

Use of Waste Engine Oil as a Rejuvenating Agent in Reclaimed Asphalt Binder to Improve Pavement Recyclability

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Abstract- Asphalt pavement Recycling is a common practice in Transportation sector. Waste Engine Oil as a rejuvenator has gained a lot of interest in pavement recyclability but there is still a significant lack of research in its application. Environmental, economic, and social benefits are the encouraging factors for pavement recycling. Problems such as disposal of reclaimed asphalt material from paving projects, high production cost of asphalt and transportation cost of virgin material are addressed by recycling of RAP. Recycling or Rejuvenating agents are organic materials which improve asphalt consistency by restoring the chemical structure of aged asphalt. Generally, a recycling agent is added with RAP to restore the chemical properties of aged asphalt binder. Viscosity characteristics are the determining factors in selecting the recycling agent for the aged asphalt binder. The global objective of sustainable development can be achieved by making use RAP in roadway projects. This paper intends to highlight previous research works conducted on RAP and Waste engine oil as a Recycling agent.

Keywords- Reclaimed Asphalt Pavement, Rejuvenating Agents, Aged Asphalt binder, Waste Engine Oil

I. INTRODUCTION

Bitumen is primarily used in road making industry for construction and maintenance purpose. Bitumen is a byproduct obtained from petroleum distillation. The most common method involves a process in which RAP is combined with virgin bitumen and virgin aggregate in a central mixing plant to produce new hot mix paving mixture. Hot in place recycling is another method in which softening of the existing surface is done with heat, by mechanically removing the aged asphalt pavement, adding a recycling or rejuvenating agent, possibly adding virgin aggregate and or bitumen thus correcting the asphalt pavement surface distress. Keeping in mind the heating capacity of hot mix plants and gaseous hydrocarbons emissions up to 50 percent of RAP quantity is widely considered in hot mix asphalt plants. . Due to less waste produced the use of reclaimed asphalt pavement (RAP) is seen as a viable option. Recycling of asphalt pavements is one of the effective and proven rehabilitation processes. Asphalt industries are compelled to find another alternative source to construct economical and sustainable roads without compromising on their quality due to fast depletion of natural material sources Aging and reduction in the performance of binder will occur after years of exposure to climate change and traffic loads. Pavement's surfaces can be removed and recycled into reclaimed asphalt pavement which is a peculiar feature of a pavement after the end of its design life. Aging of Pavement makes the binder stiffer and more brittle than virgin binder. Which makes roads more susceptible to cracking paved with unmodified reclaimed asphalt pavement (RAP). Waste engine oil obtained from vehicles such as trucks and cars can be used as a rejuvenating agent in RAP. Reduction of stiffness and improvement of physical properties of asphalt binder can be achieved by blending waste engine oil with aged asphalt binder. Waste engine oil without hampering the moisture susceptibility can easily soften the asphalt pavements.

II. LITERATURE REVIEW

Mishra Brajesh (2015) has studied Reclaimed Asphalt Pavement (RAP) materials were collected and their characteristics including gradation, California Bearing Ratio (CBR), Aggregate Impact value, Aggregate Crushing value, Specific gravity, Flakiness & Elongation Index, Loss Angles Abrasion value, Water absorption and soundness were determined and compared to the MORTH specifications. From the study it was found that the rap material can be effectively used in the soil sub-grade, sub-base and base of the flexible pavement resulting in reduction of the construction cost.

Hussain Arshad and Yanjun Qiu (2012) studied that the performance of pavements with properly prepared recycled asphalt in terms of fatigue, rutting, thermal resistance and durability proved to be satisfactory. Using Superpave system they evaluate the rheological properties of binder with various RAP percentage. Their DSR and RV tests indicated that by increasing the RAP binder percentages increases the stiffness, viscosity and critical temperature of the blend.

Dedene Christopher and You Zhanping (2014) tested the interactions between RAB and Waste engine oil. This testing reveal a decrease in two aging indices of the blended asphalt binder indicating that waste engine oil has the ability to chemically restore aged asphalt binder. Asphalt Mixture testing as then performed with mixture of virgin asphalt, virgin binder, RAP and waste engine oil in quantities similar to binder testing to see if the rejuvenation show a Fourier transform infrared spectroscopy led to an improvement in the performance of pavement specimens. Finally, the results from FT-IR testing show potential for waste engine oil as a rejuvenator, the fact that it was shown to reduce pavement performance presents a challenge. They concluded that further research will be necessary to find a balance between adding enough rejuvenator to restore the binder contained in the RAP, but not too much as to where the rejuvenator becomes detrimental on the performance of the pavement.

Veeraragavan A. (2012) conducted an Investigation on Laboratory Performance of Bituminous Mixes with Reclaimed Asphalt Pavement Materials. His Primary objectives were to estimate the bitumen and aggregate demand to fulfill the gradation and volumetric requirements of recycled mix, for a typical highway project, to carry out mix design with recycled and virgin materials and compare the mix properties and finally to investigate the influence of recycled materials on the mechanical behavior, tensile strength, durability and performance of bituminous mixes through laboratory experiments. After carrying out the investigations he concluded that the use of recycled materials brings about 78% reductions in the optimum bitumen content required for air voids level of 4% for a typical road project considered in the present investigation, Indirect tensile strength results confirm that the use of recycled materials in bituminous mix offers high fatigue cracking resistance similar to that of virgin mixes, The bituminous mixes with recycled materials are found to offer higher resistance to rutting when compared with virgin materials.

Jain P.K., Mittal Abhishek & Pradyumna T. Anil (2013) accomplish the Characterization of Reclaimed Asphalt Pavement (RAP) for Use in Bituminous Road Construction Their objectives were 1) to carry out the Laboratory studies on asphalt mixes with RAP material and rejuvenating agent and their performance has been compared with virgin asphalt mixes. 2) Various performance tests such as Retained Stability, Indirect Tensile Strength (ITS), Creep test, beam fatigue test, resilient modulus and wheel tracking test has been carried out to compare the performance properties. The studies concluded that the a) laboratory testing work which was carried out on virgin mixes and mixes with 20 % RAP, found that addition of RAP improves all the properties of the bituminous mixes. This indicates that mixes with 20 % RAP would perform better than the virgin mixes under similar conditions. B) It is possible to design acceptable-quality bituminous mixes with RAP that meets the required volumetric, mechanical properties and desired performance criteria. However, for actual field performance evaluation of RAP mixes, Accelerated Pavement Testing Facility (APTF) available at CSIR-CRRI may be put to use to get the results in a shorter time period.

Chandrasekaraiah T., Mallesh K.M. & Sunil S (2014) carried out the Experimental Investigations on the Laboratory Performance of Bituminous Mixes with Reclaimed Asphalt Pavement [RAP] Materials. Their objective was to carry out the Marshall Mix design with conventional materials added by controlled RAP and Evaluation of the mechanical properties of the bituminous mix with various proportions of the RAP. They concluded that a] the aged bitumen has shown the available paving material at different percentages of the virgin binder and there has been consistent increase in the physical properties (Penetration, Ductility, softening point etc) of the old bitumen when rejuvenated with Virgin VG-30. B] The proportioning of the aggregates with reclaimed aggregates at all specified percentages of 10,20,30 and 40 have given correct blending of the aggregates meeting the specification Requirements. C] More than 10% and less than 40% RAP can be suitable adopted in making the new roads with the RAP.

Kamaruddin Nurul Hidayah Mohd, Hainin Mohd Rosli, Hassan Norhidayah Abdul, Abdullah Mohd Ezree, Yaacob Haryati (2014) studied the Evaluation of Pavement Mixture Incorporating Waste Oil. They studied the various categories of waste oil that included waste engine oil and waste cooking oil. Later, they studied physical and chemical properties of both types of waste oil. The physical properties studied by them were specific gravity, viscosity and flash point. Different chemical properties such as ash content, iron content and fatty acids were also found out. The methods to incorporate waste oil into pavement were also discussed. The binder performance after addition of the waste oil was critically examined. Lastly, the performance of asphalt mixture was carried out. The conclusions obtained by them were a] effects of WEO and WCO are generally produced both of the adverse and good effects to the pavement b] In cold mix, it was reported that the performance was affected such as stability, strength and weakening the bonding between aggregate and binder. C] in hot mix asphalt where the oil was integrated with RAP, it offered the stiffness reduction and therefore improved resistance to cracking.

III. PURPOSE OF USING RAP

Recycled Asphalt Pavement refers to reclaimed and reprocessed pavement material containing asphalt binder and aggregates. Manufacturing of asphalt requires large amounts of crude oil. As the natural resources like crude oil are non- renewable, it is necessary to recycle and reuse the old asphalt. The dominant benefit of using Reclaimed Asphalt Pavement is a direct cost saving due to the reduction of virgin materials. Also the aged binder attached to the aggregates in RAP is assumed to replace a portion of virgin binder required for new road construction. Some of the research have concluded that a pavement containing recycled material ages more slowly as compared to that of pavements constructed from virgin materials.

Following table shows the percentage of RAP used in each project and their dates of construction:

Table – 1 Percentage of RAP used in each project and their dates of construction

Location	% RAP	Dates of Construction
North Carolina	40 %	September 2007
South Carolina	30 and 50 %	October 2007
Wisconsin	25 %	November 2007
Florida	45 %	December 2007
Kansas	30 to 40 %	May 2008
Delaware	35 %	Summer 2008
Minnesota	30 %	2008
Illinois	10 to 50 % allowed	2008

IV. BENEFITS AND ECONOMIC CONSIDERATIONS OF RAP

Some of the environmental and economic benefits of using RAP as a sustainable construction material are as follows:

- The use of already existing materials.
- The elimination of disposal problems.
- Conservation of Natural Resources.
- Sustainable development.
- Reduction in material cost, energy cost and total job cost.

V. PURPOSE OF USING WASTE ENGINE OIL

In order to improve the properties of aged binder some chemical additives, known as recycling agents are merge into the asphalt mixture. . Generally, there are two types of recycling agents that are rejuvenating agents and softening agents. Recycling Agents are usually made out of a petroleum product composed of either highly polar or aromatic oils The purpose of using recycling agents is to restore asphalt consistency. The purpose of rejuvenating agent is that it will try to restore the chemical structure of aged asphalt while a softening agent blends into a mix to reduce the overall viscosity of the binder. There are various opinions regarding the use of lubricating oil as an additive in asphalt binder since most of the research done by the authors have focused on improving the low temperature properties of asphalt. Some research has proven that use of engine oil can improve the low temperature properties of asphalt and also waste engine oil can be used as a recycling agent for lessening the stiffening effect of RAP in asphalt paving mixtures.

. Waste oil that is dumped into landfill without prior treatments brings negative impact on the environment. Spilled oil has a tendency to accumulate in the environment. This cause's soil and water pollution. It reduces the dissolved oxygen content of the water bodies. A thin layer of oil appears on the surface of a river or a lake due to the eutrophication process. This thin layer of oil can block the sunlight and thus hinder photosynthesis eventually disrupting the oxygen supply to the aquatic life. Combustion of used oil produces high concentration of chromium, lead, metal ions, zinc and copper in used oil can be toxic to ecology and human health. A eutrophication process leads to excessive growth of micro-organism, phytoplankton and algae all of which use the waste oil as a food source. In order to overcome such problems, it becomes imperative to reuse the used engine oil as a recycling agent to prevent its pollution.

VI. RESULTS AND DISCUSSION

- This study gives the balance between adding waste engine oil as a rejuvenator to restore the binder properties contained in the Reclaimed Asphalt Pavement.
- The above study indicated consistent increase in the physical properties (Penetration, Ductility, softening point etc.) of the aged bitumen when rejuvenated with waste engine oil and Virgin Bitumen.
- The Stability and Flow Value of samples containing Reclaimed Asphalt Binder +Waste Engine Oil (REB + WEO) in proportions of 50% and 20% showed comparative good results when compared with the virgin asphalt.

- Waste Engine Oil can be successfully used as rejuvenating agent in bituminous concrete mixture for road construction.
- Based on the laboratory studies it can be concluded that Reclaimed Asphalt Pavement content as high as 50% can be suitably adopted in Pavement Construction.
- Based on the laboratory studies it can also be carried out for more than 50% of the RAB with respect to reducing the Virgin Bitumen and their Marshall Properties, Dynamic loading and Rutting and Fatigue test behavior can be evaluated.
- Comparison of results between Virgin Bitumen and various proportion of Virgin Bitumen , Reclaimed Asphalt Binder and Waste Engine Oil as shown in Table 2..

Table 2 Comparison of results between Virgin Bitumen and various proportion of Virgin Bitumen + RAP + WEO

TEST	RESULT OF VIRGIN BITUMEN	RESULT OF VIRGIN BITUMEN + RAP + WEO	SPECIFICATION IS : 73 – 2006
PENETRATION TEST (mm)	65 mm	64 mm	50 -70
DUCTILITY TEST (cm)	70 cm	68 cm	MIN 40
SOFTENING POINT TEST (°C)	52.4°C	50.2 °C	MIN 47 °C
VISCOSITY TEST (poise)	2432	2646	MIN 2400 Poise

VII. CONCLUSION

Following conclusions can be made:

- Asphalt Recycling benefits the environment in many ways. In particular, it reduces quarrying, mining and oil consumption.
- Recycling asphalt also dramatically reduces the consumption of resources such as fuel, machinery, transportation and labor when compared with producing virgin asphalt materials. By increasing the percentage of RAP binder there is significant increase in the stiffness, viscosity and critical temperature of the blend.
- Use of RAP brings about 78% reductions in the optimum binder content used for the road projects.
- Use of Engine oil as a recycling agent in RAP assist to improve its low temperature properties and physical properties (Ductility, Softening Point, Viscosity etc)
- RAP reduces the cost of construction as its addition with the bituminous mixes shows better results as that of the virgin mixes.
- According to the Federal Highway Administration 73 million tons of reclaimed asphalt pavement is reused every year. This is nearly twice as much as paper, glass, aluminum and plastics combined.
- There is a profit/savings potential of \$30.00-\$80.00/ton recycled. The wide savings range relates directly to the range in asphalt costs.

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