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Utilization of Waste Engine Oil to Enhance the Ageing Resistance of Asphalt Binder

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ABSTRACT

The purpose of this study is to access and simulate the aging response when a specific neat binder typically used in asphalt pavements, is subjected to extended short-term ageing effect due to long hauling distances and unexpected traffic interruptions. Besides, the research will identify the optimum dosage of Waste Engine Oil available as a waste material, to rejuvenate the extended short-term aged binder. The results of this study reveal that the binder's physical properties of penetration, softening point, ductility, flash & fire point and viscosity recovered to 81.7%, 100%, 100%, 92 & 89.7%, and 87.4% with respect to virgin binder when 10% Waste Engine Oil (by weight of bitumen) is added in extended short term aged asphalt binder. Additionally, this research can be extended to expresses the focus not only to short-term, but also to the long-term aged asphalt binder obtained from recycled asphalt pavement(RAP), which could facilitate a sustainable pavement renewal option.

KEYWORDS: waste engine oil; asphalt binder; short term ageing; rejuvenation

1 INTRODUCTION

Between 3000 and 3800, surface seepage of natural bitumen was utilized for masonry and waterproofing in the Indus Valleys and Euphrates, where bitumen first appeared as an engineering material[1]. Air voids, asphalt (bitumen), and gravel make up hot mix asphalt. Bitumen, the binder for asphalt, is a byproduct of petroleum distillation with unique chemical and physical characteristics. The need for asphalt binder has increased significantly as a result of the growth in building operations and infrastructure development. An intricate mixture of organic compounds makes up asphalt binder [2]. One of the most significant characteristics of asphalt binder that affects how well a road is built overall is its ability to age. The process of subjecting asphalt to high temperatures for a predetermined amount of time causes aging, which is characterized by changes in the material's physical, rheological, and chemical properties such as oxidation, physical hardening, and loss of volatile material. Tougher asphalt will form as a result. As the asphalt binder age it becomes more hard and viscous, which can lead to ravelling and cracking. [3]. There are two types of bitumen ageing: short-term and long-term. Short-term ageing of hot mix asphalt happens during production, transportation, and compaction at the building site, all of which take place in a matter of hours. It stands out due to its very high temperatures (>130°C), which cause rapid oxidation. Throughout their service life, asphalt pavements in the field experience long-term aging due to exposure to weather and traffic. [4].The

Extended Rolling Thin Film Oven (RTFO) test replicates the rapid deterioration of asphalt brought on by prolonged exposure to hot conditions during transportation. Using the RTFO for extended period of time, bitumen extracted from reclaimed asphalt pavement (RAP) materials can be tested to see how well rejuvenation treatments work and how well recycling procedures work. This can lessen the environmental effect of the production of asphalt as well as the costs related to using fresh bitumen. The method of rejuvenating an asphalt binder involves returning the aged binder's mechanical qualities to their former state. In order to increase workability, reduce stiffness, and regain elasticity, rejuvenators are often applied to old asphalt binder. Physical and chemical rejuvenators fall into two groups. In order to make the old asphalt binder more workable and less stiff, physical rejuvenators, which are typically petroleum-based compounds, are added. These rejuvenators function by making the binder's elasticity and viscosity more elastic. In order to be compatible with the aged binder, physical rejuvenators are often applied in tiny amounts [5] .Chemical revitalizers are created to interact with the deteriorated asphalt binder and re-establish its mechanical qualities. These rejuvenators frequently contain substances that can dissolve the chemical bonds created during ageing and revive the binder's suppleness. Reactive and non-reactive chemical rejuvenators can be further divided into these two groups. Reactive rejuvenators are made to chemically react with the aged asphalt binder and create new chemical bonds, While non-reactive rejuvenators function by dissolving the old binder and replacing it with a new binder [6].

Waste engine oil has attracted interest as a rejuvenator in asphalt binder because it is both affordable and environmentally benign. Over time, different physical, chemical, and environmental changes to asphalt pavements cause the surface's quality and durability to deteriorate. Chemical and physical qualities of the asphalt can be restored with the use of WEO in the asphalt binder, improving the material's performance and ageing resistance. Purpose is to examine the effects of waste engine oil on the ageing characteristics of the asphalt mixture as well as its viability and efficacy as a rejuvenator in asphalt binder. An estimated 45 million tons of oil are produced worldwide each year, yet only 40 percent of that oil is collected and disposed of appropriately [7].The sector of recycled asphalt pavement offered good prospective uses for the new asphalt rejuvenator with mixed WEO. According to research, WEO and WCO share a molecular structure with asphalt, which is an advantageous circumstance for their reuse [8] .

The main obectives of this research are ,To evaluate the short-term ageing effect of asphalt binder and To optimize the fix dosage of WEO as rejuvenator in lab simulated short term aged asphalt binder

2 METHODOLOGY:

60/70 Penetration grade virgin bitumen was tested first than it was evaluated for conventional properties and aged using RTFO at two different durations of 85 and 145 minutes. Conventional property outputs are assessed following the test in accordance with ASTM specifications. The WEO was taken from mechanics shop. Subsequently, the extremely aged binder was combined with varying weights of WEO (2%, 5%, and 10%) to determine if it could be rejuvenated. These are the typical percentages selected on the base of past literature review data[1].

The conventional bitumen tests ductility test (ASTM D113-99 1999)[9], penetration test (ASTM D5-2006)[10], softening point test (D36-95 2008)[11], flash and fire point test (ASTM, D92 2007) [12]and viscosity test (ASTM D-4402)[13] were performed.

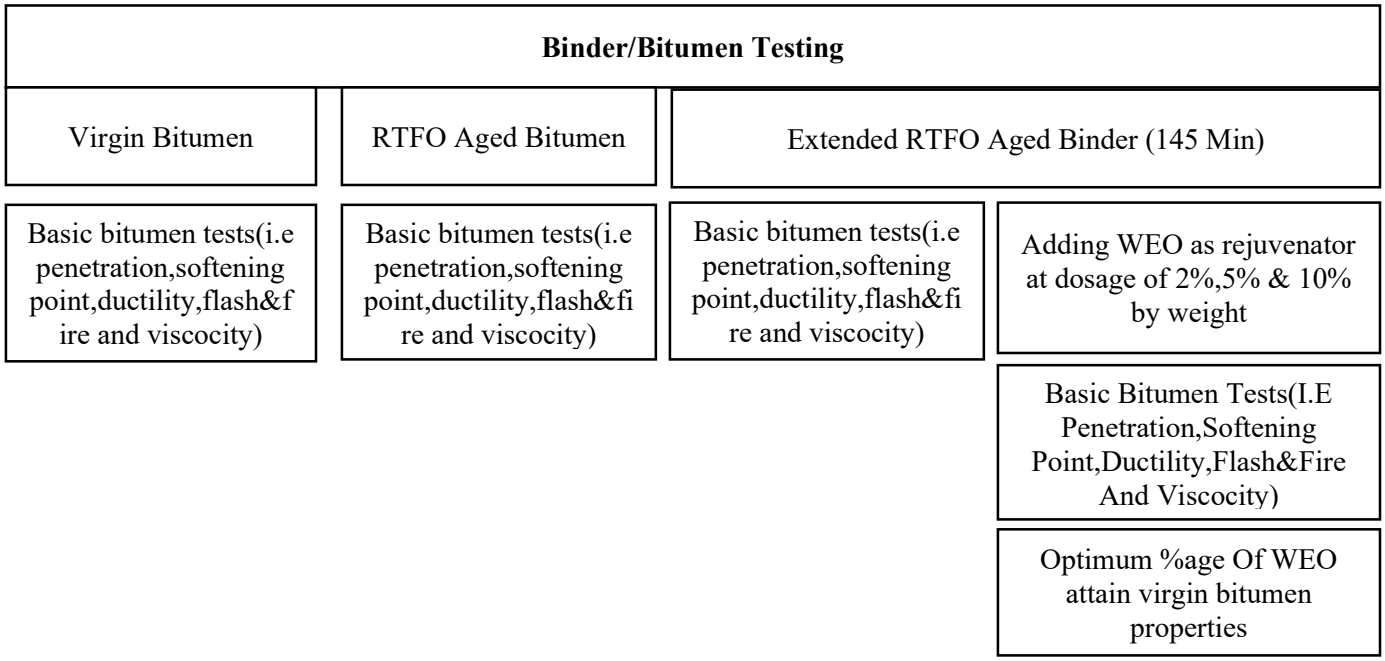

Figure 1: Methodology

3 RESULTS

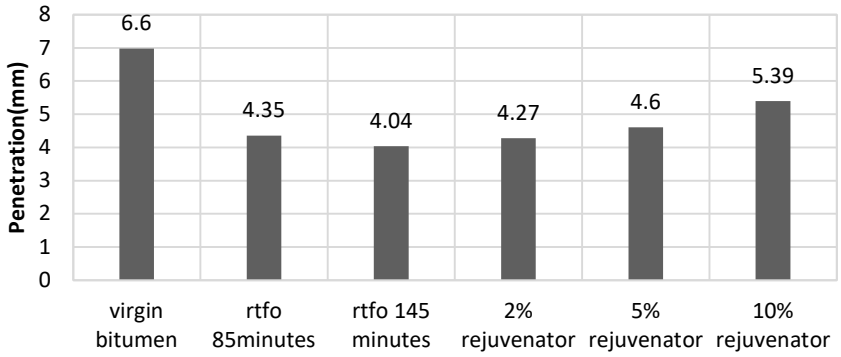

Figure 2 : Relative Comparison of Penetration test

The decrease in the penetration value occurs during the RTFO aging shows the stiffening of bitumen due to oxidative process .On the other hand increase in the penetration is because of the rejuvenation .WEO contains the comopnents which can soften and rejuvenate the aged bitumen.

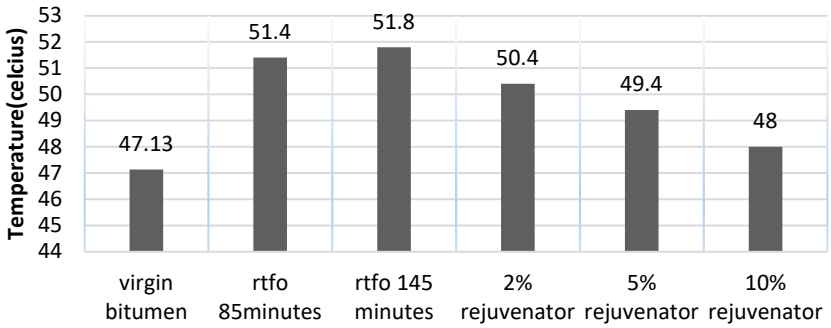

Figure 3: Relative Comparison Softening Point Test

The same goes on with softening point test as it was in the penetration test .the increase in softening point occurs because the molecular structure of bitumen changes when it is aged and it becomes more stiff.The WEO softening agents results in the reduction of softening point of bitumen.

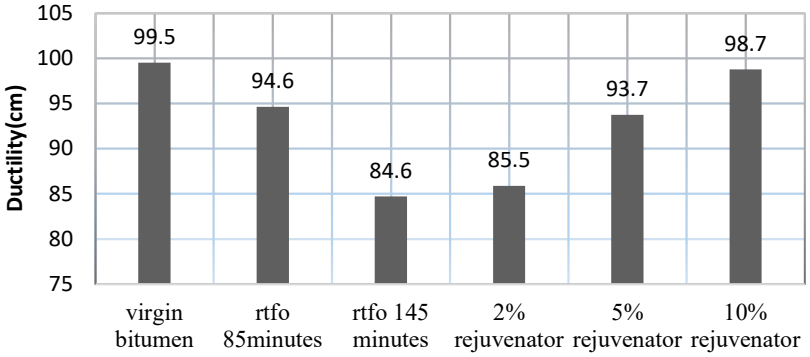

Figure 4: Relative Comparison of Ductility Test

The decrease in the bitumen occurs due to the RTFO for extended period of time which results in the stiffening of bitumen molecules.The WEO soften the bitumen which resulted in the increase of ductility.

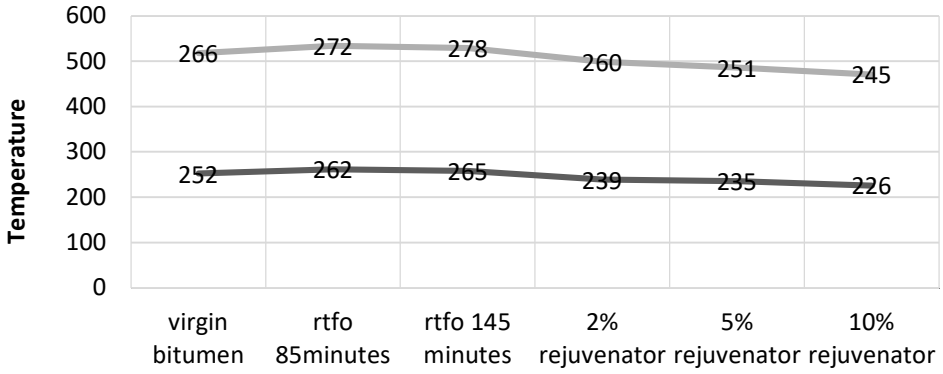

Figure 5 : Relative Comparison Of Flash And Fire Point

Under the high temperature conditions like in the RTFO aging process the properties of bitumen changed which resulted in the increase of flash and fire point.Increase in the flash and fire point of bitumen indicates that the it became less prone to the ignition as it ages.While the rejuvenation with waste engine oil shows that WEO diluted with the bitumen leading to decrease in the flash and fire point.

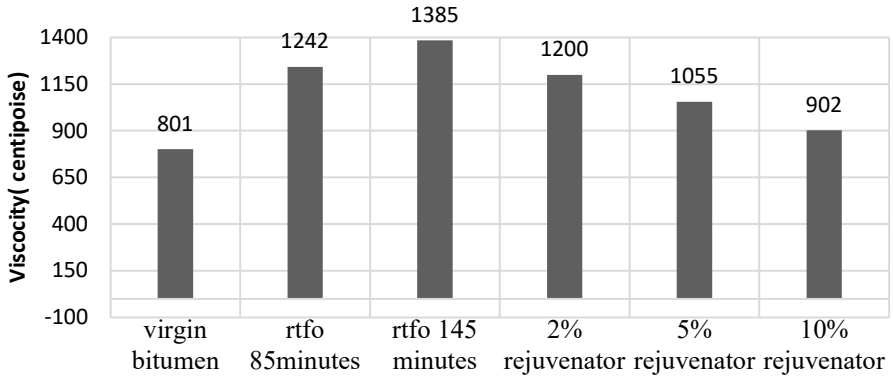

Figure 6: Relative Comparison of Relative Viscosity at 135°C

The increase in the viscocity observed during RTFO aging shows the stiffening and thickening of bitumen .Rejuvenation with WEO decreased the viscocity which resulted in the improvement of flow properties of bitumen. Using an asphalt sample in a thermostatically controlled sample holder, the torque on the apparatus-measuring geometry spins to calculate the relative resistance to rotation[13]. In comparison to other viscosity measuring methods, More precise and nearer to the field temperature of asphalt laying, the Rotational Viscometer measures viscosity at 135°C (275°F) [14].

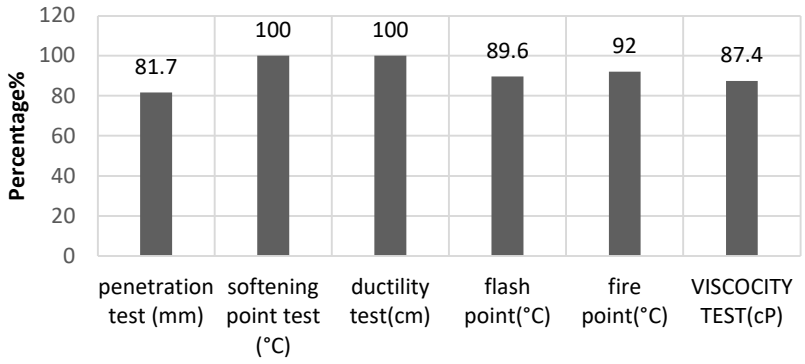

Figure 7: Recovery Percentages w.r.t Virgin Binder

The optimum percentage in this study was 10% because it showed that our bitumen properties are closed enough to the virgin binder properties.Using higher percentage of WEO may overly soften the which is beyond our desires.10% WEO concentration showed the satisfactory results in terms of the property recovery. Result s of this study reveal that the binder's basic properties of penetration, softening point, ductility, flash & fire point and viscosity are recovered by 81.7%, 100%, 100%, 89.6&92%, and 87.4% with respect to virgin binder when 10% Waste Engine Oil (by weight of bitumen) is added in extended short term aged asphalt binder.

4 CONCLUSIONS

The conclusions of this research is based on our two objectives which are to evaluate the short-term ageing effect of asphalt binder and to optimize the fix dosage of WEO as rejuvenator in lab simulated short term aged asphalt binder.

- The ageing performance evaluation indicates that percentage loss in penetration and ductility properties of extended RTFO aged binder is observed to be 39.39,15.32% as compared to virgin binder .Moreover the percent gain in viscosity , flash & fire point and softening point parameters is observed to be 42.1,5.1,4.3, and 9% as compared to virgin binder.
- The results of this study reveal that the binder's basic properties of penetration ,softening point, ductility, flash & fire point and viscosity are recovered by 81.7%,100%,100%,89.62 and 87.4% with respect to virgin binder when 10% Waste Engine Oil(by weight of bitumen) is added in extended short term aged asphalt binder.

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