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Effect of Different Mineral Filler Ratios on Viscosity in Slurry Seal Mixtures

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Abstract: Slurry seal and Microsurfacing are two of the most significant applications of pavement preservation methods on highway surfaces. The slurry seal mixtures consist of aggregate, bitumen emulsion, water, mineral filler (cement etc.), and some additives. The appropriate amounts of these materials play an important role in viscosity. In this study, laboratory research was performed to understand the viscosity changing in slurry seal samples according to Standard Test Method for Viscosity Determination of Asphalt (ASTM D 4402-15 2015), which is usually used in determining the bitumen properties. Considering the first 1 hour period, the viscosity values of the samples with 1%, 2%, and 3% cement additions are approximately 9 Pa.s, 18 Pa.s, and 38 Pa.s, respectively. Also, the results indicate that the slurry seal samples prepared with different mineral filler ratio have different viscosity values in the long term.

Harç Tipi Kaplamalardaki Farklı Mineral Filler Oranlarının Viskozite Üzerine Etkisi

Anahtar Kelimeler
Harç Tipi Kaplama,
Mikro yüzeyleme,
Viskozite

Öz: Harç tipi kaplamalar, yol kaplama yüzeylerinde kullanılan koruma yöntemlerinin en önemli uygulamalarından biridir. Harç tipi kaplamalar, agrega, bitüm emülsiyonu, su, mineral filler (çimento vb.) ve bazı katkı malzemelerinden oluşur. Bu malzemelerin oranları viskozite parametresinde önemli bir rol oynar. Bu çalışmada, normalde bitümün özellikleri için kullanılan Standard Test Method for Viscosity Determination of Asphalt (ASTM D 4402-15 2015) yöntemi kullanılarak harç tipi kaplama numunelerindeki viskozite değişimi üzerine laboratuvar araştırması yapılmıştır. İlk 1 saatlik periyot dikkate alındığında %1, %2 ve %3 çimento katkılı numunelerin viskozite değerleri sırasıyla yaklaşık 9 Pa.s, 18 Pa.s ve 38 Pa.s'dir. Ayrıca sonuçlar, farklı filler oranları ile hazırlanan harç tipi kaplama numunelerinin uzun vadede farklı viskozite değerlerine sahip olduğunu göstermektedir.

1. Introduction

Slurry seal is one of the rehabilitation methods for road pavement surfaces. The mixture of slurry consists of well-proportioned fine aggregate, water, mineral filler, and emulsified asphalt. The appropriate dosage forms a creamy, homogeneous, and liquid mixture that can be applied in thin layers. Due to its fluidity, it can penetrate cracks and cavities [1]. Since the 1950s, slurry seals have been used in the prevention and maintenance of pavement surfaces preventing surface deterioration caused by oxidation of asphalt, loss of matrix and abrasion at room temperature, slurry seals are applied to the existing asphalt surface at a thickness of fewer than 10 millimeters. When the slurry seal is applied to the existing road surface, water in emulsion evaporates and a form of a thin and dense grade of the bituminous mixture remain. The water evaporates over time, leaving behind a structure whose surface properties are similar to those of hot asphalt concrete (HMA). Generally, slurry seals are applied to low-traffic

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roads while microsurfacing was developed as a "high performance" slurry seal that can be applied in multilayers, filling ruts and improving the surface properties of a high traffic volume. The combination of high-quality materials such as cationic emulsions modified with polymers, innovated emulsifiers, and well-graded fine aggregates play an important role in micro-surfacing [2-15].

To design a good structure of slurry seal, the combination of the materials must be selected properly. If there is too much water, a segregation problem will occur. Also, an excess amount of water will result in a low-quality transverse joint [16]. Moreover, the aggregate physical characteristics play an important role in slurry seal performance. For this reason, the origin of aggregate, shape, texture, age and reactivity, cleanliness, soundness, and abrasion resistance must be controlled before application. Also, the quality and quantity of the aggregate are critical since aggregate constitutes approximately 94% by weight of the slurry mixture. The aggregate should be a crushed stone such as basalt, steel slag, high-quality limestone. In addition, the aggregate must be 100% crushed and be densely graded to meet the requirements of one of the gradations of specifications. This aggregate gradation is used to fill surface voids, address surface distresses, seal, and provide a durable wearing surface. In general, in the production of slurry seal, Conventional Portland cement is used as mineral filler [17]. The focus of this study was to investigate the viscosity characteristics of slurry seal mixtures manufactured with different amounts of portland cement. Moreover, in this study, the rotational viscometer, which is originally used to determine the properties of bitumen, was used to determine the properties of slurry seal mixtures.

2. Materials

To produce the samples, different types of materials were used. These materials are suitable materials that are also widely used in slurry seal production. In this section, the materials used for slurry seal samples were described.

2.1. Aggregates

In this study, basalt aggregates received from Tuzhisar quarry in Kayseri, Turkey were used. The general fraction of the aggregates in the quarry was 0-5 mm and 5-9.5 mm. Aggregates were washed using #200 sieve (0.075 mm) and divided into various fractions to arrange slurry seal gradation. In addition, portland cement was used as filler in the mixture. The properties of aggregates are shown in Table 1.

Table 1. Physical Properties of Aggregates.

Test	Requirements	Filler	Fine Aggregate	Course Aggregate	Standard
Bulk Specific Gravity (g/cm^3)			2.738	2.775	ASTM C 854
Apparent Specific Gravity (g/cm^3)		2.750	2.850	2.856	ASTM C 854
Water Absorption (%)			1.43	1.04	
Los Angeles Abrasion Test (%)	≤30		14.02	14.02	AASHTO T - 96
Na_2SO_4 Sulfate Soundness Test (%)	≤14		0.02		ASTM C - 88

2.2. Water and Emulsion

Slurry seals consist of aggregates, mineral fillers, water, and emulsion. In this study, tap water and C65B9-4 type emulsion were used. Properties of emulsion are shown in Table 2.

Table 2. Physical Properties of Emulsion.

Properties		Standard
Saybolt Furol sec. viscosity @ 25°C	24	ASTM D 7496
Residual Asphalt Content (%)	65	ASTM D 7497
Emulsion Type	Cationic	
Bitumen Penetration Grade	B 70/100	ASTM D5
pH Value	2.5	

3. Experimental Program

In order to analyze the viscosity characteristics of slurry seal mixtures, a rotational viscosity test (ASTM D 4402-15 2015) was conducted.

3.1 Viscosity Test

The rotational viscosity test aims to determine the torque effect of the selected spindle inside the liquid materials [18]. The results of torque values give information about the consistency and fluidity characteristics of the tested material. If the consistency of the material is high and flowing, the viscosity value is low. The rotational viscosity test is used in many sectors. In the highway sector, it is generally used to determine the viscosity of the bitumen material under the influence of temperature change. In this study, time-dependent viscosity changes of the cement added aggregate mixtures of slurry samples were investigated at room temperature. The viscosity values were recorded every minute by testing with spindle number 07 at 10 rpm speed. Figure 1 shows a picture of slurry during the viscosity test.

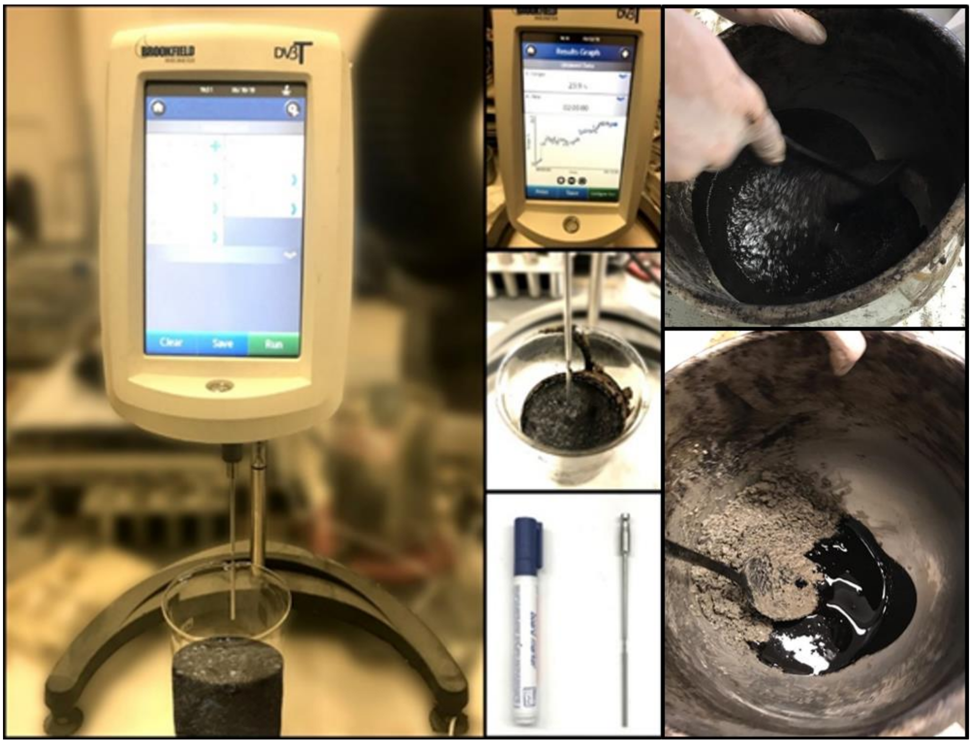

Figure 1. Sample preparation and viscosity test.

3.2 Mix Design

For slurry seal samples fabrication, the average of the lower and upper limits of the Type II gradation was used. The gradation curve of Type II according to the Turkish General Directorate of Highways was considered in determining the aggregate gradation. The selected aggregate gradation curve of the slurry seal mixtures is shown in Figure 2. The emulsion ratio and water ratio were selected as 17 % and 12 % respectively considering the suggested limits of ISSA A105. The combinations with aggregate type, aggregate gradation, emulsion, and water ratio are the same but the cement ratio varying between 1%, 2%, and 3% is used. Samples were kept at room temperature in a closed drawer to be removed from the effects of wind and temperature, and the results were compared by examining the cure changes depending on the time.

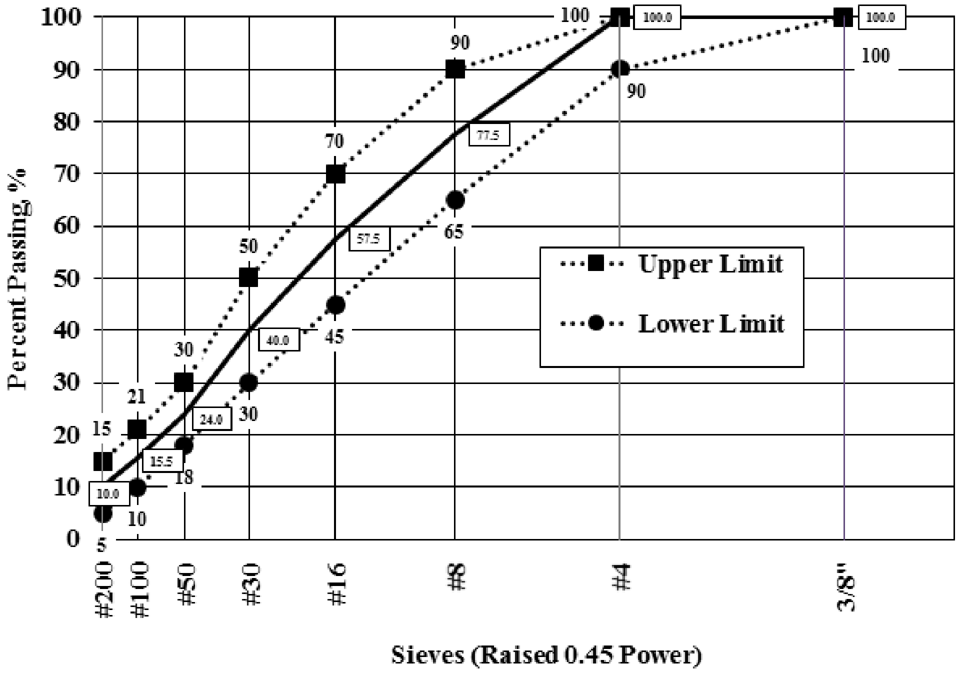

Figure 2. Slurry Seal Type II Design Limits and Gradation Curve

3.3 Viscosity Test Results

The results of rotational viscosity values of the samples with 1%, 2%, and 3% of cement additives can be seen in Figure 3. The test was conducted on the samples containing aggregates, emulsion, water and mineral filler. Due to the structure of the mixtures, during the rotation, sometimes the viscosity values may increase or decrease rapidly. This is because of the possible contact of the spindle of the device with large-size aggregates during its rotation. Therefore, the results were interpreted from a larger perspective rather than focusing on the results from a narrower perspective. Consequently, in general, the viscosity results increase as the amount of filler increases.

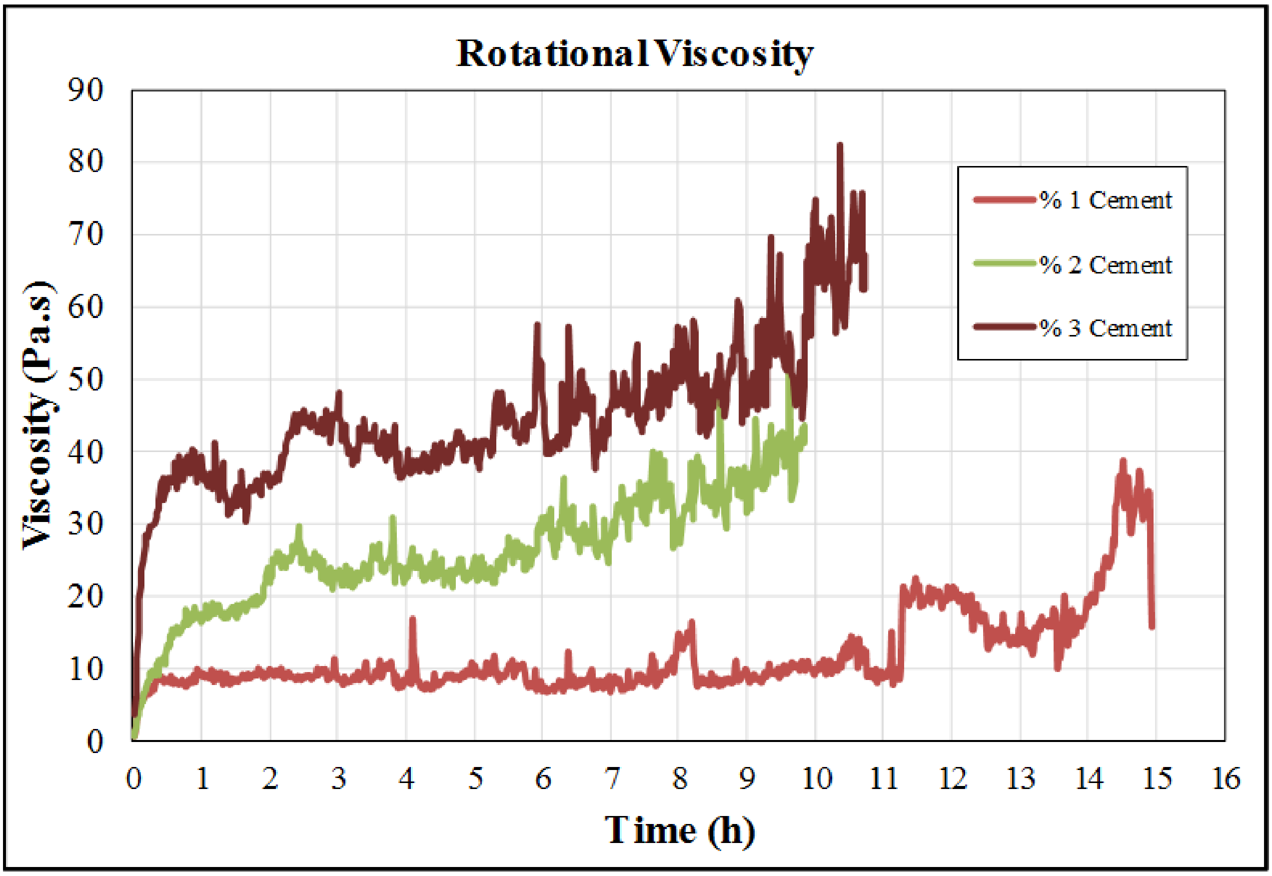

Figure 3. Viscosity test results of the slurry seal samples

Short-term viscosity values obtained from slurry seal samples differ within the first hour. While a rapid increase in the viscosity value of the 3% filler added sample is observed in a short time, this increase is slower in the samples with 2% and 1% filler added samples. Considering the first 1 hour period, the viscosity values of the samples with 1%, 2%, and 3% cement additions are approximately 9 Pa.s, 18 Pa.s, and 38 Pa.s, respectively. These values remain constant for a certain period of time and then increase again. Considering the periods, the viscosity values increase in the long term.

The reason why these results are different is that the cement added to the mixture as fillers react chemically with the water existing in the bitumen emulsion and harden the mixture. With the hardening, the viscosity value of the mixture increases over time. When the viscosity values of the mixtures are examined at the same moment, it is seen that the mixtures with a higher cement ratio yield higher viscosity values.

4. Conclusion and Discussion

The consistency of slurry seals is one of the most significant properties and it plays a vital role in the performance of the slurry seal production. To develop a better application of slurry seals, the consistency characteristics must be examined at the design phase. A small change in the percentages of the materials or/and gradation may cause big problems, which can be difficult to fix. In this research, the consistency values of slurry seal mixtures, which contain different amounts of filler, were compared according to ASTM D 4402. The amount of filler has a direct effect on the viscosity values of the slurry seal. Especially in the first hour after the fabrication, a rapid increase in the viscosity value of the 3% filler added sample is observed. This increase is slower in the samples with 2% and 1% filler added samples. Considering the first 1 hour period, the viscosity values of the samples with 1%, 2%, and 3% cement additions are approximately 9 Pa.s, 18 Pa.s, and 38 Pa.s, respectively. Consequently, the different amounts of filler in the slurry seal mixtures yield different viscosity values. As the filler ratio increase, the higher viscosity values are observed at the same time of different mixtures. Therefore, the effect of filler in the slurry seal mixtures can be easily determined by considering the rotational viscometer test results.

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