blending proportion 0%, 25%, 50%, 75%, and 100%, and (2) RBP blending proportion 100%, 75%, 50%, 25%, and 0%. The five cement blending contents are 0.5%, 1.0%, 1.5%, 2.0%, and 2.5%. The optimum moisture content and maximum dry density were determined according to the conventional compaction test.

Mix design

According to "Technical Specifications for Construction of Highway Road Base", designing cold mix recycled mixture with cement stabilization (CTB-25) specified gradation limits. Figure 2 shows the gradation curve.

Determine the maximum dry density (MDD) and optimum water content (OWC)

Construction of cold mix recycled mixture with cement stabilization need the right amount of water, which ensure the workability for the mixture, but excessive moisture will have negative effects on mixture performance. Conventional compaction test was used to determine the MDD and OWC. In the testing process, cement content was set at a constant value of 2.0%, while moisture content varying from 4.0%, 5.0%, 5.5%, 6.0%, 6.5%, to 7.0%. Test results are shown in Table 3. From quadratic fitting curve of dry density and water content, maximum dry density and optimum water content were obtained.

Table 3 Optimum Water Content and Maximum Dry Density for Mixture with Various Blending Ratio

RAP proportion	RBP proportion	Optimum water content %	Maximum dry density g/cm^3
0	100	6.6	2.171
25	75	6.4	2.129
50	50	6.1	2.115
75	25	5.6	2.111
100	0	5.6	2.078

The effects of RAP content on MDD and OWC is presented in Figure 3. It indicates that with increasing RAP blending content, there was a MDD and OWC decline trend. When the RAP blending content is more than 75%, there is a reduced changing trend of OWC. When the RAP blending content is between 25% and 75%, changing trend of maximum dry density is mild. This phenomenon can be explained that thin film of asphalt wrapped in the aggregate surface makes the aggregate surface in the closed states. When RAP and mineral aggregate have equal volume, the density of RAP is lower than mineral aggregate. That is to say the compacted dry density of RAP is lower, for the effect by asphalt thin film.

7-Day unconfined compressive strength

The specimens prepared for UCS testing were compacted in a steel mold. Following compaction, the UCS specimens were then extruded from the mold. After extrusion, all specimens were placed in a moisture curing room, where they were subjected to more than 95 percent relative humidity for a 7-day curing period. The 7-day unconfined compressive strength value of 2.068 to 2.758 Mpa is recommended by Portland Cement Association. Figure 4 represents the drawing of UCS sample mean.

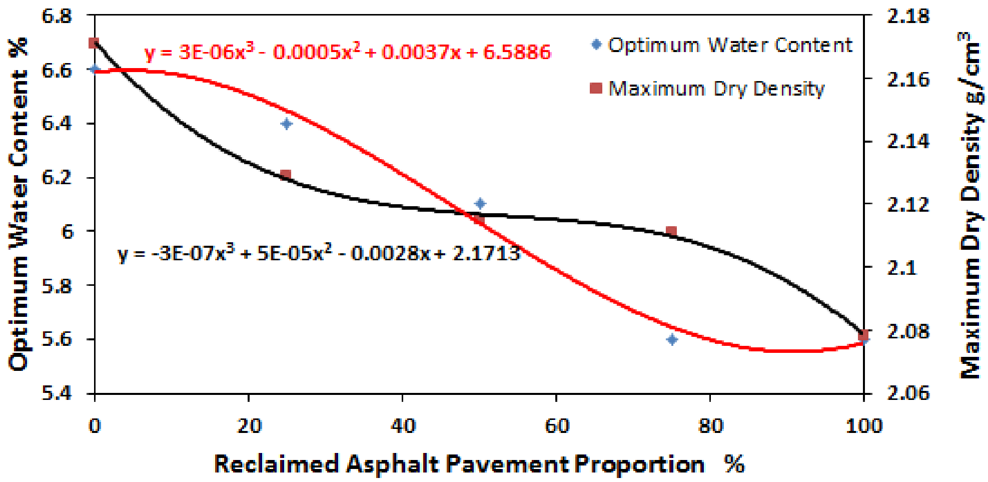

Figure 3 Dosage of RAP Effect on the Optimum Water Content and the Maximum Dry Density

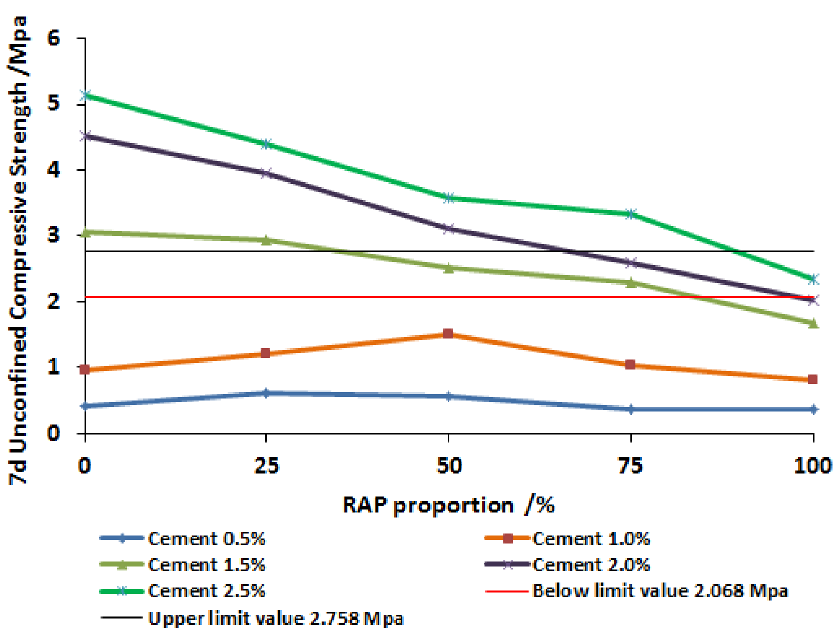

Figure 4 Interactions between RAP Content and Cement Content for UCS