*Kufa Journal of Engineering*
*Vol. 9, No. 4, October 2018, P.P. 1-12*
*Received 30 July 2017, accepted 7 September 2017*

# ASSESSMENT OF THE HOT MIX ASPHALT PROPERTIES USING REED PLANT MODIFIED ASPHALT

**Sahar S. Neham[1]**

**[1] Ph. D., Lecturer, Building and Construction Department, Kerbalaa Technical Institute, Al-Furat Al-Awsat Technical University, Email: Naham_1969@yahoo.com**

http://dx.doi.org/10.30572/2018/kje/090401

## ABSTRACT

Many researchers' attention was drawn by the process of improving the characteristics and the performance of hot mix asphalt. In this research, Reed Plant Ash (RPA) and Reed Plant Powder (RPP) were used as a substance to optimize the characteristics of asphalt at (5, 10, 15, and 20) % by asphalt weight. The laboratory work included two parts to get the requirements of the research: the first part is the physical properties for pure and modified asphalt. The second part is the prepared specimen of HMA with pure and the best percent of modified asphalt according to the Marshall criteria using limestone dust at 7% as a filler to the surface layer. The study found that the HMA with modified asphalt by 10% RPP has more effects on its performance by improving the Marshal Stability, volumetric properties, tensile strength ratio, and retained Marshall Stability rather than control mix and HMA with modified asphalt by 15% RPA.

**KEY WORDS:** Modified asphalt; Reed plant ash (RPA); Reed plant powder (RPP); Stiffness modulus and Marshall assetes.

## 1. INTRODUCTION

The reed plant was chosen in the purpose of preserving the environment and its sustainability, and it is a material where there is an abundance of it in Iraq, especially near drainage banks and sewage pipes as well as it is an inexpensive material.

NCHRP 459 (2001) indicated that modification of asphalt binders is helpful to reach the requirements of the performance of flexible pavement at high - and low temperature grades, or it can improve the binder's performance at severe-service condition, such as very high traffic volume or at a high percentage of slow-moving and heavy vehicles.

The replacement of a fine aggregate of asphalt mixture by recycled concrete aggregate and steel slag improves Marshall Stability and decreasing flow Arabani and Azarhoosh, (2012).

Do and keun (2008) stated that using recycled waste lime (RWL) as a filler in asphalt concrete mixture improved the resistance to permanent deformation at high temperatures.

Many researchers studied how to improve hot mix asphalt concrete properties and performance, the resisting to moisture damage ability and reducing temperature sensitivity by modifying it using additives materials as a partial replacement of mineral filler or using the same materials to modify the asphalt cement with many methods. Table 1 summarizes some of the previous work using modified asphalt cement, as well as Table 2 summarizes studies to modified asphalt concrete mixture.

**Table 1. Summary of some Literature Review to Studies Modified Asphalt in HMA.**

| Author and Year | Additives Material | Additivs by Asphalt Cement Weight;% | Test | Summary of Finding |
|---|---|---|---|---|
| Ghaly 2008 | Tire Rubber (TR) | 2,3,4 and 5% | **1.** Marshall Properties;<br>**2.** Wheel Track Apparatus**.** | **1.** Improved Marshall Stability by 26.8%;<br>**2.** Reduction in the value of Rut Depth by 23.5%. |
| Al-ani 2009 | Rubber-Silicone | (1%, 2%, 3% and 5%) | **1.** resistance to plastic flow (Marshall Stiffness)<br>**2.** Permanent Deformation ( diametric tensile creep ). | **1.** Increasing the Marshall stability, air voids;<br>**2.** Decreasing in flow and bulk density;<br>**3.** Increasing the flexibility properties. |
| FHWA 2012 | Polyphosphoric Acid (PPA) | (0.5-3)% by wt. of binder | **1.** Dynamic Modulus;<br>**2.** beam fatigue;<br>**3.** flow number testing. | **1.** Use PPA improving the delayed elastic response of the modified asphalt;<br>**2.** Use PPA between 1.0% to 1.5% increase the moisture damage potential. |
| Khalid *et al.*, 2015 | (Waste plastic bottles Polyethylene Terephthalate (PET) ) | (2, 4, 6, 8 and 10%) | **1.**Marshall Stiffness;<br>**2.**Marshall properties. | **1.**The values of the bulk density, stability ,stiffness and VFA have been increased;<br>**2.**The values of flow, VTM, VMA have been decreased;<br>**3.**Reducing Permanent Deformation and fatigue life of asphalt mixture. |
| Mohammed& Hamid 2015 | Aspha-min®; Sasobit® and crumb rubber | 1.5% | **1.** Indirect tensile strength;<br>**2.** Indirect tensile resilient modulus;<br>**3.** Flexural beam fatigue;<br>**4.** Hamburg wheel-tracking. | **1.** Use Aspha-min® reduced the indirect tensile strength and resilient modulus values;<br>**2.** WMA with two additives increased the rut depths of the mixes;<br>**3.** Both the additives reduced the tensile strength ratio of the mixes. |

**Table 2. Summary of some Literature Review to Studies Modified Asphalt Concrete Mixtures.**

| Author and Year | Additives Material | Additivs;% | Test | Summary of Finding |
|---|---|---|---|---|
| Al-Ani & Ahmed 2011 | Tires Crumb | 2, 4 and 8% | 1. Marshall Properties<br>2. Indirect Tensile Strength | **1.** Improved Marshall Stability after using 2% Tir Crumb then MS decreased.<br>**2.** Icreased the value of air voides.<br>**3.** Reduction in the tensile strength of HMA about 10% - 30% than control mixture. |
| Nabil *et al.*, 2014 | Concrete aggregate for old and demolition building | (0,25,50,75, 100)% from weight of coarse aggregate. | **1.** Marshall Properties;<br>**2.** Indirect Tensile Strength. | **1.**50% of recycled concrete aggregate improving the Marshall stability, bulk density, stiffness, flow, air void of asphalt mixture;<br>**2.**50% of recycled concrete aggregate improving the temperature susceptibility. |
| Abbaas; 2014 | Recycled cement concrete filler RCCF | 7% filler | **1.**X-ray Diffraction;<br>**2.**Chemical Composition;<br>**3.**Scanning Electron Microscopy (SEM);<br>**4.** Resistance to Plastic Flow;<br>**5.** Static Creep Test. | **1.**Use the RCCF can improve the resistance of asphalt mixture to permanent deformation especially in hot region;<br>**2.**Use the RCCF in HMA at cold region leads to increase the value of permanent deformation (rutting) in asphalt surface layer. |
| Nahla & Ammar 2015 | Polymers with natural sand (desert sand and river sand ) | (0, 25, 50, 75 and 100% by weight of the sand passing sieve no. 8 and retained on sieve no 200) | **1.** Marshall Test;<br>**2.** Indirect Tensile Strength;<br>**3.** Wheel Track Apparatus. | **1.** Decreasing in Marshall stability when increasing the natural sand content;<br>**2.** Marshall stability, indirect tensile strength and Wheel Track tests of asphalt mixture with desert sand in gives better results than river sand ;<br>**3.** Decreasing in the rutting depth for the modified specimens . |
| Saad & Ammar 2015 | Silica fumes and fly ash | 1,2 and 3% (SF), 2,4, and 6% (FA) | Repeated Flexural Fatigue Beam Testing | Fatigue lifeof HMA increased by 50% and 111% with silica fumes and fly ash respectively, as compared with control mix. |

## 2. PREPARING OF USED MATERIALS

AL-Dura refinery Asphalt Cement (40-50) penetration grade is used in this study; Table 3 shows the physical properties of it.

Physical properties of coarse and fine aggregate crushed quartz from Al-Nibaie quarry are used according to the mid specification of (SCRB, 2003/ R9) requirements of surface course gradation type IIIA; as showed in Table 4, also Table 5 shows the used gradation.

Limestone dust is used as mineral filler from lime factory in Karbala governorate.

Reed plant was collected, dried, scorched, and sieved by sieve #200 to prepare Reed Plant Ash as shown in Fig. 1. Preparing Reed Plant Powder by drying it in an oven in 110 ± 10$^{o}$C then grinding and sieving it by sieve #200 as shown in Fig. 2. Table 6 explains the physical properties of the filling materials used in this study.

**Table 3. Properties of Pure Asphalt Cement (40-50) Penetration Grad Used.**

| Property | ASTM Designation | Test Results | SCRB Specification |
|---|---|---|---|
| Penetration at 25°C,100 gm, 5 sec. (0.1mm) | D-5 | 48 | 40 - 50 |
| Rotational viscosity at 135°C (cP.s) | D-4402 | 483 | ------ |
| Softening Point (°C) | D-36 | 41 | ------ |
| Ductility at 25°C, 5cm/min, (cm) | D-113 | 133 | >100 |
| Flash Point, (°C) | D-92 | 308 | Min.232 |
| Specific Gravity | D-70 | 1.038 | ------ |
| Solubility in trichloroethylene, % | D-2042 | 99.7 | > 99 |
| After Thin Film Oven Test D-1754 | | | |
| - Retained penetration, % of original | D-5 | 57.69 | >55 |
| - Ductility at 25°C, 5cm/min,( cm) | D-113 | 64 | >25 |

**Table 4. Summary of Physical Properties of Aggregate.**

| Property | ASTM Designation | Test Results | SCRB Specification |
|---|---|---|---|
| Coarse Aggregate | | | |
| Bulk Specific Gravity | C – 127 | 2.62 | ------ |
| Apparent Specific Gravity | C – 127 | 2.69 | ------ |
| Water Absorption, % | C – 127 | 1.58 | ------ |
| Percent Wear by Los Angeles Abrasion, % | C – 131 | 16.40 | 30 Max. |
| Fine Aggregate | | | |
| Bulk Specific Gravity | C – 127 | 2.685 | ------ |
| Apparent Specific Gravity | C – 127 | 2.73 | ------ |
| Water Absorption, % | C – 127 | 2.43 | ------ |

**Table 5. Aggregate Gradation for Surface Course (Type IIIA).**

| Sieve size (mm) | 19 | 12.5 | 9.5 | 4.75 | 2.36 | 0.3 | 0.075 |
|---|---|---|---|---|---|---|---|
| %Passing Selected | 100 | 95 | 83 | 59 | 43 | 13 | 7 |
| %Passing (SCRB) | 100 | 90-100 | 76-90 | 44-74 | 28-58 | 5-21 | 4-10 |

**Fig. 1. Reed Plant Ash Used.**

**Fig. 2. Reed Plant Powder Used.**

**Table 6. Physical Properties of Mineral Filler.**

| Property | Test Result | | |
|---|---|---|---|
| | LSD | RPA | RPP |
| Specific Gravity | 2.64 | 2.03 | 2.21 |
| Passing Sieve No.200 (0.075 mm) | 94 | 98 | 96 |

## 3. PREPARATION OF MODIFIED ASPHALT

According to Sarsam S.I., 2015 Modified Asphalt was prepared as follows:

1. Heating asphalt cement up to160°C.

2. While the mixture was being stirred added gradually RPA and RPP separated from each other to make two different types of modified asphalt. Added RPA and RPP in four percentages which are 5%, 10%, 15% and 20% from the asphalt weights stayed in the stirring machine for about 45 min at the same heated temperature.

## 4. EXPERMINTAL WORK

1. Checking penetration, softening point, ductility before and after laboratory aging for pure and modified asphalt at each percent of modification by RPA and RPP.

2. Calculating Stiffness Modulus at 104 sec loading time and 25°C from the Shell Nomo graph.

3. Determining the optimum asphalt cement content for the mix with pure asphalt and with the best modification percent of RPA and RPP.

4. Check the Marshall properties at optimum asphalt cement content to each prepared specimen.

5. Testing the indirect tensile strength for the all prepared mixes according to (AASHTO T 283).

6. Finding the Marshall Retained Stability to each mix prepared.

## 5. FINDING RESULTS

Tables 7, Table 8 and Fig. 3 show the penetration, softening point, and ductility before and after aging for the pure and modified asphalt by RPA and RPP respectively and Stiffness Modulus after aging results. Optimum asphalt content for the best percent of the modified asphalt with RPA and RPP according to the stiffness modulus value is shown in Table 9, Table 10 and Fig. 4 indicate the Marshall, volumetric properties, and indirect tensile strength results for the prepared specimens.

**Table 7. Properties of the Modified Asphalt Cement by RPA.**

| Binder Type | Test Result | | | | | | Stiffness Modulus, N/m$^2$ |
|---|---|---|---|---|---|---|---|
| | Penetration; 0.1 mm | | Softening Point; °C | | Ductility; mm | | |
| | Before aging | After aging | Before aging | After aging | Before aging | After aging | |
| Control | 48 | 37 | 41 | 43 | 133 | 72 | 1*107 |
| 5% RPA | 48 | 35 | 43 | 48 | 132 | 68 | 1.16 *107 |
| 10% RPA | 45 | 34 | 47 | 54 | 132 | 67 | 1.19 *107 |
| 15% RPA | 42 | 31 | 48 | 59 | 127 | 65 | 1.24*107 |
| 20% RPA | 39 | 28 | 53 | 63 | 121 | 64 | 0.94 *107 |

**Table 8. Properties of Modified Asphalt Cement by RPP.**

| MIX | Test Result | | | | | | Stiffness Modulus, N/m$^2$ |
|---|---|---|---|---|---|---|---|
| | Penetration | | Softening Point | | Ductility | | |
| | Before aging | After aging | Before aging | After aging | Before aging | After aging | |
| Control | 48 | 37 | 41 | 43 | 133 | 72 | $1*10^7$ |
| 5% RPP | 47 | 34 | 45 | 51 | 133 | 70 | $1.18*10^7$ |
| 10% RPP | 41 | 31 | 49 | 57 | 131 | 67 | $1.27*10^7$ |
| 15% RPP | 38 | 28 | 53 | 61 | 128 | 62 | $1.23*10^7$ |
| 20% RPP | 33 | 25 | 57 | 67 | 124 | 58 | $1.21*10^7$ |

**Table 9. Optimum Asphalt Content.**

| Optimum Asphalt Content* for Modified Materials | |
|---|---|
| 15% Reed Plant Ash (RPA) | 10% Reed Plant Powder (RPP) |
| 5.10 | 5.67 |

*Optimum Asphalt Content for control mix = 4.64%

**Table 10. Summary of Test Results.**

| MIX | Control | 15% RPA | 10%RPP | Specification Limits |
|---|---|---|---|---|
| Marshall Stability (M.S), (KN) | 12.04 | 19.23 | 23.08 | Min. 8 |
| Marshall Flow(M.F), (mm) | 3.16 | 2.78 | 2.31 | 2 – 4 |
| Voids In Mineral Aggregates (VMA) | 21.56 | 17.84 | 14.83 | Min. 14 |
| Air Voids (AV) | 4.46 | 3.82 | 3.36 | 3 – 5 |
| Voids Filed With Asphalt (VFA) | 79.31 | 78.59 | 77.34 | 70 – 85 |
| Tensile Strength Ratio (TSR), % | 76.84 | 88.95 | 92.51 | 70 – 80 |
| Retained Marshall Stability (RMS),% | 67.03 | 74.83 | 85.32 | Min. 70 |

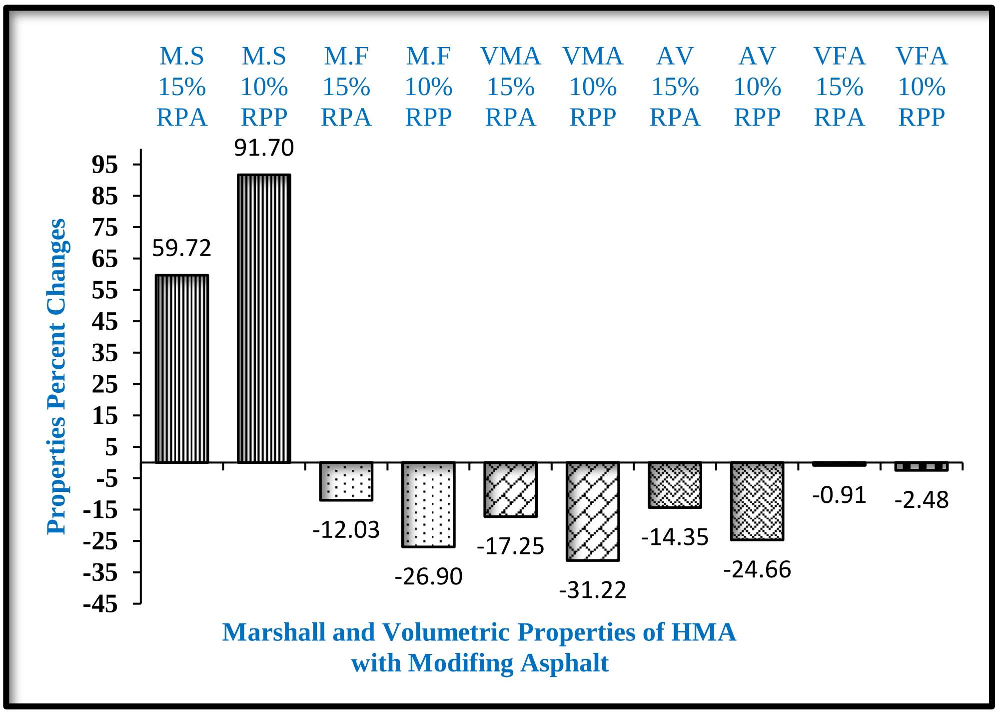


**Fig. 3 Percent Varies in HMA Properties with Modifying Asphalt.**

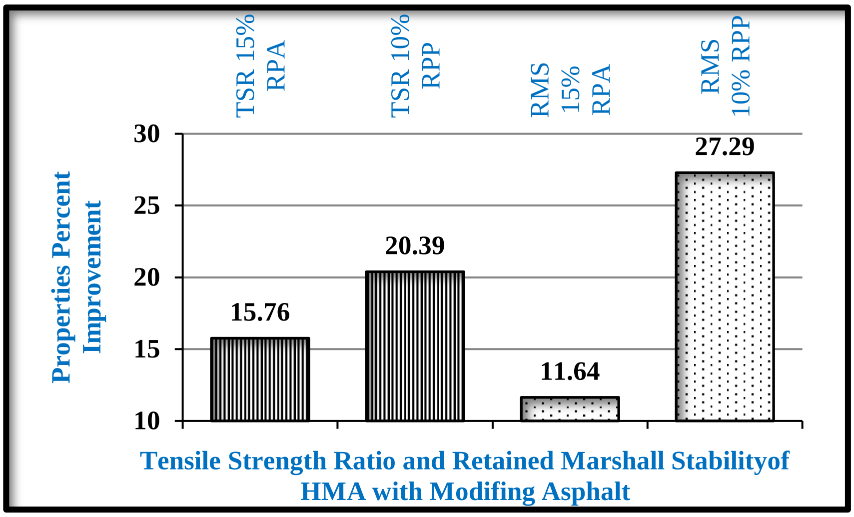


**Fig. 4. Percent Varies in TSR & MRS of HMA with Modifying Asphalt.**

## 6. CONCLUSIONS

1. Adding RPA as a modifying material: penetration before and after aging decreased by 18.75% and 24.32%, respectively, softening point before and after aging increased by 29.27% and 46.51% respectively, ductility before and after aging decreased by 9.02% and 11.11%, respectively, and stiffness modulus increased by 24.00% when the percent of RPA increase to 15% then the value of it decrease by 4.72%.

2. Adding RPP as a modifying material: penetration before and after aging decreased by 31.25% and 32.43%, respectively, softening point before and after aging increased to 39.02% and 55.81% respectively, ductility before and after aging decreased by 6.77% and 19.44% respectively, and stiffness modulus increased to 27.00% when the percent of RPP increase up to 10% then the value of it decrease by 24.19%.

3. 15% of RPA and 10% of RPP was selected to check the Marshall Properties and indirect tensile strength because it meets the requirements of (SCRB, 2003/ R9) specification.

4. Optimum asphalt content to prepare the specimens using modified asphalt by 15% RPA 10% RPP was higher than with pure asphalt by 9.91% and 22.20%, respectively.

5. Addition of 15% of RPA and 10% of RPP develop the Marshall stability by 59.72% and 91.70%, respectively, as well as they decreased: flow, voids in mineral aggregate, air voids, and voids filled with asphalt by (12.03%, 26.90%), (17.25%, 31.22%), (14.35%,24.66 %) and (0.91%, 2.48 %), respectively.

6. Indirect tensile strength from tensile strength ratio and Retained Marshall Stability ware improved when using 15% of RPA and 10% of RPP by (15.76%, 20.39 %) and (11.64%, 27.29%), respectively.

## 7. REFERENCES

Abbaas, I. 2014, "Evaluation of Recycled Cement Concrete (RCC) as Filler for Asphalt Mixture" Journal of Engineering and Development, Vol. 18, No.5, ISSN 1813- 7822.

Al-Ani, T.M and Ahmed Th. Y. 2011, "Using Crumb of Tyres in Hot Asphalt Mixture as Part of Aggregate" Al-Rafidain Engineering Vol.19 No.2, PP. 29 -39.

Arabani, M. and Azarhoosh, A., 2012, "The Effect of Recycled Concrete Aggregate and Steel Slag on the Dynamic Properties of Asphalt Mixtures." Journal of Construction and Building Materials, Vol. 35, PP. 1-7.

Do H. Mun P. & keun R. 2008, "A study on Engineering Characteristics of Asphalt Concrete using Filler with Recycled Waste Lime." Journal of Waste Management, Vol. 28, PP. 191–199.

FHWA, 2012, "The Use and Performance of Asphalt Binder Modified with Polyphosphoric Acid (PPA)", Office of Pavement Technology -HIF-12-030, March.

Ghaly, N. F. 2008, "Effect of Sulfur on the Storage Stability of Tire Rubber Modified Asphalt" World Journal of Chemistry 3 (2): 42-50, ISSN 1817-3128.

Khalid, M., Besma M. and Dalia, A. 2015, "Utilization of Waste Plastic Water Bottle as a Modifier for Asphalt mixture Properties" Journal of Engineering and Development, Vol.20, No.2, march. ISSN 1813- 7822.

Mohammed, A. and Hamid, A. 2015, "Influence of Selected Additives on Warm Asphalt Mixtures Performance", Kufa Journal of Engineering Vol. 6, No. 2, June, P.P.49-62.

Nabil, I., Hanaa K., Suham, E. and Samar S. 2014, "Use of Recycling Building Demolition waste As Coarse Aggregate in Hot Mix Asphalt", Tikrit Journal of Engineering Sciences ISSN: 1813-162X, 21(1) PP.63-76.

Nahla, Y. Ahmed and Ammar, J. Kandouh. 2015, "Performance Evaluation of Modified Asphalt Concrete Mixes Containing Natural Sand" Journal of Babylon University/Engineering Sciences, Vol.23, No.3.

National Cooperative Highway Research Program NCHRP 459, 2001, "Characterization of Modified Asphalt Binders in Superpave Mix Design", National Acad emy Press Washington.

Sarsam, S.I., 2015, "Impact of Modyfied Materials on Rheological and Physical Properties of Asphalt Cement", International Journal of Advanced Materials Research, (IJAMR) Vol. 1, No. 1, pp. 8-14, March.

Sarsam, S. I., and AL-Lamy A. K., 2015 "Fatigue Life Assessment of Modified Asphalt Concrete" International Journal of Scientific Research in Knowledge, 3(2), pp. 030-041, ISSN: 2322-4541.

SCRB/R9, 2003, General Specification for Roads and Bridges, Section R/9, Hot-Mix Asphalt Concrete Pavement, Revised Edition. State Corporation of Roads and Bridges, Ministry of Housing and Construction, Republic of Iraq.

Taher, M. A. Al-ani. 2009 "Modification of Asphalt Mixture Performance by Rubber-Silicone Additive" Anbar Journal of Engineering Sciences (AJES), Vol. 19, No.2