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Application of Waste Oil as An Effective Construction Material with Reclaimed Asphalt Pavement

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ABSTRACT

The current asphalt pavement industry faces two major issues. These two main issues are the increasing call for eco-friendly asphalt mixtures and the charges of raw materials. The usage of cultivated asphalt pavement will be an key effort to reduce the prices of aggregates and bitumen in the ultimate mixture. On the other hand, the main trial for implementing RAP (Reclaimed Asphalt Pavement) is to overcome quality issues. RAP doesn't perform like a new pavement since it is an old material and needs to be upgraded. This puts forward the necessity for extra practices like consuming of rejuvenating agents. Since bitumen drops its oily components when it ages, the use of oil-containing additives can be effective. In this study, two types of waste oils were used to revitalize aged asphalt mixture. The chief contents of Waste Engine Oil (WEO) and Waste Vegetable Oil (WVO) flavours were resolute in order to instrument various RAP contents. The special effects of these two oily based rejuvenators on utilization of RAP in bituminous mixtures were studied. The results signified that the use of WEO and WVO as rejuvenators for mixtures containing RAP enhances the amount of RAP used in bituminous mixtures.

Keywords : Waste Vegetable Oil, Waste Engine Oil, Reclaimed Asphalt Pavement

I. INTRODUCTION

Due to augmented environmental consciousness and limited resources, researchers are looking for innovative methods and technologies to safeguard sustainability, efficiency and less greenhouse gases in asphalt industry. In recent years, reutilizing of materials has been on the forefront of new technologies predominantly in construction sector. Reclaimed Asphalt Pavement (RAP) is old pavement materials reclaimed to be utilized over. In road construction industry, the deployment of reclaimed asphalt pavement (RAP) in hot bituminous mixtures can relief the agitated use of natural resources and as a matter of passage can cause less damage to our nature [1]. There are similarly other zones of implementation for RAP in construction sector. RAP can be castoff as embankment material, but also as aggregates in hot and cold recycling technologies [1]. Cold recycling of bituminous mixtures comprises RAP, water and a recycling agent without smearing heat generally by use of emulsions, since hot recycling implements recycling agents in presence of heat. Together hot and cold recycling methods can be carried out at a production plant or in situ. The shared point in both recycling methods is the existence of a recycling agent utilized to make the application more convenient and to augment the quality.

Pavements:

Adaptable Pavements are built from bituminous or unbound material and the pressure is communicated to the sub-level through the parallel dissemination of the applied burden with profundity.

Adaptable asphalt is made out of a bituminous material surface course and basic base and subbase courses. The bituminous material is all the more regularly black-top whose thick nature permits noteworthy plastic misshapening. Most black-top surfaces are based on a rock base, albeit some 'full profundity' black-top surfaces are constructed legitimately on the subgrade. Contingent upon the temperature at which it is applied, black-top is arranged as hot blend black-top (HMA), warm blend black-top, or cold blend black-top. Adaptable Pavement is so named as the asphalt surface mirrors the complete redirection of all ensuing layers because of the traffic load following up on it. The adaptable asphalt configuration depends on the heap disseminating qualities of a layered framework.

It communicates burden to the subgrade through a blend of layers. Adaptable asphalt circulates load over a generally more modest zone of the subgrade underneath. The underlying establishment cost of an adaptable asphalt is very low which is the reason this kind of asphalt is all the more ordinarily observed all around. Notwithstanding, the adaptable asphalt requires upkeep and routine fixes like clockwork. Also adaptable asphalt falls apart quickly; breaks and potholes are probably going to show up because of helpless waste and weighty vehicular traffic.

An important favorable position of adaptable asphalt is that it tends to be opened for traffic inside 24 hrs after finish. Additionally the fix and upkeep of adaptable asphalt is simple and practical.

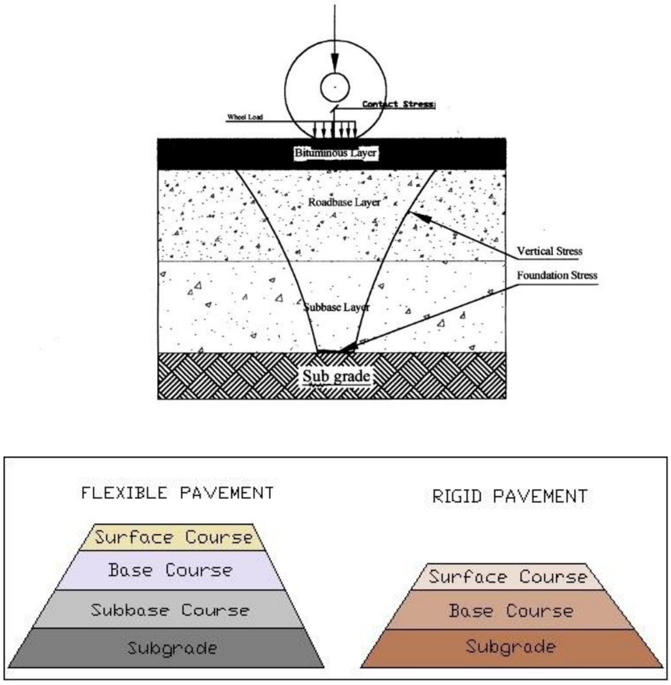

Fig 1 : Pavement

About WEO and WCO

Squander motor oil which is normally an oil based commodity and is regularly commonly defiled by pollutions during physical or potentially substance measures. The utilization of motor oil oils after some time makes the oil not, at this point reasonable for its unique reason and should be supplanted by virgin or re-refined oil (U.S. EPA, 1996). The waste motor oil which comprises of non-degradable segments as a major aspect of its constituents that are difficult to be decayed (Vazquez-Duhalt, 1989); if inappropriately arranged, the contamination of the waste motor oil may make unsalvageable harm the climate (Baker, 1970). Following the way that there is an enormous amount of side-effect from the car business and side-effect of searing nourishments from cooking eateries, for example, KFC, Chicken Licken, among numerous others, if not arranged appropriately can force unfavorable effect on the climate. Reusing of the side-effect can be viewed as a promising feasible activity, which offers preservation of characteristic assets and monetary advantages (Nurul et al., 2014). Lake or waterway quality gets weakened and dirties the characteristic balance of the oceanic life environment. The wellspring of waste oil contamination to the waterway can be contributed by motor oil from car industry and furthermore squander cooking oil from neighborhood. With the worry of high asphalt development cost and the requirement for characteristic asset protection, squander oil reusing is turning into the suitable option in relieving these issues (El-Fadel and Khoury, 2001). During vehicular motor ignition activity, substantial metals including lead, zinc, calcium, and magnesium bit by bit collect in the motor oil as work is done in the motor as the vehicle moves starting with one spot then onto the next (DeDene, 2011; Dominguez-Rosado and Pichtel, 2003). These metals are demonstrated to cause groundwater and soil pollution forever when unloaded into the ground or into water streams (Hopmans, 1974). The U.S. DOE assessed that 83% of waste motor oil is singed in a sum of 945 million gallons of researched reused utilized oil (U.S. DOE, 2006). As an oil based item, squander motor oil has comparative sub-atomic structures as black-top cover (DeDene, 2011).

II. Literature Review

1. Shen et al. (2007) assessed the usage of reviving specialists on Superpave combinations containing RAP. It is accounted for that the mechanical properties of blends including RAP and the reviving specialist were improved. Furthermore, more measure of RAP could be incorporated inside the Superpave blends by utilization of sleek based rejuvenators.
2. Asli et al. (2012) explored the achievability of waste cooking oil as a rejuvenator in reused blends. Creators showed that the utilization of waste cooking oil restored the properties of matured bitumen. It is said that the restored bitumen carried on like virgin bitumen as far as infiltration and mellowing point. The scientists likewise guaranteed more measure of RAP inside the reused combinations could be available by execution of waste cooking oil.

III. Proposed Methodology

Materials

The 50/70 penetration virgin bitumen grade acquired from Aliaga/Izmir Oil Terminal of Turkish Petroleum Refinery Corporation was castoff in this study. In order to describe the characteristics of the virgin bitumen, conventional test such as: penetration test, softening point test, ductility test, etc. were executed. These tests were directed in conformity with the relevant test methods that are presented in Table 1.

Table 1. Properties of virgin bitumen

Test	Specification	Results	Specification limits
Penetration (25° C; 0.1 mm)	TS EN 1426	63	50–70
Softening point (°C)	TS EN 1427	49.7	46–54
Viscosity at (135° C)-Pa.s	ASTM D4402	0.425	–
Viscosity at (165° C)-Pa.s	ASTM D4402	0.1	–
Rolling Thin Film Oven (163° C)	TS EN 12607-1		
Change of mass (%)		0.05	0.5 (max)
Retained penetration after RTFO (%)	TS EN 1426	74	50 (min)
Softening point rise after RTFO (°C)	TS EN 1427	4.5	7 (max)
Specific gravity	ASTM D70	1.038	–
Flash point (°C)	TS EN 22592	+260	230 (min)

The asphalt mixtures were fashioned using limestone aggregates. Fine and coarse limestone aggregates were obtained from Dere Madencilik/Izmir quarry. In order to calculate the characteristics of the limestone aggregate, sieve analysis, specific gravity, Los Angeles abrasion resistance test, sodium sulfate soundness test, fine aggregate angularity test and flat & elongated particles tests were conducted on the aggregates. The results are presented in Table 2. Grading of aggregate was selected in conformity with the Type I Wearing Course of Turkish Specifications. Table 3 applies to the final gradation.

Table 2. Properties of limestone aggregate

Test	Specification	Result	Specification limits
Specific Gravity (Coarse Agg.)	ASTM C 127		-
SSD		2.717	-
Bulk		2.704	-
Specific Gravity (Fine Agg.)	ASTM C 128		-
Apparent		2.741	-
Bulk		2.691	-

Table 2 Properties of limestone aggregate

Test	Specification	Result	Specification limits
Specific Gravity (Coarse Agg.)	ASTM C 127		-
SSD		2.717	-
Bulk		2.704	-
Specific Gravity (Fine Agg.)	ASTM C 128		-
Apparent		2.741	-
Bulk		2.691	-

Table 3 Properties of limestone aggregate (cont.)

Test	Specification	Result	Specification limits
SSD		2.709	–
Apparent		2.739	–
Specific Gravity (Filler)		2.732	–
Los Angeles Abrasion (%)	ASTM C 131	22.6	Max. 30
Flat and Elongated Particles (%)	ASTM D 4791	7.5	Max. 10
Sodium Sulphate Soundness (%)	ASTM C 88	1.47	Max. 10–20
Fine Aggregate Angularity	ASTM C 1252	47.85	Min. 40

Table 4 Gradation Table

Sieve Size/No.	Gradation (%)	Specification	Specification Limits (%)
19 mm.	100	Type I Wearing	100

12.5 mm.	92	Course (Turkish Specification)	83–100
9.5 mm.	73		70–90
No.4	44.2		40–55
No.10	31		25–38
No.40	12		10–20
No.80	8		6–15
No.200	5.3		4–10

Reclaimed type I wearing surface course exposed to traffic loads for a age of 12 years was used as RAP 16 x 1000 gr. of batch models were designated randomly using a random separator. The bitumen percent and gradation of RAP materials were determined. The bitumen of the aged asphalt was extracted and refined using a laboratory type extractor and distillatory. Conferring to the test results, the bitumen percent of the RAP was found 4.30%. As a last point, sieve analysis performed on the extracted aggregates. The results are given in Table 4. The conventional bitumen tests were conducted to the extracted bitumen of RAP. The results for the extracted bitumen are presented within Table 5

Table 5. Sieve analysis of RAP aggregates

Sieve No	Retained (%)	Passing (%)	Spec. Limits (%)
19 mm.	0	100	100
12.5 mm.	1.6	98.4	83–100
9.5 mm.	10.1	89.9	70–90
No.4	45.9	54.1	40–55
No.10	69.8	30.2	25–38
No.40	86.5	13.5	10–20
No.80	91.18	8.82	6–15
No.200	94.17	5.83	4–10

Table 6. Properties of RAP bitumen

Test	Specification	Results
Penetration (25 °C; 0.1 mm)	TS EN 1426	38
Softening point (°C)	TS EN 1427	61
Viscosity at (135 °C)-Pa.s	ASTM D4402	0.538
Viscosity at (165 °C)-Pa.s	ASTM D4402	0.188

The waste engine oil that will be used as a rejuvenator was delivered from varies industrial organizations and waste vegetable oil was acquired from retail a supply who possesses the license for collection of waste oils.

IV. Experimental Results

Table 7. Properties of rejuvenated RAP binder modified with optimum WEO content.

Test	Specification	Results		Specification limits
		WEO (5.4%)	WVO (5.1%)	
Penetration (25 °C; 0.1 mm)	TS EN 1426	63	63	50–70
Softening point (°C)	TS EN 1427	54	55.3	46–54
Viscosity at (135 °C)-Pa.s	ASTM D4402	0.412	0.400	–
Viscosity at (165 °C)-Pa.s	ASTM D4402	0.087	0.075	–
Rolling Thin Film Oven (163 °C)	TS EN 12607-1			
Change of mass (%)		0.12	0.1	0.5 (max)
Retained penetration after RTFO (%)	TS EN 1426	53	59	50 (min)
Softening point rise after RTFO (°C)	TS EN 1427	6	5	7 (max)

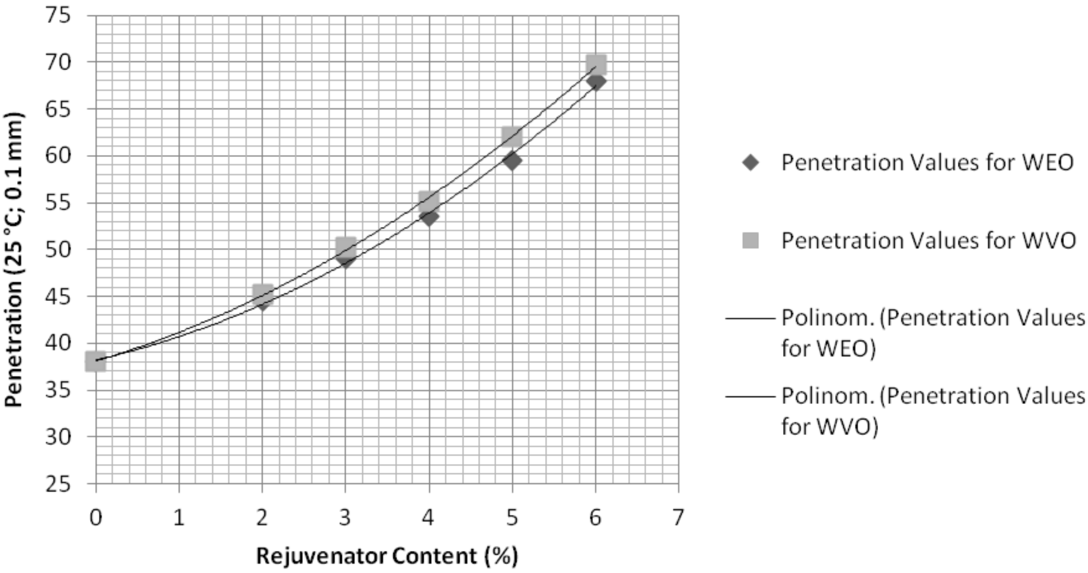

Fig. 2 Penetration values corresponding various contents of WEO and WVO

Mixture test results

As declared before, the maximum RAP percent were obtain for mixture containing non-rejuvenated and rejuvenated RAP in the way to relate the highest potential of RAP to be employed within a type I wearing course.

Marshall Stability and flow results

Volumetric analysis together with Marshall Stability and flow values were basic criteria in choice of maximum possible RAP percent for both mixtures involving non-rejuvenated and rejuvenated RAP. Outcomes for air void contents, stabilities and flow rates are correspondingly presented in Fig. 5.2 to Fig. 5.4 for WEO and WVO rejuvenated specimens as well as control specimens.

From Fig. 3, entire mixtures containing rejuvenated RAP could encounter volumetric criteria in terms of air voids since mixtures containing non-rejuvenated RAP flop to satisfy preferred air voids percent for mixtures containing more than 40% of non-rejuvenated RAP. The purpose that volumetric characteristic of rejuvenated RAP containing mixtures stayed within the desired percent is attributed to inferior viscosity readings of rejuvenated RAP binder and therefore improved workability. At standard mixing and compaction temperatures, it is more suitable to process WEO and WVO rejuvenated RAP mixtures than non-rejuvenated RAP mixtures. Vegetable centred oil performed better than engine oil in relations to softening the stiff RAP materials. This is in similar with the result of penetration test. This can be recognised to greater resistance of vegetable based oils to volatilization during production (mixing & compaction) phase at high temperatures.

When Fig. 4 is analysed, it is understood that all stability readings are over specification boundary. This outcome is predictable since the bitumen within RAP is considered as an aged binder and thus the mixtures containing RAP are stiffer than virgin bituminous mixtures and therefore these mixtures callibrated high stabilities. In fact, the utmost alarmed issue for RAP recycling technologies is considered as durability rather than stability. Thus, volumetric properties and flow rates (somehow, as an indicator of flexibility) are more determinative for maximum possible RAP percent than stability readings.

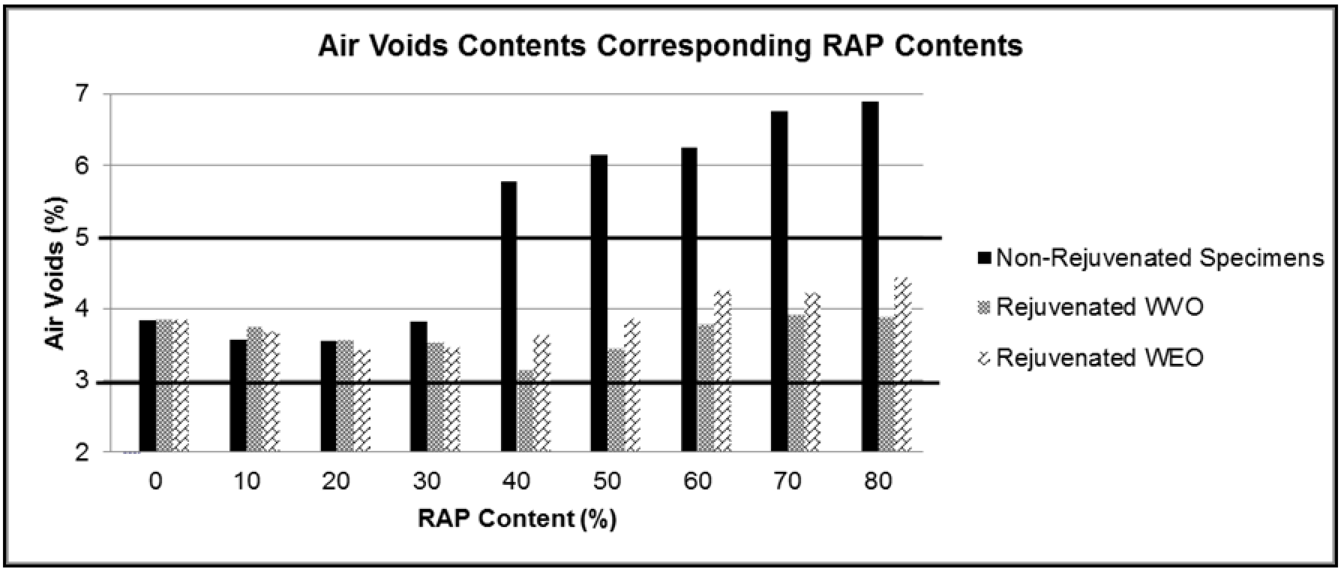

Fig. 3 *Air void contents*

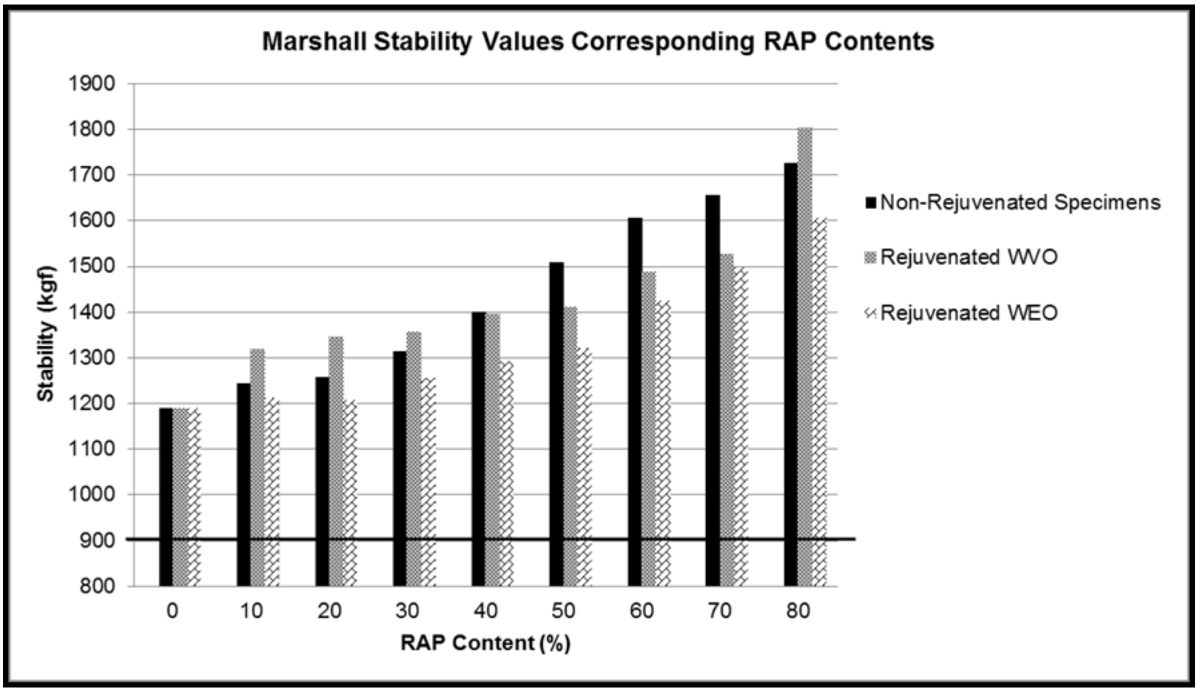

Fig. 4 *Marshall stability values*

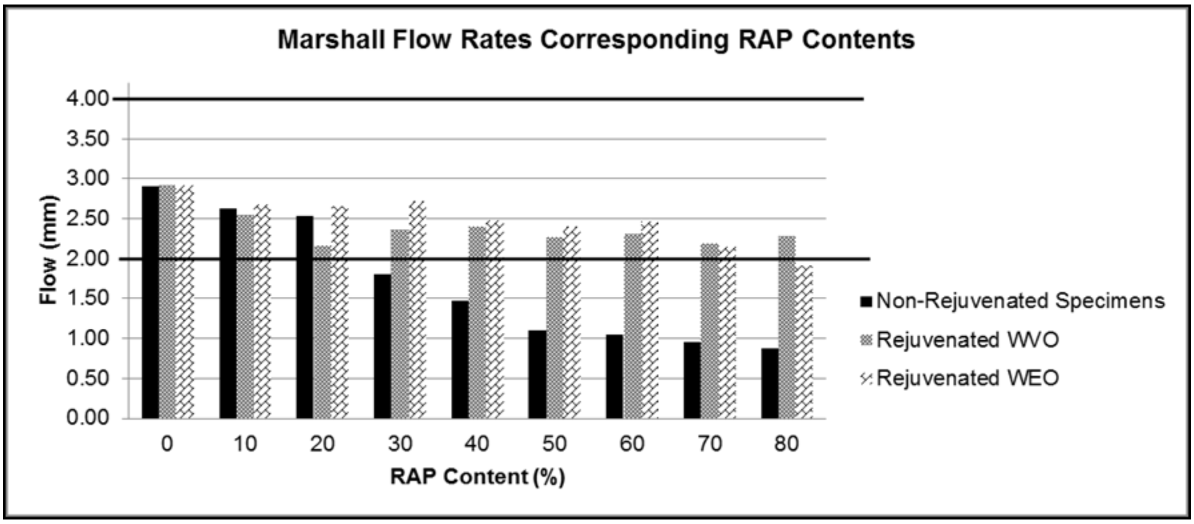

Fig. 5 *Marshall flow rates*

V. CONCLUSION

Proficient placement of assets should be managed in asphalt paving industry and real attention should be given to the matter. Aggregate quarries and petroleum industry together consume natural resources to feed asphalt paving industry with raw materials. Sustainability should not persist in just paper subjects but also it must developed a communal and institutional responsibility. Recycling is now conceivable with modern techniques and novel technologies are introduced all alongside the time to industrial domain. Reutilizing of aggregates and bitumen will protect natural resources and accordingly the road construction expenses to a large extent. Furthermore, recycling of RAP with waste oily additives will also be in support of waste management. WEO and WVO additives as their name says are waste materials and are supposed to be recycled, reutilized or disposed.

Under the possibility of this study, the impact of WEO and WVO rejuvenators on characteristics of RAP was examined. It was established that, these rejuvenators as oily additives participate actively taking the duty of previously evaporated and/or separated oil ingredients of aged RAP binder. The characteristics of RAP binder can be improved by usage of WEO and WVO to accomplish specification requirements. Binder penetration and softening point readings as well as viscosity of binder can be revised by optimum WEO and WVO contents. Penetration value is determinant in calculation of optimal rejuvenator content. For any other of rejuvenator present in the market, the choice process can be conducted in order to obtain optimum content. In this research, 5.4% of WEO by weight of binder and 5.1% of WVO by weight of binder have been found tolerable based on penetration values. It is suggested to execute supplementary tests in lights of Superpave standards and specifications. Rheological valuation of rejuvenated binders can be extra interpretive in terms of characterization of rejuvenated binder. Rejuvenated binder not only can achieve desired properties, it is also capable of meeting after RTFOT necessities. It can be state that both WEO and WVO are substantial additives in rejuvenation of aged RAP binder.

Applying WEO and WVO as rejuvenators makes it possible to include high amounts of RAP within HMA wearing courses. By rejuvenation technology up to 70-80% of RAP can be operated without adverse effects (as per Turkish specifications) within the surface courses. Rejuvenated mixtures are suitable to practice in terms of mixing and compaction. WEO and WVO appropriate for the compaction at standard HMA application temperature ranges. Investigations existing represents that rejuvenated RAP mixtures are less brittle and more durable than non-rejuvenated RAP mixtures. Aging indices of rejuvenated mixtures are enhanced matched to non-rejuvenated mixtures. It is suggested to estimate mechanical properties of rejuvenated RAP mixtures in accord with Superpave criteria. Mixtures should be made by means of a gyratory compactor and estimated for volumetric analysis. Supplementary performance based experiments should be conducted. For RAP mixture tests, rutting and fatigue performance evaluation are highly recommended as well.

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