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Evaluation of Asphalt Binder Properties Modified With Biomass Ashes and Waste Engine Oil

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Abstract:- Disposal of huge amount of waste product such as Rice Husk Ash (RHA), Wheat Straw Ash (WSA) and Waste Engine Oil (WEO) are causing environmental risk in the form of air and water pollution. In addition, non-availability of space is another big concern related to its safe disposal. The use of these waste materials in asphalt binder not only improves asphalt properties but also helps in reducing environmental problems. In this analysis RHA with 2% 4% 6%, WSA with 2% 4% 6% are mixed with WEO with 2% have been used to modify virgin bitumen. The modified binder specimens are evaluated by Bitumen Bond Strength test and Rolling Bottle test along with conventional testing to evaluate the adhesion and moisture susceptibility of modified asphalt binder. Experimental results explain that bitumen modified with 6% RHA and 2% WEO by weight of virgin binder shows better adhesion and moisture susceptibility as compared to control binder.

Keywords:- *Waste Engine Oil, Rice Husk Ash, Wheat Straw Ash, Asphalt, Adhesion.*

I. INTRODUCTION

Hot mix asphalt is used all over the world over a long period of time for flexible pavement. Using this conventional job mix formula (hot mix asphalt) a number of stress-related problems are developed, resulting in rutting, fatigue cracking and moisture damage. These problem are caused by overloading, climatic conditions, high and low temperatures[1][2]. To solve all the stress related problems binder modification is the best option[3]. In order to resolve rutting, fatigue and moisture damage, different binder modifications are used. Currently disposal of dumps is now a big concern due to lack of land and disruption to the environment. As the population grows, there is a rise in solid waste, which causes dumpsites and health problems[4][5].

Agricultural operations produce a significant amount of waste from harvested crops[6]. Plant/crop-derived biomass comprise mainly straws and husks. Production of vast amount of industrial waste causes significant environmental issues including similar concerns with landfills[7]. Agriculture waste produced is typically burned energy production supply in plants or mills [8]. Data from the FAO study showed that the annually mass production of rice and wheat worldwide are 7.82E + 08 tonnes and 7.34E + 08 tonnes, respectively200 kg of rice husk contains one tonnes of rice[9]. 1 tonnes of wheat grain yields over 1300–1400 kg wheat straw[10].

Arabani and Tahami evaluated the mechanical properties related to RHA-modified asphalt mixture and confirmed that inclusion of RHA hold major impact on rutting and fatigue [8]. Sargın et al. also claimed that RHA was a beneficial filler for asphalt mixture so finally concluded that using 50% RHA along with 50% limestone filler was the best mixture to increase Marshall 's stability and flow.[11]. Xue et al. used RHA as asphalt binder additive also have discovered its inclusion has enhanced physical properties. In addition, using FT-IR spectroscopy, this was observed that there is no chemical reaction between asphalt binder and RHA[12]. Zaidi et al. performed a systematic analysis of HL disruption to the moisture content of bitumen mastic and asphalt mixtures. Moisture damage evaluation can be produced by doing RBT, BBS tests, etc. and HL-modified asphalt concrete has demonstrated improvement in adhesion and resistance to moisture damage [13].

A large amount of RHA is dispose in form of dump causes land filling problem and WEO is dispose in rivers has been littered uncaringly, threatening the water and damaging the environment and human health. The use of these waste materials in asphalt mixture can help in solving these environmental problems and at the same time giving a more durable asphalt mixture.

The objective of this study:
To investigate the effect of RHA and WSA with WEO on properties of bitumen

II. EXPERIMENTAL AND RESEARCH METHDOLOGY

The material use in this research are 60-70 Pen grade bitumen, which is very common type of binder used in Pakistan. The aggregate from Margalla queries are obtained. RHA and WSA is taken from brick kiln in form of ash and WEO is taken from oil change shop.

The technique for preparing modified asphalt is to take percentage by weight of asphalt binder. A high shear mixer of 1500 rpm is used to ensure proper mixing of RHA and WSA in WEO modified asphalt. The mixing is done at 40 minutes at temperature of 160°C.

The effect of RHA and WSA in WEO binder was characterized by performing penetration and softening point test as per ASTM D5[14][15], ASTM D36 [16] respectively.

To investigate the bonding of bitumen with the aggregate after dry and wet condition PATTI (Pneumatic Adhesion Tensile Testing Instrument) was performed in terms of BBS test as per ASTM D 4541 [17]. For the preparation of the sample, the bitumen binder and sandstone aggregates were heated at 145ºC to ensure the proper bonding of stud with aggregates.

To investigate the moisture susceptibility, RBT as per BS EN 12697-11 [18] was performed. For the preparation of sample 170g aggregate and 8g bitumen was mixed. The bitumen coating on the sample was taken after 6, 24, 48 and 72 hours of rolling time.

The research methodology takes up for this work is given below in Figure 1.

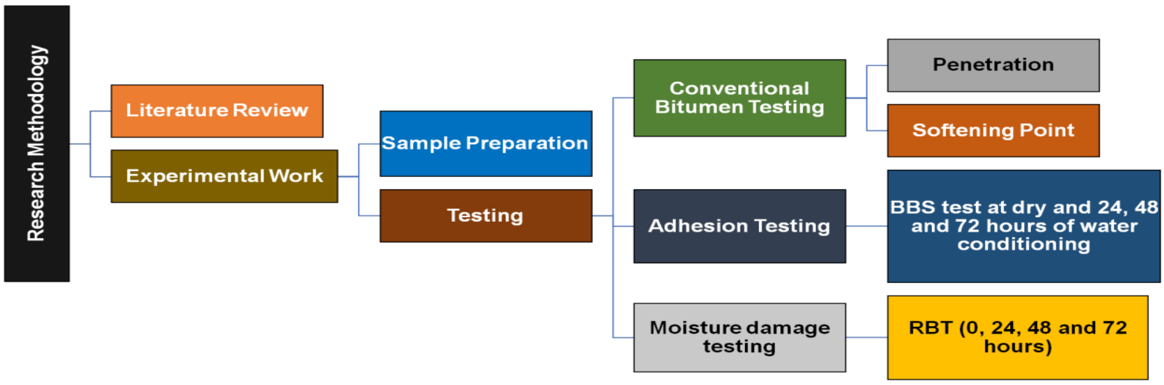

Figure 1: Research Methodology

Following combinations are used in our research study are given in table 1:

Combinations	**RO-1**	**RO-2**	**RO-3**	**WO-1**	**WO-2**	**WO-3**
Material %	2%RHA+2%WEO	4%RHA+2%WEO	6%RHA+2%WEO	2%WSA+2%WE0	4%WSA+2%WEO	6%WSA+2%WEO

III. RESULTS AND DISCUSSION

A. Conventional Testing

In this approach to study the effect of modifiers on bitumen conventional testing was performed. The purpose of performing penetration and softening point test is to check whether modified bitumen becomes soft or hard because softening and hardening of bitumen has a direct effect on adhesion and moisture damage.

The addition of RO-3 by weight of binder in 60-70 pen bitumen decreases the penetration value by 16%, whereas an increase of 31% in the softening point was observed as compared to control binder. In WO-3modified 60-70 pen bitumen a decrease of 12% in penetration value and increase of 27% value of softening point was observed as compared to control binder.

Hence, as the dosage of RHA and WSA in WEO increases, penetration values decreases and softening point increases which means the addition of RHA and WSA in WEO in 60-70 pen bitumen, the binder become harder.

The experimental results of conventional testing are shown in Figures 2

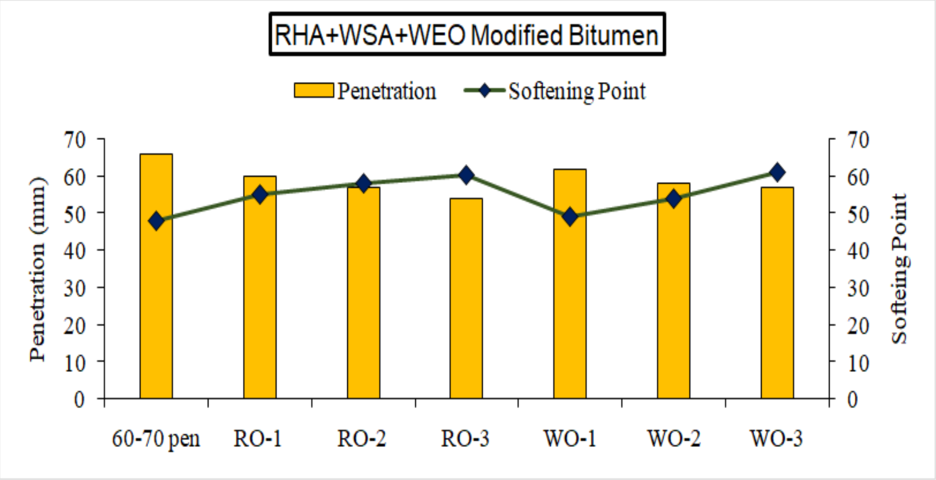

Figure 2: 60-70 pen grade modified and unmodified bitumen penetration and softening point values

B. Evaluation of adhesion using BBS test

The experimental evaluation of the effect of RHA and WSA in WEO on adhesion, the Pneumatic Adhesion Tensile Testing Instrument (PATTI) was used. The main test advantage is that adhesion between bitumen and aggregate can be found easily in the sense of force. All samples were tested under dry and water cured conditions (24, 48, and 72 hours). The RHA and WSA (2%,4%,6%) and WEO (2%) by weight of binder were used in the control binder to check the bond strength ofbitumen aggregate system. The burst pressure at which stud detaches from the aggregate sample can be determined from PATTI which is then used in equation 1 to calculate Pull Off Tensile Strength (POTS).

$$\text{POTS} = \frac{(\text{BP}\times A_g)-C}{A_{ps}} \qquad (1)$$

POTS is the pull-off tensile strength
BP is the burst pressure
A_g is contact area having a value of 2620 mm^2
C is the piston constant 0.286

A_{ps} is the area of pull-stub having a value of 127 mm^2, for this study F-4, stub type was used. The addition of RO-3 and WO-3 by weight of binder in 60-70 pen bitumen 48% and 39% POTS values increase at dry condition compare to control binder respectively.

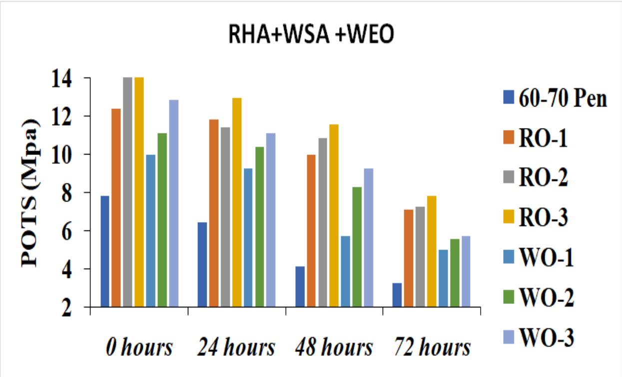

Figure 3: POTS values of 60-70 pen grade modified and unmodified bitumen at dry and wet conditioning

After 24, 48 and 72 hours of wet conditioning the POTS values of the RO-3 and the WO-3 decrease but remain higher than control binder because the water penetrates the bitumen-bitumen interface and bitumen-aggregate interface which weakens the bond.

In 60-70 pen modified bitumen with the RO-3 higher POTS values as compared to control binder were observed in dry conditions. But the WO-3 modified bitumen showed lesser values after water conditioning as compared to dry conditions.WO-3 shows lesser values of POTS in dry and water conditions as compared to RO-3 but shows improved results as compared to the control binder.

C. Failure surface analysis

When stub detaches from the aggregate surface, there are two types of failures, one is an adhesive failure and the other is cohesive failure. Visual identification of bitumen remains on aggregate sample determines the type of failure. When bitumen remains on the aggregate surface are greater than 50% then it is cohesive failure else it is an adhesive failure. In the case of 50% bitumen remains on aggregate the failure is cohesive-adhesive.

Table. 2 Percentage of bitumen and failure type after dry and wet conditioning

CT*	60-70 Pen	RO-1	RO-2	RO-3	WO-1	WO-2	WO-3
0 hours	55C	60C	70C	85C	70C	80C	90C
24 hours	45A	50C/A	65C	70C	65C	70C	70C
48 hours	30A	40A	55C	55C	40A	60C	65C
72 hours	25A	25A	45 A	45 A	30A	40A	40A

CT* curing time; A, adhesive failure; C, cohesive failure; C/A, 50% adhesive 50% cohesive failure

Table 1 show the percentage of bitumen coverage and the failure type after dry and wet conditioning of the sample. In 60-70 pen bitumen modified by RO-3 higher bond strengths were achieved and failure changes from cohesive

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to adhesive after 48 hours of water conditioning. Whereas in 60-70 pen bitumen modified by WO-3 show higher bond strength and failure changes from cohesive to adhesive after 48 hours of wet conditioning.

IV. MOISTURE DAMAGE EVALUATION USING RBT

Rolling bottle test was performed to measure the affinity between bitumen and aggregate.From figure 4, it could be concluded that increase in rolling time decreases bitumen coverage. RHA and WSA in WEO modified bitumen adhesion effect is clear as compared to control binder. The RO-3 and WO-3 modified binder increases 40% and 34% coverage respectively as compared to control binder after 72 hours of rolling time. In the RHA with WEO modified bitumen of 60-70 pen grade adhesion effect is prominent.

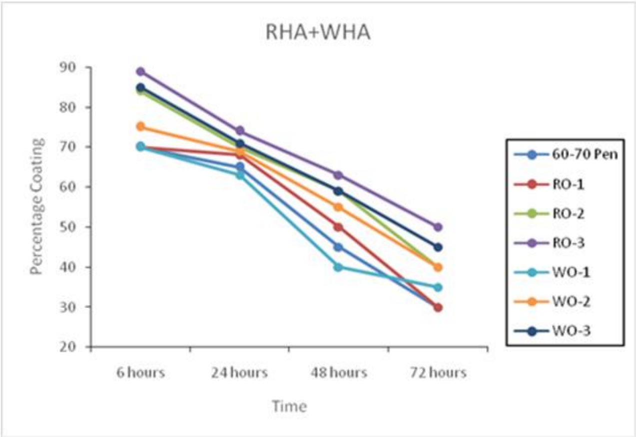

Figure 4: Comparison of the percentage of bitumen coverage of 60-70 modified and unmodified bitumen at different duration

V. CONCLUSION

The following conclusions are drawn from our research study:

- Addition of RO-3 in virgin binder shows least penetration value and highest softening point value in all the studies combinations. RO-3 penetration value decrease by 16% and softening point increased by 31% and for WO-3 penetration value decreased by 12% and softening point increased by 27% than virgin binder.
- Addition of RO-3 and WO-3 in virgin binder resulted in an increase 48% and 39% of POTS under dry conditions as compared to control binder. After 24, 48, and 72 hours of wet conditioning a direct trend of reduced POTS values with conditioning timehas been observed.
- In RBT, RO-3 gave the best results after 72 hours compared to all other combinations followed by WO-3, RO-2 and W2 respectively.

Considering the results from this study, it can be concluded that combination RO-3 has been observed best performing in all the studied combinations and can be considered as a good option to modify the bitumen samples having weak adhesion properties.

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