PERFORMANCE EVALUATION OF RAP MODIFIED BITUMINOUS BINDER

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Abstract : The composition of bitumen plays a vital role in deciding durability of bituminous roads. During the aging process, its composition changes with passage of time. Reclaimed asphalt pavement (RAP) is the term given to removed and/or reprocessed pavement materials containing asphalt and aggregates. These materials are generated when asphalt pavements are removed for reconstruction, resurfacing, or to obtain access to buried utilities. When properly crushed and screened, RAP consists of high-quality, well-graded aggregates coated by asphalt cement. Using RAP has been favored over virgin materials in the light of the increasing cost of asphalt, the scarcity of quality aggregates, and the pressuring need to preserve the environment. The paper describes the comparison of properties of RAP modified samples with conventional virgin bitumen samples. Various properties like Ductility, Penetration, and Softening point have been compared. The results indicate that the RAP mixes show better performance.

***IndexTerms*- Reclaimed Asphalt Pavement, Centrifugal Extractor, Rejuvenator**

I. INTRODUCTION

Recycling of (black road covering) hard road surfaces are one of the effective and proven healing/repairing processes. It has been successfully used at many places all over the world and has shown acceptable performance. Reasons to why recycling was not given importance in India during the first half of the 20th century are those of money-based things to think about and availability of good technology. The cost of new hot mix materials about twenty years ago had been less than the cost of handling, transportation and reprocessing of in-situ material. Also the availability of machinery was another restriction in adopting this technology.

Here in this study attention was laid on the use of Reclaimed (black road covering) hard road surface which is created by removal of old hard road surface layer. Using RAP has few advantages like it lowers the cost of construction; reduces the consumption of valuable things from nature; transportation of materials is (made something as small as possible/treated something important as unimportant) resulting in saving of energy.

Hot mix recycling is the process in which Reclaimed (black road covering) Hard road surface materials are mixed with new materials, sometimes along with a rejuvenator or modifier, to produce hot bituminous mixtures. A well- designed recycled mixture can have better or identical performance to that of ordinary hot bituminous mixtures. The heating of bituminous binder, groups and production of huge amounts of Hot Mix (black road covering) (HMA) releases a big amount of green house gases and harmful (things that dirty the air, oceans, etc.). The amount of (things sent out or given off) become double for every 10Â°C increase in mix production temperature and higher temperature is actually being used for the production of HMA with changed binders. Hard road surface recycling is a logical and practical way to (use less) our reducing supply of construction materials and to help reduce the cost of keeping our existing hard road surface network. When properly designed and built, recycled hard road surfaces have been found to (do as expected) as well as hard road surfaces built with all new materials.

II. LITERATURE REVIEW

Asli et al. (2012) investigated the feasibility of waste cooking oil as a rejuvenator in recycled mixtures. Authors indicated that the use of waste cooking oil rehabilitated the properties of aged bitumen. It is said that the rejuvenated bitumen behaved similar to virgin bitumen in terms of penetration and softening point. The researchers also claimed more amount of RAP within the recycled mixtures could be accessible by implementation of waste cooking oil [1]. Yu et al. (2014) implemented waste vegetable oil and an aromatic extract in order to rejuvenate the aged bitumen. The rejuvenator was used to enhance the rheological properties of the aged bitumen. It is reported that the use of these agents could modify the chemical structure of the aged bitumen and thus the mechanical behavior of the mixtures. The researchers evaluated the samples at both macro- and micro-scales and found out that the characterization of rejuvenating impact on the aged bitumen could gain the advantage of improved recycling for bituminous materials [2]. In another study, high temperature properties of bitumen rejuvenated with waste cooking and cotton seed oil was examined [3]. Nayak and Sahoo (2015) tried two kinds of local oil for rejuvenating of aged bitumen. Panogamia oil and composite castor oil were employed within this study. The rheological evaluation of effect of rejuvenators on aged bitumen represented that, these oils are capable of enhancing both rutting and fatigue properties of aged bitumen [4]. Zaumanis et al. investigated the performance properties of RAP bitumen and 100% recycled asphalt mixtures with six different rejuvenators. WEO was employed in order to enhance RAP bitumen within the study. The authors reported improvement in many aspects such as reducing the performance grade of the rejuvenated RAP bitumen to the level of virgin bitumen, passing rutting requirement, enhancing of mixture cracking resistance and an improved workability for rejuvenated mixtures [5]. Jia et al. (2015) employed WEO within another study conducted by aiming to investigate its influence on the rheological properties of RAP bitumen as well as fatigue properties of HMA containing RAP. It was reported that the use of WEO within HMA involving RAP can offset the increase of stiffness imposed by aged RAP bitumen. The authors claimed limited enhancements on fatigue properties of the mixtures containing WEO rejuvenated RAP [6]. Ji et al. (2016) within a study tried to recover the aged asphalt (extracted from RAP materials) by use of two waste cooking vegetable oil rejuvenators (corn oil and soybean oil). They aimed to replace these light oil components with better temperature resistance with heavy oils. They compared the effectiveness of these waste cooking vegetable oils with a heavy oily rejuvenator and a commercial rejuvenator in different ratios. The study shows that the by use of these waste

cooking vegetable oils the aged asphalt binder viscosity and stiffness decrease. The fatigue and low-temperature cracking resistance improves significantly by use of these rejuvenators [7] Gong et al. (2016) showed that Bio-oil can be used to rejuvenate aged bitumen. They observed that the physical characteristic of aged asphalt is enhanced via mixing with bio-oil [8]. Sun et al. (2016) implemented a kind of bio-oil derived from waste cooking oil into aged bitumen as rejuvenator. They investigated the chemical compositions of bio-oil and control specimen. They reported that bio-oil contribute in reducing of the deformation resistance and in improving of the stress relaxation property of control bitumen samples [9].

III. MATERIALS AND METHODOLOGY

From a performance point of view, bitumen is one of the most important constituents of an Asphalt mixture. The response of bitumen to stress depends on temperature and loading time. At low temperatures or short loading times, bitumen behaves predominantly elastic. At high temperature or long loading time bitumen behaves like a liquid. To achieve the main objectives of this study, an experimental program was designed. The first step is collecting the study materials. These materials are: RAP, Virgin Bitumen (having the same grade as that of the RAP mixture), Benzene, and Vegetable Oil (To be used as a Rejuvenator.)

In this experimental study milled Reclaimed Asphalt Pavement (RAP) collected from Shivaji Chowk Chembur road which was paved 8 years ago and had deteriorated to a considerable extent. It was made using 60/70 grade of bitumen and it served heavy traffic volume. The road surface was milled for paving of concrete overlay. In this particular case we evaluated RAP for asphalt content. We took 5 kg sample for extraction purpose to avoid variations in sampling. Extraction of aged bitumen from RAP sample is done using Centrifuge Bitumen Extractor (CBE) using benzene solvent. The percentage of bitumen extracted from the RAP is 5%. The grade of Bitumen used in the RAP mixture is found out to be VG30.

The bitumen is characterized for the following basic properties: Penetration, Softening Point, Viscosity and Ductility. Considering the conventional bitumen test results for virgin and RAP bitumen, the objective was defined as to rejuvenate RAP binder in order to obtain a binder similar to virgin binder in terms of specifications. A rejuvenating agent is supposed to enhance and cure the RAP binder in terms of physical and chemical properties. Several studies address the penetration value as an indicator for determining the optimum rejuvenator content. Within the study, the optimum rejuvenator content was determined as the content required to achieve a rejuvenated binder having the same penetration value of the virgin binder. In other words, when the RAP binder is modified with that percentage of rejuvenator, the acquired binder should have the same penetration value of virgin binder.

IV. RESULTS AND DISCUSSION

After various trials it was observed that 3% of vegetable oil was the optimum rejuvenator content.

4.1 Basic Properties of Virgin Bitumen

Table 4.1 Test Results on Virgin Bitumen

Tests	Results
Penetration	69 (1/10mm)
Softening Point	48.5°C
Ductility	78.7cm
Viscosity	285 sec

4.2 Test results on Virgin Bitumen, Virgin Bitumen + 10% RAP & Virgin Bitumen + 20% RAP

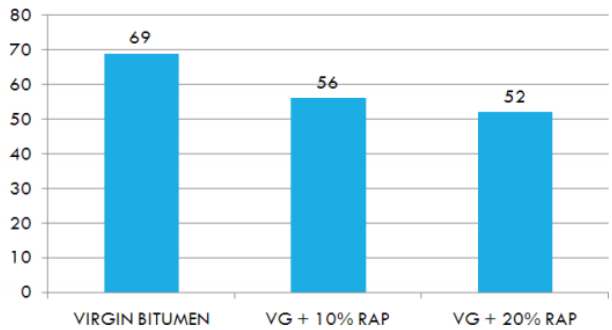

Figure 4.2.1 Comparison of Penetration test values

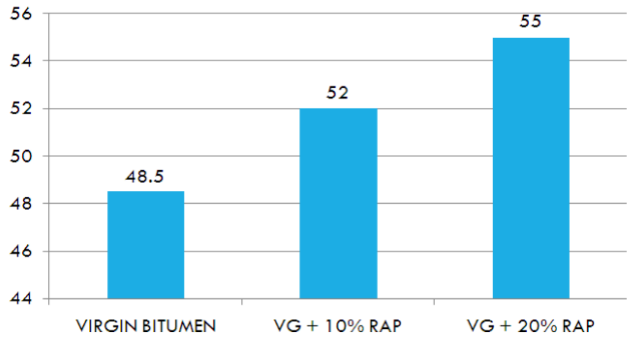

Figure 4.2.2 Comparison of Softening Point test values

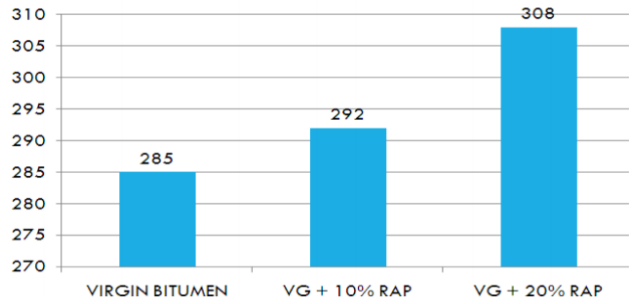

Figure 4.2.3 Comparison of Viscosity test values

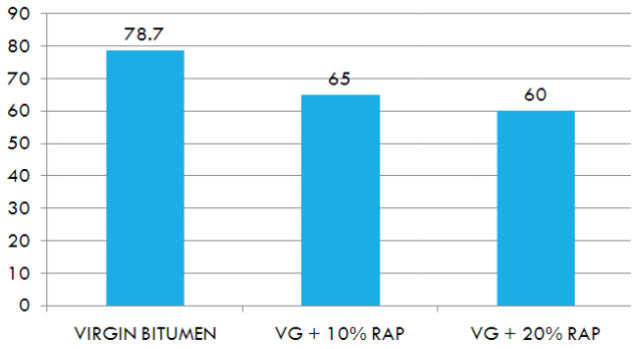

Figure 4.2.4 Comparison of Ductility test values

4.3 Test Results for Virgin Bitumen + 10% RAP + 3% Vegetable Oil

Table 4.3 Test Results for Virgin Bitumen + 10% RAP + 3% Vegetable Oil

Sr No	Tests	Virgin bitumen	VB+10% RAP	VB + 10% RAP +3% oil
1	Penetration	69 (1/10mm)	56 (1/10mm)	68 (1/10mm)
2	Softening	48.5°C	52°C	50°C
3	Ductility	78.7 cm	65 cm	72.6 cm
4	Viscosity	285 sec	292 sec	288 sec

4.4 Test Results for Virgin Bitumen + 20% RAP + 3% Vegetable Oil

Table 4.4 Test Results for Virgin Bitumen + 20% RAP + 3% Vegetable Oil

Sr No	Tests	Virgin bitumen	VB+10% RAP	VB + 10% RAP +3% oil
1	Penetration	69 (1/10mm)	52 (1/10mm)	66 (1/10mm)
2	Softening	48.5°C	55°C	54°C
3	Ductility	78.7 cm	60 cm	76 cm
4	Viscosity	285 sec	308 sec	293 sec

The summarizing results of various combinations of proportions of RAP and natural aggregates are shown below: With the inclusion of 10% RAP binder into the virgin binder the penetration, ductility decreases initially and after the addition of 20 % RAP it reduces furthers more. But after the addition of 3% oil the penetration and ductility value comes back almost to the

original value. With the inclusion of 10% RAP binder into the virgin binder the softening point and viscosity increases initially and after the addition of 20 % RAP it reduces furthers more. But after the addition of 3% oil the softening point and viscosity value comes back almost to the original value. Also, addition of optimum content of vegetable oil rejuvenated and restored the properties of the bitumen.

V. CONCLUSION

Use of RAP for repaving is gaining importance day to day due to the extinction of the paving materials. Many experimental investigations have been carried out on inclusion of RAP for repaving. In light of this context performance of aged binder present in RAP, in terms of efficiency of blending, resistance to rutting and changes in chemical structure has to be better understood. So, the main thrust of this study was to investigate the changes occurring in the virgin bitumen when it was blended with RAP binder. Unfortunately, in India, the concept of bituminous pavement recycling has not yet gained much popularity. India has set ambitious road construction future targets which requires huge reserves of natural resources It already has the second largest road network in the world, thus, it cannot afford to ignore bituminous pavement recycling anymore.

Thus bituminous pavement recycling is the need of the day. Based on the results from the present study, the following conclusions can be summarized: The inclusion of RAP binder into the virgin binder should generally be restricted to certain lower percentage to avoid some critical negative effects on the performance of virgin binder. The penetration and softening point consistently decrease and increase, respectively after severe aging conditions for all RAP modified binders. There is a significant decrease in penetration values for modified blends, indicating the improvement in temperature susceptibility resistant characteristics. The softening point increases with increase in percentage of RAP binder as the bitumen becomes increasingly viscous. Further Due to ageing of bitumen the bitumen gets hardened. Also during the extraction process the volatile material inside the bitumen mix gets evaporated. So it's necessary to restore them. This is achieved by using a rejuvenator. We are using vegetable oil as a rejuvenator over here.3% vegetable oil was added as a rejuvenator which almost regained the properties to that of that of original bitumen.

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