ASSESSING EFFECT OF WASTE ENGINE OIL ADDITION ON REPAIR OF RECALIMED ASPHALT PAVEMENT PROPERTIES

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ABSTRACT

Road infrastructure is prioritized for speedy development. Exponential use of aggregates and decreasing natural resources directs towards the increasing importance of conserving natural resources for long term and moving toward sustainable practices. The acquired material, known as reclaimed asphalt pavement (RAP), is used now a day with new asphalt roads. The reuse of RAP needs to be treated before using it with new asphalt. RAP are weathered during their course of use. Repeated exposure of RAP to ultraviolet rays and moisture deteriorates the properties of the aggregates and binders. This study focuses on the possibility of using waste engine oil as a rejuvenator for the higher percentage of reclaimed asphalt pavement. Asphalt samples containing waste engine oil and RAP were subjected to rotational viscometer testing. The tests indicate that use of waste engine oil is advantageous as a rejuvenating agent in restoring the asphalt pavements with RAP.

Keywords: *Reclaimed Asphalt Pavement (RAP), Waste Engine Oil, Tensile Shear Ratio (TSR), Reclaimed Asphalt Binder (RAB)*

1.0 INTRODUCTION

Road infrastructure is prioritized for speedy development. Exponential use of aggregates and decreasing natural resources directs towards the increasing importance of conserving natural resources for long term and moving toward sustainable practices. The acquired material, known as reclaimed asphalt pavement (RAP), is used now a day with new asphalt roads. The reuse of RAP needs to be treated before using it with new asphalt. RAP are weathered during their course of use. Despite the fact that asphalt has been a part of human society for over 6,000 years and contemporary society for over a century, many of its complication remain a secret to scholars. The ability to recycle wasted asphalt pavement into new pavements is the need of present and topic of this study. When an old asphalt pavement needs to be repaired or replaced, the old material can be mechanically ground and utilized as a raw material in new roads. Reclaimed asphalt pavement is an old, recyclable material (RAP). Because the old material has oxidized and became stiffer and more brittle than unaged asphalt pavements, a chemical recycling agent must be applied to counteract the ageing in order to use RAP (*Lins et al. 2008*). The use of RAP and its effects on the performance of new pavements has been thoroughly studied (*Widyatmoko 2008),* and it is known that using RAP without modification results in a stiffer asphalt pavement overall (*Zaumanis et al 2019*).
Waste motor oil from vehicles and trucks is one waste resource that may be able to revive RAP to original form by incorporating softness in binders (*Villanueva et al. 2008; Liu et al 2018*). In India, an estimated 295 million registered automobiles are travelling on 5 million miles of public road *(Statista 2021)*. During a typical oil change, this is the oil that is extracted from the car. Engine oil in large quantities on pavements causes harm to the asphalt. When coupled with RAP, however, modest volumes of waste oil thoroughly integrated in the mix may prove useful by countering the increased stiffness to provide a pavement with performance comparable to that of vestal and unused materials before in any structure.

Over the years, several methods of characterization for asphalt binder have been developed to satisfy the necessity for asphalt binder to manage high and low temperature failure causes. The Superior Performing Asphalt Pavements system is the most recent materials characterization system. Asphalt binder performance is graded using two temperatures: a high temperature and a low temperature. The maximum seven-day average temperature that the pavement will see during its design life is referred to as the high temperature. The low temperature represents the pavement's lowest single-day temperature during its design life. This range is indicated by a binder classification of PG XX-YY, where XX denotes the permissible high temperature in degrees Celsius and YY denotes the binder's low temperature rating in negative degrees Celsius. In the present study, to measure the performance grade (PG) temperature of asphalt binder rotational viscometer testing is done.

2.0 LITERATURE REVIEW

The viscosity of asphalt samples is determined using the rotational viscometer test. The protocols for the rotating viscometer test are described in ASTM D 4402. (*ASTM 2008d*). Because the properties of asphalt binder are temperature sensitive, the rotating viscometer is used to determine how the viscosity of asphalt binder changes as the temperature changes. Ten grams of asphalt binder are placed inside a temperature-controlled thermo-chamber to conduct this test. Inside the binder, a spindle connected to a revolving motor is suspended and made to spin at a steady speed. The machine with the spindle attached displays the viscosity of the binder in centipoise once the spindle and binder have equilibrated (cP). Superpave requires a maximum of 3000 cP at 135°C to meet specification; nevertheless, due to the temperature sensitivity of asphalt binder, testing are carried out at various temperatures and the results analysed to better understand the material's behaviour.

2.1 Superpaver

Under the Superpave system, laboratory ageing of the binders was also specified. To replicate different periods of ageing for asphalt binder, the system uses two machines: the rolling thin film oven (RTFO) and the pressure ageing vessel (PAV). ASTM D 2872 specifies the RTFO testing process (ASTM 2008e). Glass bottles are filled with 35 grams of asphalt binder and spun freely in a 163°C oven for 75 minutes in this test. This is known as short-term ageing since it is designed to mimic the ageing binder that occurs during mixing and transit to the construction site.

2.2 Aging of Asphalt

To simulate long-term ageing, the pressure ageing vessel (PAV) is used. The processes for obtaining PAV aged asphalt binder are outlined in ASTM D 6521. (ASTM 2008f). RTFO aged binder is put into shallow steel pans at a weight of 50 grams of binder per pan to conduct this test. The pans are then loaded into the PAV, which is finally sealed. The temperature in the sealed chamber is set to 100°C, with a pressure of 2.10 MPa (305 psi). Despite the fact that the sample is merely heated and compressed for 20 hours, the end product is a binder with a simulated field age of 5 to 10 years. The accelerated ageing takes place in an oxygen-rich atmosphere, with high pressure forcing oxygen into the asphalt binder to mimic field oxidation.

2.3 Asphalt Binder

Binding of aggregates in asphalt with asphalt binders are typically categorized by their properties at changed temperatures and steps of in-service properties (*Speight, 1992; Button, 1994*). The asphalt binder, occasionally referred to as the asphalt cement binder or the asphalt cement, is an essential component of asphalt concrete—it is as the name implies the cement that clamps the aggregate together. The asphalt binder is a co-product of the petroleum-refining arrangement that produces gasoline, diesel fuel, lubricating oil, as well as several other petroleum products. The asphalt binder is formed from the thick, heavy residue (residuum) that leftovers after refinement of petroleum to remove fuels and lubricants. The residuum is treated more by means such as steam treatment (steam distillation) to eliminate any vestiges of gas oil or lubricating oil elements and/or by oxidation until the treated residuum meets the desired specifications required of an asphalt binder. Once the binder has been formed, for tough, high-performance applications, minor amounts of additives may be mixed with the binder to prepare an improved binder—for example, polymer additives produces a polymer-improved binder.

At room temperature, asphalt binder is a black, sticky, odorous, viscous fluid that is semi-solid. Asphalt binder has been used as an industrial sealant because of its high waterproofing capabilities and chemical resistance to corrosion from acids and salts; nevertheless, asphalt binder is most commonly utilized in the building of asphalt pavements. The asphalt binder becomes more liquid and flows more easily when heated. The heated binder is mixed with aggregates at high temperatures (about 160°C, or 320°F) to make asphalt concrete. The binder will return to a semisolid condition after cooling, with the aggregates suspended inside its matrix.

Petroleum distillation produces asphalt binder as a by-product. A distillation column can be used to extract several valuable hydrocarbons from crude oil. Crude oil also contains gasoline, kerosene, diesel oil, and lubricating oil, ranging from the lightest distillate to the heaviest. The lubricating oil distillates are used to make engine oil. The leftover substance at the bottom of the distillation column is even heavier than lubricating oil. Asphalt binder is contained inside this leftover material (Institute 1960). The relevance of this research is not in figuring out how asphalt binder is made, but in figuring out how asphalt binder and engine oil from the same source interact.

2.4 Recycling Agent

Chemical additives known as recycling agents are incorporated into the asphalt mixture to decrease the amount of variance seen with different RAP sources and to improve the qualities of the aged binder. Recycling agents are used to restore asphalt chemistry and uniformity. Rejuvenating agents and softening agents are the two types of chemical additives that can be added to RAP-coated pavements. The main distinction between a softening agent and a rejuvenating agent is that a rejuvenating agent attempts to rebuild the chemical structure of ageing asphalt, whereas a softening agent is blended into a mix to reduce the binder's overall viscosity (*Chen et al. 2007*). It is considered a softening agent until it can be demonstrated that the recycling agent is chemically modifying the asphalt binder. Recycling agents are often manufactured from a petroleum product containing either highly polar or aromatic oils in either case (*Kiggundu et al 2004; Zaumanis et al 2014*).

2.5 Waste Engine Oil

Most of the research has concentrated on trying to improve the low temperature qualities of asphalt cement, therefore there are differing viewpoints on the viability of using lubricating oil as an additive in asphalt cement (*Villanueva et al. 2008; Borhan et al. 2009; Soleimani et al. 2009*). Although it has been demonstrated that adding engine oil to asphalt improves its low-temperature qualities, little study has been done on using waste engine oil as a recycling agent to reduce the stiffening effect of RAP in asphalt paving mixtures (*Hayner 1999; J. H. Collins and Jones 2000*)

3.0 EXPERIMENTAL METHODOLOGY

3.1 Asphalt Binder

The asphalt binder, commonly called as asphalt cement, is a vital element of asphalt concrete—it is as the name infers the cement that holds the aggregate composed. The asphalt binder is a co-product of the petroleum-refining classification that produces gasoline, diesel fuel, lubricating oil, as well as numerous additional petroleum products. The asphalt binder is formed from the thick, heavy residue (residuum) that leftovers after distillation of petroleum to eradicate fuels and lubricants. The residuum is treated further by means such as vapor treatment (steam distillation) to eliminate any vestiges of gas oil or lubricating oil ingredients and/or by oxidation until the treated residuum meets the desired specifications required of an asphalt binder.

The vestal binder selected for this study was a PG 70-22 neat binder attained from a pavement project of NHAI. This binder was joined with RAP- attained binder at the ratio of 75% neat binder to 25% RAP-attained binder. The RAP-attained binder was collected from the prior pavement at the site. In extracting the RAP binder, the ASTM D 2172 procedure was followed (*ASTM 2005b*). The extraction procedure includes soaking the RAP in trichloroethylene, thereafter centrifuging the resolution of asphalt binder and trichloroethylene by the aggregates. When extracted, the binder was attained utilizing the rotary evaporation method as mentioned in ASTM D 1856 (*ASTM 2005a*). The retrieval process included distilling the solution of trichloroethylene and asphalt binder. The resolution was heated till the trichloroethylene boiled obtainable of solution, leaving only the attained asphalt binder (RAB). The extraction process produced 88 grams of RAB by 2800 grams of the material of RAP.

3.2 Asphalt Mixture Testing

The testing of ready mixture trials was also conducted, trial mixtures were ready in the laboratory and exposed to standard performance tests to analyze if the inclusion of waste engine oil in combination of RAP is changing asphalt pavement properties or not. Mixture testing is simple and comparatively economical way to approximate a certain asphalt concrete mixture earlier to laying of a full road stretch. Mixture tests can be empirically adjusted to pavements which were sound, and are normally utilized to approximate the performance. The study observed at two separate mix tests in order to analyze the expected modification in field performance with the incorporation of RAP and waste engine oil. Preparations of the trials was done and rotational viscometer testing was completed as per the procedure of ASTM D 4402. The viscosity observations were taken on four different temperatures 160 ^{0}C, 140 ^{0}C, 125 ^{0}C, and 100 ^{0}C.

4.0 RESULTS AND DISCUSSION

Super pave asphalt binder testing is the accepted standard for establishing a usable service range of temperatures for which different asphalt binders are acceptable. Rotational viscometer testing was performed first on vestal asphalt binder to establish a baseline for modification. Aged asphalt binder was tested in the same fashion as the vestal binder. Then waste engine oil was added to the aged binder in the hopes of showing the aging effects can be offset with the oil acting as a softening agent.

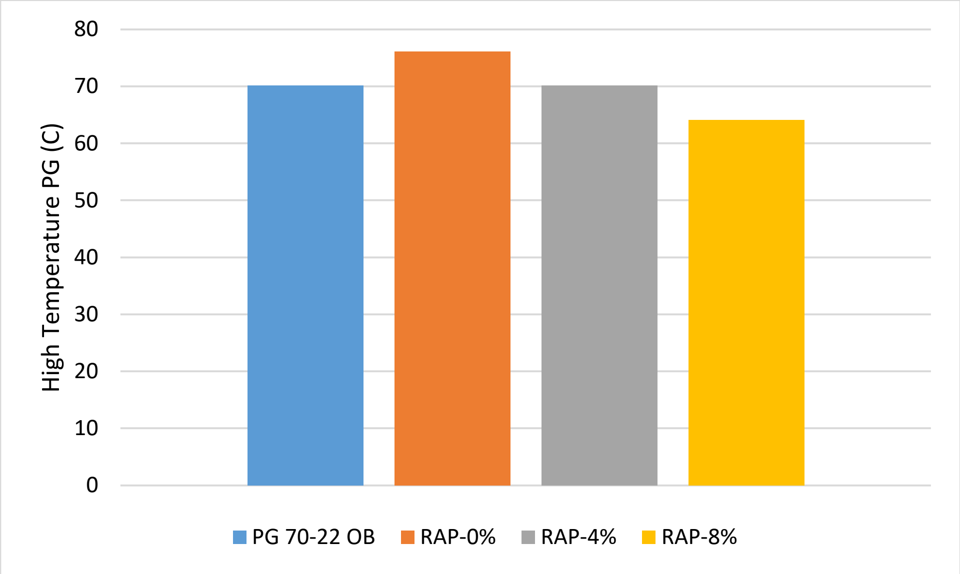

Figure 1 Testing with PG 70-22 Asphalt Binder

Based on the rotational viscometer results, the addition of RAB into vestal asphalt binder caused an increase in viscosity. The asphalt blends with RAB and waste engine oil were shown to decrease in stiffness as oil was added. These results support the claim that waste engine oil can be used as a softening agent to counteract the stiffening inherent with using RAP.

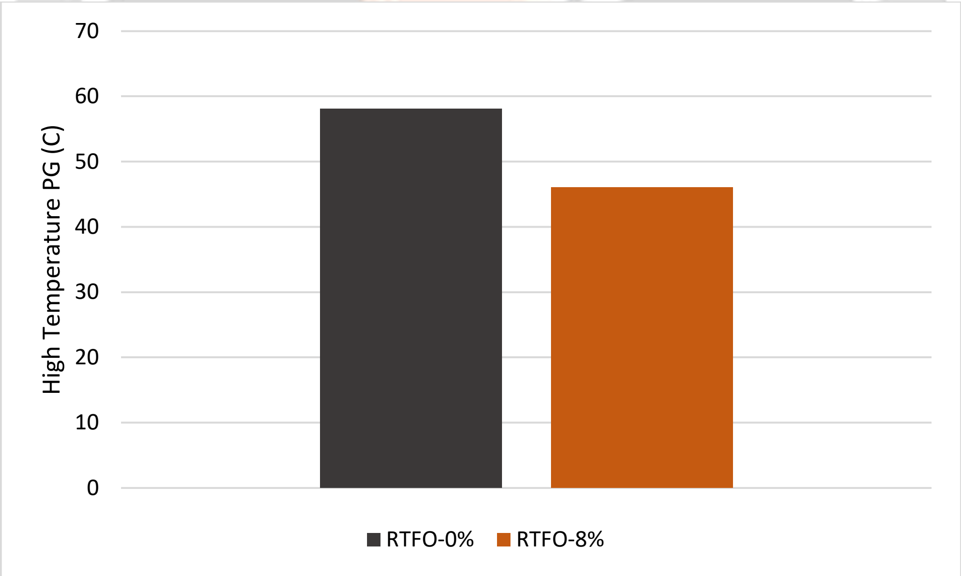

Figure 2 Dynamic Testing with Aged Asphalt Binder

Rotational viscometer, it was shown that waste engine oil has the potential to counteract the stiffening and counter the PG increase when RAB is used. Asphalt binder testing is the first step in any research because it has a relatively low cost of operation. Many of the tests can be performed in the scope of a few days, and require small amounts of material to test. To further support this concept of a more sustainable pavement, testing on the chemical interactions between the RAB and waste engine oil should be studied. Lastly, conducting sample mixture testing will give insight as to how samples perform under simulated field conditions.

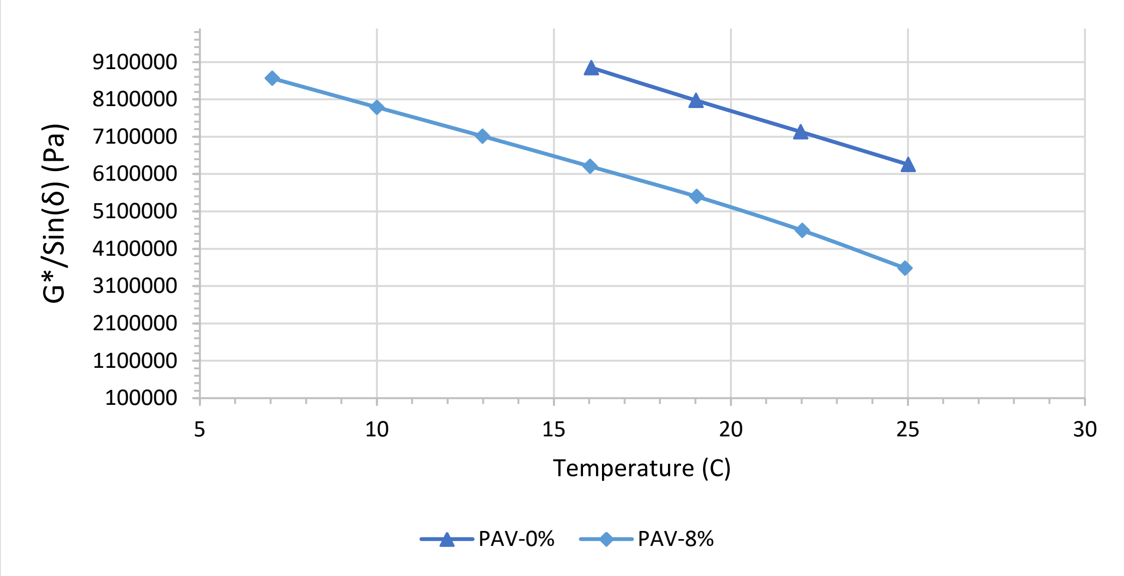

Figure 3 PAV aged binder mixed with RAP and WEO

The PG 70-22 binder and the blends of RAP and oil, a comparison of the high temperature performance grades of the asphalt binders can be made, as shown in *Figure 4.6*. Initially the RAP caused an increase in PG because it increased the G*/Sin(δ) parameter to a point where it was less than 1000 Pa at the test temperature. The increase in PG corresponds to an increase in stiffness and rutting resistance. With subsequent percentages of oil added, that stiffening was reduced and ultimately the binder was softened beyond the initial PG before RAP was added.

5.0 CONCLUSIONS

Now days, proper disposal of waste materials is a major problem. Developing countries like India, where road infrastructure is on verge of expansion. State highways being broadened for faster movement of vehicles, goods, travelling etc. conservation of material and sustainable use by utilizing the reclaimed asphalt pavement is important. Also, the vehicles moving on the roads require engine oil for lubrication and proper running of vehicles. Some waste engine oil is recycled and leftover is disposed of. Unattended disposal of waste engine oil is hazardous. Reclaimed Asphalt Pavement is identified to yield stiffer pavements with underperformance in temperature inversely Waste Engine Oil (WEO) when mixed with asphalt pavement is observed to yield softer pavement thereby improving the asphalt binder low temperature PG grade.

In the present study the testing of asphalt mixture depicts a rise in rutting when WEO is mixed to asphalt samples showing that engine oil softens the pavement WEO did not impact to a large extent on Tensile Shear Ratio (TSR) of mixes having Reclaimed Asphalt Pavement; although some reduction in tensile strength was observed.

The testing of mixes in rotational viscometer showed that asphalt incorporates stiffness after addition of Reclaimed Asphalt Binder. The stiffness is observed by comparing the change in viscosity of the mixes teste in DSR. Also the decrease in G*/Sin(δ) parameter directs towards the increased stiffness of the mixes with reclaimed asphalt binder.

When waste engine oil was added to the binder, the viscosity dropped as well as the G*/Sin(δ) parameter. The sample pucks, when mixed with waste engine oil, showed an increase in rutting, which was predicted by a decrease in the G*/sin(δ) parameter in the asphalt binder testing. The reduction in tensile strength from the TSR test can be explained.

This study observes that use of Waste Engine Oil (WEO) in small proportions can effectively overcome the stiffness of Reclaimed Asphalt Pavement and regain the polymer grade of vestal binder vestal binder.

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