# A Simple Approach for Modification of RAP Bitumen

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ABSTRACT: The present work is an attempt to explore a simple approach to reuse the stiff bitumen collected from reclaimed asphalt pavement (RAP) by mixing with conventional VG 10 and VG 30 bitumen, in suitable proportions to achieve the property similar to that of VG 40 bitumen, normally used now-a-days in bituminous mixes. Based on the penetration test the optimum composition of the modified blend was observed when 70 % VG 30 bitumen and 60 % VG 10 bitumen, each by weight of the blend was added to the RAP bitumen. The blends, thus developed were evaluated based on conventional tests as well as rheological properties. The results of the softening point, viscosity and SHRP grade determination tests for the modified blends were also found to match well with respect to the target VG 40 bitumen normally used in bituminous paving mixes.

## 1 INTRODUCTION

A number of works have been taken up in recent years for using reclaimed asphalt pavement material (RAP) collected from old or damaged bituminous pavements. This approach has been encouraged for the purpose of reuse, recycle, resource conservation and moreover achieving economy in pavement construction. Some agencies use RAP in sub-base and base course and many utilize the same in bituminous layers. The bitumen present in RAP obtained from an old bituminous layer normally appears to be dry or stiff because the same has already been subjected to long term aging (oxidation being a main cause) during the service period of a pavement. As a result, the bitumen becomes hard with an increase in its viscosity, making the bituminous mix stiff. In order to make it suitable for reuse in fresh bituminous layers, either some fresh bitumen and/or other materials, including rejuvenating agents are added to the RAP material to compensate the deficient and unsuitable bitumen in the bituminous mix.

The main objectives of the present study are as follows:

- Development of modified bitumen using RAP bitumen and fresh bitumen for achieving required consistency
- Evaluation of resultant modified bitumen in terms of conventional and rheological characteristics

## 2 BRIEF BACKGROUND LITERATURE

A number of literature related to RAP are available. However, a few important literature related to binder development are given in this paper. Corbett (1970) reported that the stiffness and strength of bitumen are related to asphaltins and resins while the viscous properties are related to aromatics and saturates. He mentioned that the property and rheology of materials depends on all fractions which change with time due to oxidation, volatilization and weathering. McDaniels et al. (2010) and Masad et al. (2006) made attempts to evaluate solvent and extraction process of bitumen from existing RAP materials. Cipione et al. (1991) concluded that bitumen from RAP can be blended appreciably with fresh bitumen. Copeland (2009) observed that the properties of fresh bitumen get altered by addition of RAP bitumen, which influences the resultant mix properties in terms of rutting, fatigue and moisture damage.

From the above review of literature the authors have been motivated to use RAP collected locally, recover bitumen from the RAP, and add fresh bitumen suitably to the RAP bitumen in order achieve the desired properties, conventional as well as rheological properties.

## 3 EXPERIMENTAL METHODOLOGY

### 3.1 *Materials used*

#### 3.1.1 *RAP Bitumen*

RAP which was dumped on a nearby road site was collected. Then, a centrifuge extractor was used to extract the bitumen from the RAP material as per ASTM D2172 with Trichloroethylene used as solvent to extract the bitumen. The bitumen content of the RAP material was found to be 4.2%. Residual bitumen of the RAP was recovered from the above solution as per ASTM D5404 specification.

#### 3.1.2 *Fresh bitumen*

Commonly used VG 10 and VG 30 bitumens were used to modify the stiff RAP bitumen. Bitumen VG 40 was considered to be the target binder as the same is being used commonly used in major road projects in India. In order to verify the properties of the modified blends developed, the physical and rheological properties of bitumen of different grades were determined.

### 3.2 *Procedure for modification of RAP bitumen*

Fresh bitumen and RAP bitumen were heated separately to an appropriate flowing consistency. Then required quantity of fresh hot bitumen of a particular grade was added to the preheated RAP bitumen and stirred manually at about 150-160°C in for about 5 minutes. The composition of the RAP bitumen and fresh bitumen in the mix varied from 50:50 to 10:90 respectively by weight. For comparison purposes VG 10 and VG 30 bitumens were separately used. Thus ten blends of modified bitumens were prepared, five each using VG 30 and VG 10 bitumens.

### 3.3 *Experimental works*

In order to understand the effects of addition of fresh bitumen to the recovered aged bitumen, the following basic physical and rheological characteristics were studied. In addition to the modified blends, four control bitumens i.e. normal VG 30, VG 10, recovered RAP bitumen and target VG 40 bitumen need to be tested for important physical and rheological properties. Each sample excluding RAP bitumen was subjected to short term aging by using rolling thin film oven (RTFO) at 163°C as per ASTM D 2872.

#### 3.3.1 *Penetration Test*

The penetration test was done as per IS 1203-1978. Once the desired composition of the blend was obtained, the designed blend was subjected to further tests.

#### 3.3.2 *Softening point Test*

The ring and ball softening point tests were conducted as per IS 1205-1978 for the said two developed blends and four control bitumens.

#### 3.3.3 *Viscosity Test*

The above binder samples were also tested for absolute viscosity at 60°C using capillary viscometer as per ASTM D 2171. The rotational viscometer was used as per ASTM D 4402 to determine the viscosities of these six blends at different temperatures, i.e. 120, 135, 150, 170, 190°C.

#### 3.3.4 *Rheological test*

Dynamic shear rheometer was used to evaluate the high temperature visco-elastic response of all such blends as per AASHTO T315-08. A temperature sweep of 46°C to 88°C at every 6°C increment was conducted at a frequency of 10 radians per second to determine the complex moduli and phase angles of the samples. The rutting parameter, i.e. $G^*/\sin\delta$ was obtained for both un-aged and RTFO aged samples. The temperatures at which $G^*/\sin\delta$ is 1 kPa and 2.2 kPa for unaged and RTFO aged samples respectively were found out from rutting parameter versus temperature curve. The minimum of these two values was considered as the upper performance grade of the sample.

## 4 RESULTS AND DISCUSSION

### 4.1 *Determination of optimum quantity of fresh bitumen*

To determine the optimum composition of the modified blend, it was considered to go for penetration test for each binder considered. The percentage of fresh bitumen required to be added to RAP bitumen were determined from the Penetration value- bitumen content relationships with respect to the penetration value of VG 40 bitumen. Total ten blends of modified bitumen and four control bitumens such as VG10, VG30, VG40 and RAP bitumen were tested for their penetration value. The results of the penetration tests of all such blends and virgin bitumens are presented in Figure 1, in the form of variation of the penetration value with the amount of fresh bitumen added to the RAP bitumen. It was observed that 70 % VG 30 and 60 % VG 10 addition to RAP bitumen almost matches the penetration value 46 dmm of the target VG 40 bitumen.

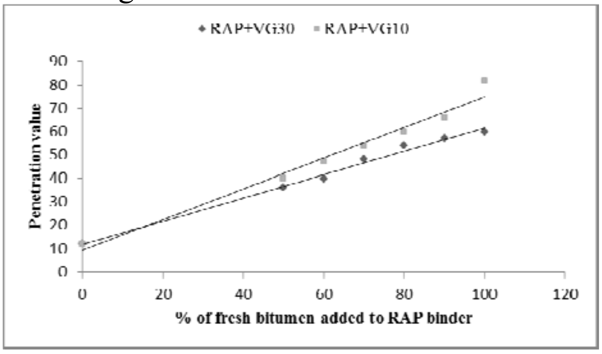


Figure 1. Variation of Penetration value bitumen content in modified blend

## 4.2 *Study of modified bitumen blends*

After achieving the optimum composition of the bitumen blends the study was focused on evaluation of the two modified blends obtained, and compared with the control bitumens considered in respect of some important conventional and rheological characteristics. The softening point test and absolute viscosity tests were conducted, the results of which are presented in Table 1. The softening point of RAP bitumen was found to be 70°C. It was observed that the softening point and absolute viscosity of both modified blends were found to be matching with the target VG 40 bitumen.

Table 1. Results of softening point and absolute viscosity of various binders

| Material | Softening point (°C) | Absolute viscosity at 60°C (Poise) |
|---|---|---|
| VG 10 | 42 | 1362 |
| VG30 | 47 | 2783 |
| VG 40 | 53 | 4076 |
| VG30+RAP | 53 | 4198 |
| VG10+RAP | 52 | 4125 |
| RAP | 70 | - |

The viscosities of bitumens and modified bitumen blends determined by using Rotational viscometer at different temperatures are presented in Figure 2. It was observed that at all test temperatures the viscosity of stiff RAP bitumen decreased considerably. It was observed that both the selected modified blends show similar results as that of the target VG 40 bitumen with respect to their viscosity values at various temperatures.

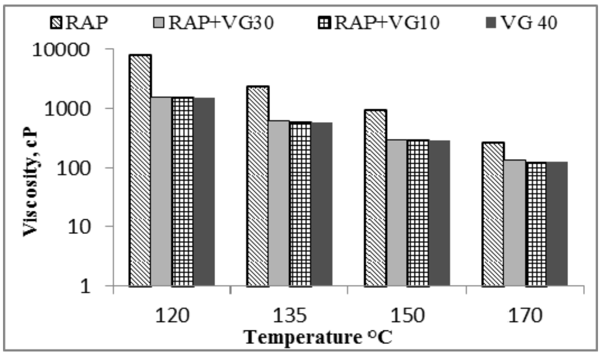


Figure 2. Viscosity values of different binders at various temperatures

## 4.3 *SHRP Grade determination test*

The SHRP grade determination test was performed for both modified blends and control bitumens for unaged as well as short term aging conditions. The results of this test in terms of the three rheological parameters at different temperatures for unaged binders are presented in figures 3 through 5. Similar trends were also observed for RTFO aged binders as shown in figures 6 through 8. It is seen that as usual the complex modulus increases and phase angle of conventional bitumen VG 30 and VG 10 decreases showing a better elastic response in the modified blend. The rheological parameters show similar results as that with VG 40 bitumen. The upper PG temperatures for unaged and short term aged bitumens were determined from the rutting parameter versus temperature relationships. The minimum of those values was considered as the upper PG temperatures, as presented in Table 2. Similar trends were observed for both selected bitumen blends and the target VG 40 bitumen.

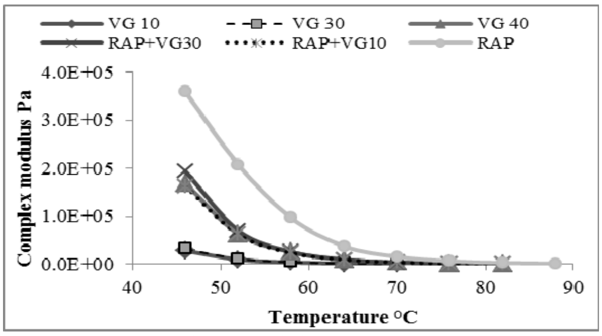


Figure 3. Complex modulus versus temperature for unaged binders

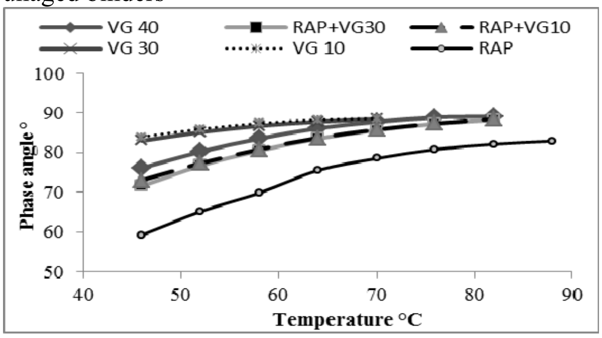


Figure 4. Phase angle versus temperature for unaged binders

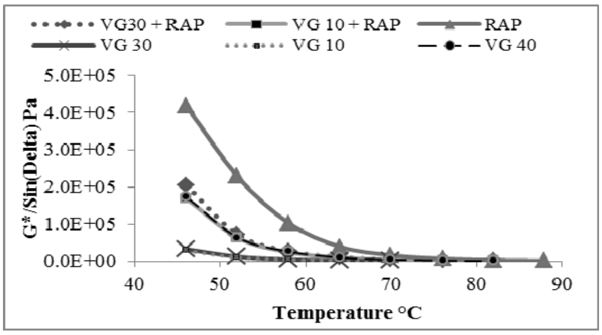

Figure 5. Rutting parameter versus temperature for un-aged binders

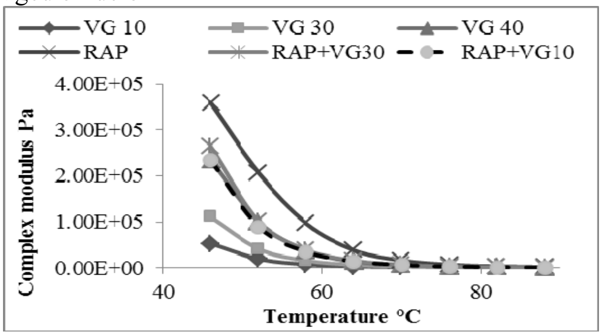

Figure 6. Complex modulus versus temperature for RTFO aged binders

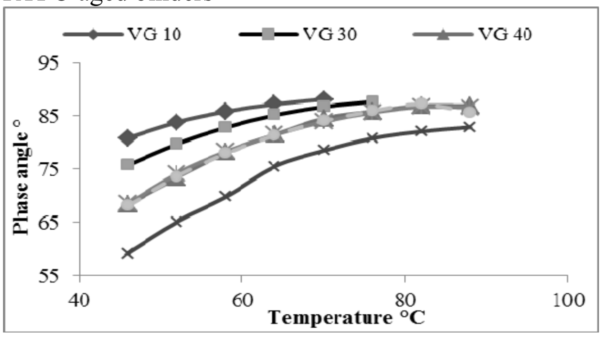

Figure 7. Phase angle versus temperature for RTFO aged binders

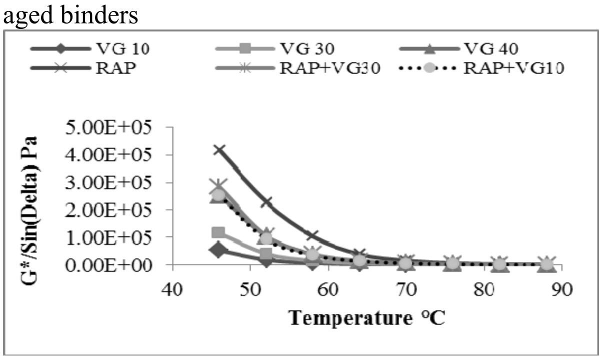

Figure 8. Rutting parameter versus temperature for RTFO aged binders

Table 2. Upper PG temperature for various blends

| Material | Upper PG temperature (°C) |
|---|---|
| VG 10 | 67.2 |
| VG30 | 69.8 |
| VG 40 | 78.1 |
| VG30+RAP | 78.6 |
| VG10+RAP | 77.7 |
| RAP | - |

## 5 SUMMARY

From the results of the present study the following salient findings are summarized. The RAP-Bitumen blends made with70% VG 30 bitumen and 60% VG 10 bitumen, each in terms of weight of the respective blend, match with the target VG 40 bitumen in terms of penetration value. A consequent decrease in softening point and viscosity was observed by blending RAP with fresh bitumen. The results of viscosity and softening point of the modified blends at various temperatures are also found to match with respect to the target VG 40 bitumen. The complex modulus of the modified blend increases with increase of RAP bitumen content in the blend. Addition of normal bitumen causes a decrease in phase angle, indicating better resistance to rutting. The upper PG temperatures for the modified blends as well as control VG40 bitumen were found to be around 70°C.

Based on the limited study, it is concluded that the stiffness of RAP bitumen decreases with addition of fresh VG 30 / VG10 bitumen, which makes it suitable for further use in bituminous pavement construction. This simple approach of using RAP by blending with conventional bitumen can pave ways for reuse of existing materials for economic and sustainable bituminous paving works.

## 6 REFERENCES

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