Investigation the effect of different types of mineral fillers on mechanical properties of Hot Mix Asphalt

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**Abstract.** The use of waste materials in the construction process has become more popular during the last decades since it reduces the initial cost and reduces the cost of solid waste disposal. Rice Husk Ash (RHA) is a waste material available in a huge quantity of Iraq and used as mineral filler in this study. The current research focuses on the investigation of the effect of three types of mineral filler on mechanical properties of Hot Mix Asphalt (HMA). In addition to RHA, the limestone and Ordinary Portland Cement (OPC) were used as mineral fillers (MF). The RHA was prepared by burning it in two stages, the first stage involves burning the RHA in a closed space and the second stage involves burning the RHA in an oven at 800 °C for two hours. Different percentages of these mineral fillers as (25%, 50%, 75% and 100%) RHA and OPC replacement with conventional mineral filler were used in produced HMA. The obtained mixes were tested to determine Marshall Stability, Marshall Flow, indirect tensile strength and tensile strength ratio. The results showed that the RHA can be used as mineral filler in HMA; however, the optimum ratio of mineral filler was 25% RHA and 75% limestone.

**Keywords.** HMA, Indirect tensile strength, Marshall Stability, Rice Husk Ash

### 1. Introduction

The great growth of the number of vehicles and axles loads requires more increase in roads network and consequently natural materials used in its construction [1-3]. Bituminous materials have been used extensively in highway construction all around the world. These hydrocarbons may present in the natural deposits or are produced as a result of crude petroleum distillation. Asphalts or tars are the bituminous components used in highway construction. The bituminous materials mainly consist of bitumen and also have good adhesion properties, varying from dark brown to black in color. They range from liquid to solid in consistency; they are therefore classified into liquids, semi-solids, and solids. They differ from liquid to solid inconsistency; they are thus classified into liquids, semi-solids, and solids. At normal temperatures, the solid shape is normally hard and brittle, but when exposed to long, continuous loading, it can flow. The predominant component of asphalt mixtures is bituminous materials [4].

Asphalt mixtures can be used for all forms of applications, from suburban streets to motorways, from parking areas to port facilities, including bridge deck waterproof coating to rainwater barriers, and from cycle paths and airport runways [5]. Generally, the flexible pavement has many layers, i.e., surface, binder, base, involve of graded minerals bound together by the binder, i.e., asphalt. Asphalt is the most common binder used in highway building. While the aggregate, include fine and coarse aggregate parts, serves as
that of the structural skeletal of a pavement, accounting for approximately 90 percent of the total volume of hot mix asphalt. Asphalt mixtures can be made from a variety of aggregate combinations, each of which has its own unique characteristics tailored to specific construction and design uses. Mixtures consist of a mixture of evenly blended and coated asphalt binder aggregate. In order to dry the aggregates and obtain adequate asphalt binder fluidity for proper mixing and workability, before mixing, that both asphalt and the aggregate type should be heated, hence the expression "hot mix." [6]. Depending on the form of asphalt cement used, the hot-mix, hot-laid asphalt mixture is formed by properly mixing asphalt, fine aggregate, coarse aggregates, and filler (dust) at temperatures varying from about 175 to 325 F (80 to 163 °C) [4]. The Filler which is a non-plastic material, usually used to improve the properties of the mixture, minimize plasticity, decrease the volume change, primarily passes sieve No. 200 (0.075 millimeters), so it is defined as a much more important material. The mineral filler is confined to that content, which is fine enough, as determined by a 75 mm sieve. That should be clear of organic impurities and also have a plasticity index of not more than 4 (with the exception of cement and hydrated lime). When got from rock crushing (stone dust), fillers can either have a natural origin or can be produced in industries such as ash, cement, slag, lime and rice husk ash [7, 8]. By dispersing fine materials into it, the mineral filler helps to stiffen the asphalt mixture. Several materials are usually used as mineral fillers in HMA, such as limestone dust, cement, fine sand and lime are well known to be costly and used efficiently for other purposes. Although ash finer and fine sand than 0.075 mm sieve size tends to be suitable as mineral filler using the waste powders as filler in Hot Mix Asphalt (HMA), several researchers have earlier investigate [9].

Fillers' physical properties including such particle shape, texture, size distribution, specific gravity, size, and porosity as well as chemical properties like active clay content and mineralogy all seem to have a significant impact on pavement distress, including fatigue, susceptibility to moisture, rutting, aging, and cracking at low temperatures [10]. Kim et al. [11, 12] described how the filler helps to monitor the engineering characteristics of asphalt mixes due to its important function in mixed characteristics such as hardness, susceptibilities to moisture and fracture resistance and asphalt concrete rutting. To obtain a solid dry bond, the mineral filler may be mixed with a little bit of asphalt cement content for the purpose of filling the voids. Also, overfilling the asphalt gives fluid properties to the mixes [13]. It is also possible to increase the elastic modulus of HMA by adding mineral fillers. Various studies have been performed to investigate the effect of mineral fillers on the actions of bituminous mixes, the role in improving the connection between the asphalt binder and aggregates, and in reducing the required optimum bitumen content. Fillers can increase the stability and density of the mix, enabling improvement in paving efficiency [14]. However, because of the increase in the quantity needed of asphalt to covering the aggregate, a large amount of filler material will create a poor mixture [15, 16]. Asi and Assa’ad [17] pointed out that a small amount of mineral filler (about 5-7% of an aggregate in the mixture) has a major effect on the physical characteristics of (HMA).

Wojciech, G., and Jaroslaw, W., [18] studied the structure of limestone mineral filler and evaluated their stiffening properties in fill-bitumen mastic. They concluded that specific surface area, average grain diameter, grain diameter and grain morphology greatly influenced the stiffening properties in filler-bitumen materials.

Nowadays, in the use of waste materials, which is one of the key priority plans aimed at environmentally friendly operations, there is now a growing interest. The tendency towards the manufacture then uses of the waste as supplements cement materials have been growing in the case of the construction industry. In addition to the economic problem, the traditional pozzolanic agents from industry and biomass by goods like Ground Granulated Blast Furnace Slag (GGBFS), fly ash and RHA are becoming active research areas because of the positive impacts on the environment [19-21]. Numerous waste materials are produced from various sectors of industry, construction, domestic and agriculture. Agricultural waste such as wood waste (b) industrial waste such as fly ash, cellulose waste, slag; (c) municipal/household/domestic waste such as scrap rubber, incinerator residue and waste glass; (d) mining waste such as coal mine waste and (e) building and demolition (C&D) waste such as recycled fine concrete aggregates and recycled concrete aggregates
[22]. Rice husk is a natural sheath formed during its growth on rice grains and is a very common solid waste in Asia. RHA is a by-product generated to generate power and energy of manufacturing facility by burning rice husks as a fuel source for a boiler at 600-800 °C. The first process is costly and generates amorphous silica ash, a high specific surface area of smaller, non-agglomerated particles and non-spherical. [6]. in certain places, unregulated open burning, which is comparatively inexpensive but result Pollution of the environment, also generates RHA. Partial and full replace of RHA has provided better mixtures than traditional mineral fillers in most studies. RHA manufactured asphalt mixtures with enhanced volumetric properties and Marshall stability at a 50 percent replacement rate with limestone filler [23].

Cardone et al.[24] Suggested that the cost and pavement performance effect, an acceptable filler for the bitumen mix should be chosen. While limestone is the most widely used filler, many filler materials involve Portland cement and hydrated lime. Ordinary Portland cement (OPC) is also used to prevent binder strips and enhance the coating of bitumen with hot-mix asphalt wet aggregates made of recycled aggregates [25]. Adding OPC and lime to HMA lead to improve the dry resilient modulus and water resistance [26]. Head, et al [27] report that OPC increases the strength also the stability of the cold mixture increase. Brown, et al.[28] report that the mechanical properties provided by OPC in cold mixes or asphalt-emulsion mixes are affected by variables such as binder grades, void content, curing time and additives like OPC.

Abdel-Wahed, et al[29] investigated how the characteristics of asphalt paving mixes and filler-mastic are influenced by different filler-asphalt ratios via five different types of fillers (OPC, sulphate, hydrated lime, lime dust stone and powder of crushed gravel). Moreover, the spectrum of the filler asphalt ratio is affected by the type of filler used. In addition, it was shown that many available local materials can be used to replace OPC as the asphalt paving mixture filler. Even more, study has recently been conducted on different types of fillers and the potential impact on the final asphalt concrete pavement (ACP). A successful type of study has shown us that OPC is an outstanding way to develop HMA[30]. Because of the tensile strength of the mixture increases and the energy of the strain increases [31]. The ACP is much more resistant to permanent deformation with higher stress energy. For projects in hot climates, this is very important. Also, the use of fillers such as Ordinary Portland Cement (OPC) and cellulose fiber (CF) as substitute materials may give various advantages in the construction of roads, such as improving paving efficiencies, reducing road and road costs and also being environmentally friendly [32]. Alijassar, A.H., et. al. [33] studied the influence of the filler type on the strength properties of asphalt mixtures particularly Portland cement and limestones. They concluded that cement filling created higher strength values. The importance of mineral fillers in the bituminous mixtures has been overlooked where their effect was considered to be only filling the voids in the aggregate particles. In this literature review, it is exhibited that different mineral fillers and quantity influence the performance of HMA mixtures. Some filler has a considerable effect on the properties of asphalt cement mortar as compared to the neat asphalt cement and some filler types are also found to make HMA mixtures more susceptible to moisture-induced damages. While considering the effect of filler types in the bituminous mixtures, various desirable characteristics such as: increased stability, resistant to moisture effect and rutting were obtained by many researchers. The current research investigated the effect of three types of mineral fillers on the mechanical properties of HMA. These types are lime, OPC and RHA. This research is the first part of continuous research on using these types in HMA contain a specific Polymer Modified Bitumen (PMB) which is very limited in use during the past studies.

2. Materials
The materials used for this study are domestically manufactured and widely used in my country road pavements to assess the effectiveness in improving pavement performance. The materials are consisting of asphalt cement grade (40-50) was equipped from Al-Nasiriyah refinery, South East of Baghdad, which is extensive used in Iraq. Tests that are done to find out the properties of asphalt such as (penetration, ductility, softening point, viscosity, flash point and thin-film oven tests). Table (1) shows the physical properties of asphalt binder. The aggregate used in this work was obtained from local sources (Badra quarries), in eastern
Iraq. Dense graded surface course type A with (12.5 mm NMAS) In AASHTO standard M 323-13, the nominal maximum aggregate particle size is defined as 'one sieve larger size than the first sieve to retain more than 10 percent.' (AASHTO, 2013), mid gradation, according to the State Corporation for Roads & Bridges (SCRB, 2003). The physical characteristics of fine and coarse aggregates in the tables. (2,3,4). The Filler is a No. 200 (0.075mm) non-plastic material passing sieve typically used to fill voids in a pavement mixture and enhance the properties of the mix. There are three types of mineral filler (MF) used in this work Lime Stone (LS), Ordinary Portland Cement (OPC) and Rice Husk Ash (RHA), Limestone dust obtained from the lime factory of the City of Fallujah, the physical and chemical properties of the used filler are presented in Table (5,6). The cement used is ordinary Portland cement (OPC) was provided from the Karbala cement plant.

The chemical properties of OPC in Table (7). RHA was obtained from the local rice mill in Shaimaa is burned initially burned in the yard outside the lab using oil and where a second burn was in an oven at 800 °C for 2 hours [7], to avoid carbonization of rice husks then, the ash was milled the burning rice husk in the mill to get softer, lastly, RHA was sieved using sieve No.200 (0.075 mm). The chemical properties of RHA were demonstrated in Tables (8). To assess the viscosity of the asphalt binder by ASTM D4402 [34], Brookfield DV-III rotary viscometer was used (ASTM, 2015c). This method was conducted to test the required temperature for mixing and compacting the net asphalt binder. The mixing viscosity must be 170 ± 20 cP and 280 ± 30 cP for compaction. The mixing temperature within range (158–163) °C and the compaction temperature is within range (148.5–153.5) °C.

Table 1. presents the physical properties of asphalt binder

| Property | ASTM designation | Test results | SCRB requi |
|----------|------------------|--------------|------------|
| Penetration,100g m., 25 °C , 5 sec (1/10 mm) | ASTM D5 | 40 | 40- |
| Specific Gravity, 25 °C, (gm/cm³) | ASTM D70 | 1.0326 | - |
| Ductility, 25 °C, 5 cm/min (cm) | ASTM D113 | 123 | >10 |
| Flash point, °C | ASTM D92 | 300 | >23 |
| Softening point, °C | ASTM D36 | 53 | |

After the Thin Film Oven test

| Property | ASTM designation | Test results | SCRB requi |
|----------|------------------|--------------|------------|
| Penetration,100gm., 25 °C, 5 sec (1/10 mm) | ASTM D5 | 83 | - |
| Ductility 25 °C ,5cm/min | ASTM D113 | 102 | - |

Table 2. Gradation of Aggregate for Surface Course Type A (SCRB, 2003)

| Sieve size | mm | % passing by weight according to SCRB | mid-range of SCRB specification |
|------------|----|-------------------------------------|--------------------------------|
| ¾         | 19 | 100                                 |                                |
| ½         | 12.5 | 90 - 100                             | 95                             |
| 3/8       | 9.5 | 76 - 90                             | 83                             |
| No. 4     | 4.75 | 44 - 74                             | 59                             |
| No. 8     | 2.36 | 28 - 58                             | 43                             |
| No. 50    | 0.3 | 5 - 21                              | 13                             |
| No. 200   | 0.075 | 4 - 10                             | 7                             |
### Table 3. The Physical Properties Of the coarse Aggregates

| Property                                      | ASTM Designation | Obtained Value |
|-----------------------------------------------|------------------|----------------|
| Bulk specific gravity, gm/cm³                | ASTM C127        | 2.56           |
| Apparent specific gravity, gm/cm³            | ASTM C127        | 2.672          |
| Percent wear by Los Angeles abrasion, %       | ASTM C131        | 20.7           |
| Water absorption, %                          | ASTM C127        | 1.63           |
| Percent of crushed surfaces in coarse aggregate particles, (%) | ASTM D5821 | 95             |

### Table 4. The Physical Properties of the fine Aggregates

| Property                                      | ASTM designation | Obtained value |
|-----------------------------------------------|------------------|----------------|
| Bulk specific gravity, gm/cm³                | ASTM C128        | 2.496          |
| Apparent specific gravity, gm/cm³            | ASTM C128        | 2.595          |
| Water absorption, %                          | ASTM C128        | 1.52           |

### Table 5. Physical properties of LM, OPC &RHA

| Property                                      | LM   | OPC  | RHA  |
|-----------------------------------------------|------|------|------|
| Specific gravity                              | 2.5  | 3.13 | 2.56 |
| %Passing Sieve No.200 (0.075)                 | 95   | 98   | 90   |

### Table 6. Chemical properties of Limestone properties

| Chemical Compositions                        | % Content of LM |
|----------------------------------------------|-----------------|
| Silica, SiO2                                 | 4.19            |
| Sulfuric Anhydride, SO3                      | 2.08            |
| R2O3 (Aluminum oxide Al2O3+Ferric oxide Fe2O3)| 1.01            |
| Lime, CaO                                    | 43.7            |
| Magnesia, MgO                                | 0.036           |
| Loss on Ignition                             | 41.39           |
| Non-soluble substances                       | 4.62            |

### Table 7. Chemical properties of Portland cement

| Chemical compound                            | % Content of OPC |
|----------------------------------------------|------------------|
| Silica, SiO2                                 | 24.8             |
| Lime, CaO                                    | 61.4             |
| Sulfuric Anhydride, SO3                      | 1.42             |
| Alumina, Al2O3                               | 3.51             |
| Magnesia, MgO                                | 1.7              |
| Ferric Oxide, Fe2O3                          | 4.5              |
| Loss on Ignition                             | 2.5              |
Table 8. Chemical properties of Rice Husk

| Chemical compound          | %Content of RHA |
|----------------------------|----------------|
| Silica, SiO₂               | 69.194         |
| Lime, CaO                  | 7.641          |
| Sulfuric Anhydride, SO₃    | 0.188          |
| K₂O                       | 16.616         |
| Ferric Oxide, Fe₂O₃        | 6.361          |
| Loss on Ignition           | 7.177          |

3. Mixture design and Testing Procedure

3.1. Marshall Test:
Marshall Test was performed to determine the stability and flow of the traditional mixture. The asphalt mixes were prepared according to ASTM D6927, where the test conditions are shown in Table (9). Three samples were prepared for five different asphalt binder contents (4, 4.5, 5, 5.5 and 6) % by total weight of mixture with different types of mineral fillers (100% LS, 100% OPC, 50% LM+50% OPC) [9, 10]. The 50% of limestone has been used with 50% of OPC as a third reference mix to compare the final results of the research. Optimal asphalt content OAC was found equal to 4.7%. The resistance of asphalt mixtures to strain, horizontal and shear stress caused by the loading indicates Marshall stability. After determination of the OAC, several specimens were prepared with the percentage of filler such as (25, 50, 75 and 100%) RHA and OPC.

Table 9. Marshall Test Conditions According to ASTM D6927

| Parameter                                | Test standard | Used value for testing                        |
|------------------------------------------|---------------|-----------------------------------------------|
| Asphalt temperature, °C                  | 150-165       | 160                                           |
| Aggregate temperature, °C                | 170           | 170                                           |
| Mix temperature, °C                      | 130-180       | 165                                           |
| Number of specimens                      | 3             | 3                                             |
| Measuring device accuracy                | Min. 0.01 N   | 0.01 N                                        |
| The load application rate, mm/min        | 50 ± 5        | 50                                            |
| Test temperature, °C                     | 60 ± 1        | 60 ± 1                                        |
| Duration of conditioning before test, min| In a water bath| 30 min in a water bath                       |
| Specimen compaction                      | 75 blows each face | 75 blows each face                           |
| Specimen diameters, mm                   | 101.6-101.7   | 101                                           |
| Specimen thickness, mm                   | 63.5 ± 2.5    | 63.5 ± 2.5                                    |
| Curing, hr                               | 24hr at Lab temperature | 24hr at Lab temperature                      |

3.2. Indirect tensile strength (ITS)

The indirect tensile strength (ITS) testing is used to assess the asphalt concrete's tensile properties that can further be linked to the pavement's cracking properties. Table (10) Indirect Tensile Strength Test Conditions According to T283 (AASHTO, 2007a) [35, 36]. This test is summarized in applying compressive loads along a diametrical plane through two opposite loading strips. This test is described as applying compressive loads along with the total level by two reverse loading strips. This type of load is generated by relatively uniform tensile stresses that operate vertically at the applicable load level, and the specimen
usually fails by splitting along the loaded plane \cite{37,32}. A total of 6 samples for conventional and 48 samples for (six for each filler ratio) was prepared and the mean ITS value was compared. That maximum tensile strength produced has been calculated as Eq. (1) below:

\[
ITS = \frac{2000P_{\text{max}}}{\pi D T} \quad \text{Eq. (1)}
\]

Where ITS is the indirect tensile strength (kPa); \(P\) the maximum load (N); \(D\) is the specimen diameter (mm); \(T\) the specimen thickness (mm).

The moisture susceptibility of the compacted samples is assessed by tensile strength ratio (TSR) using Eq. (2) below.

\[
TSR = \frac{S_{\text{tm}}}{S_{\text{tc}}} \quad \text{Eq. (2)}
\]

Where; TSR: tensile strength ratio, \(S_{\text{tm}}\): average tensile strength of the moisture conditioned samples; \(S_{\text{tc}}\): average tensile strength of the control (unconditioned) samples.

**Table 10.** Indirect Tensile Strength Test Conditions According to T283 (AASHTO, 2007a)

| Parameter                        | Test standard | Used value for testing |
|----------------------------------|---------------|------------------------|
| No. of specimens                 | 3             | 3                      |
| Rate of loading, mm/min          | 50 ± 5        | 50                     |
| Accuracy of the device           | Min. 0.01 N   | 0.01 N                 |
| Test temperature, °C             | 25 ± 2        | 25 ± 2                 |
| Specimen diameters, mm           | 100, 150      | 101.6                  |
| Specimen thickness, mm           | 63.5±2, 95±5  | 63.5 ± 2.5             |
| Compaction (Marshall Hammer)     | Compacted to 7 ± 0.5% air void | Depended on the required air void 7% |
| Curing                           | Placed in water bath for 24 hr at 60 °C Then 25°C for 1 hr | Placed in water bath for 24 hr at 60 °C then 25°C for 1 hr |

4. Results

4.1. Marshall Test

The stability of Marshall is a significant factor in HMA pavements, which demonstrates HMA pavement's resistance to deformation due to the loads used \cite{31}. Table (11) illustrates the relationship between Marshall Stability and flow with the filler ratios used in the asphalt mixture, three different proportions of mineral filler were used (100% LS, 100% OPC, 50% LS + 50% OPC). The optimal bitumen content for each filler rate with test results prepared for Marshall Specimens with the aid of specified filler rates was determined to step by step. Optimal Bitumen Content (OBC) has been calculated as 4.7% for 100% LS, 4.65% for 100% OPC, 4.63% for 50% LS + 50% OPC. So, the value of the optimal asphalt content is 4.7% with limestone as filler and the greatest stability value (i.e., 13.3 kg) and flow value (i.e., 2.8) was obtained from the mixtures compared with mixtures that content 100% OPC stability value (i.e., 11.45 kg) and flow value (i.e., 2.75) while 50% LM+50% OPC mixtures stability value (i.e., 13.1 kg) and flow value (i.e., 3.45). The reason for the increase in stability is the improvement of the adhesion between the bitumen and aggregate, especially when adding limestone compared with adding 100% OPC and 50%OPC with 50%LS. This shows that the limestone enhances the mixture's stability and flow increases slightly. Limestone reduces
the aging of the bitumen and improves the adhesion of bitumen with the aggregate and thus improves the engineering and mechanical properties of the HMA mixture, consequently; improves its resistance to traffic loads and environmental conditions and provides better resistance to water. Table (12) illustrates the properties of reference mixtures with 100% LS+ OAC 4.7%. Table (13) illustrates properties of mixtures with RHA & OPC with OAC 4.7%. The replacement ratios for RHA were determined by 25%, 50%, 75% and 100% with limestone and by comparing the results with [23]. Test results have shown that the mixtures with 25% RHA and 75% LS of filler rate (FR) had the best Marshall stability (MS) (15kN) compared with other percentages of replacement. The enhancement in the property of Marshall stability is attributed to that the RHA particles improved asphalt cement content, resulting in a comprehensive increase in stiffness and cohesion, so this value is higher than that of samples which just have limestone dust, also there is a noticeable reduction in stability with increasing the percentage of RHA up to 100% but still acceptable comparing with reference mix and minimum requirement of wearing layer. It is noted that the flow value in the design mix will be equal (3.5) because RHA is a very pozzolanic material and contains silica, also, the surface area is high and may requires more binder for coating. The using of OPC as a mineral filler replacement was also evaluated at a rate of 25%, 50%, 75%, and 100% as shown in Table (13) of (MS) test. Asphalt mixtures containing a mixture of 25 percent OPC and 75 percent limestone powder as filler gave the greatest result compared to the reference mix in terms of Marshall Stability and Marshall Flow. This reinforcement may be due to decreasing in air voids and/or increased adhesion between both the binder and the aggregates. It was also noted that Marshall's values are gradually decreasing as the cement ratio increases to 100%. This value is lower than that of the control mix which contained 100% limestone, this may be attributed to that the chemical composition of cement and the source of its manufacture is different from one place to another and that may affect the general response, in addition to that even cement can improve some the tensile strength of mix, it may affect the flexibility of it.

Table 11. Properties of mixtures with 100%LS, 100%OPC, 50%LS+50%OPC

| parameter                | Stability (kN) | Flow (%) |
|--------------------------|----------------|----------|
| % Asphalt content        |                |          |
| 4%                       | 12.4           | 13.4     | 13.2     | 12    | 10.9 | 2  | 2.5 | 3  | 4.2  | 5  |
| 5%                       | 13.2           | 12       |          |        |      |    |     |    |      |    |
| 5.5%                     | 12             | 13.3     | 12.7     | 12    | 9.9  | 2.5 | 3.5 | 4  | 4.2  | 5  |
| 6%                       | 12             | 13.3     | 12.7     | 12    | 9.9  | 2.5 | 3.5 | 4  | 4.2  | 5  |

Table 12. Properties of mixtures with 100% LS + OAC 4.7%

| Property                  | Test method          | Result of test | Standard limitation       |
|---------------------------|----------------------|----------------|---------------------------|
| Mechanical properties     | Marshall Stability (kN) | 13.30          | Min 8 kN (SCRB, 2003)     |
|                           | Marshall Flow (1/10mm)| 2.8            | 2-4, 1/10mm (SCRB, 2003)  |
|                           | Air void (%)          | 4              | 3.5                       |
| Volumetric Properties     | V.M.A (%)             | 15.1           | >14 (SCRB,2003)           |
|                           | V.F.A (%)             | 73.5           | >15 MS2                   |
|                           | Bulk Density(gm/cm³)  | 2.335          | 65-75 MS2                 |
Table 13. Properties of mixtures with RHA&OPC +OAC 4.7%

| parameter | Stability (kN) | Flow (%) |
|-----------|---------------|----------|
| % MF      |               |          |
| 25%       | 50%           | 75%      | 100%     | 25% | 50% | 75% | 100% |
| RHA       | 15            | 14.1     | 13.8     | 13.4 | 3.5 | 3.5 | 3.5 | 3.5 |
| OPC       | 14.2          | 14       | 13       | 12.8 | 3.5 | 3.5 | 3.5 | 3.8 |

4.2 Indirect tensile strength (ITS)
The ITS test was conducted to assess the effect of two fillers on the resistance to moisture and the tensile strength of specimens. Mixes with higher ITS and TSR amounts have better resistance to moisture. The ITS inspection results and specimens with different types of fillers and percentages are shown in Figure 1 and Figure 2. Results indicated that the ITS value of mixtures containing 25%RHA + 75%LM as filler were greater than the control mixture by about 21.3%. This can be related to the higher surface area of RHA which improves the adhesion between particles[38]. Also, the ITS values decrease by increasing RHA percentages, because the increasing of RHA quantity may increase the absorption of the binder and consequently, decrease the coating of aggregate particles and increase the voids so, reducing the values of the ITS. Generally, the addition of OPC as filler to the mixture, lead to an increase the ITS values and it had a slightly decreasing trend by the addition of a higher percentage of OPC as filler. The 25%OPC+75%LM produces increase by about 32.4% compared with the control mix due to the more the cohesion and adhesion of the binder with the aggregate, increase and decreases, respectively; due to the interaction of cement with water increases resistance to the applied of stresses as a result of the process of hydration but the reason for the decreased of values is due to the softness of cement leads to increased cracking in addition to increasing the surface area of the compound (C3A) which requires increasing the amount of limestone to delay the interaction of (C3A) with water. Figure 3 and Figure 4 show the TSR values of asphalt mixtures and as shown that the results are within the specification requirements AASHTO T283 (AASHTO, 2007a) where they were higher than the minimum specification requirements which is 80% which are acceptable values.
Figure 2. Effect of Different OPC Percentage as Mineral Filler on ITS of HMA

Figure 3. Effect of Different RHA Percentage as Mineral Filler on TSR of HMA

Figure 4. Effect of Different OPC Percentage as Mineral Filler on TSR of HMA
5. Summary and conclusions

This article presents an several experimental test to illustrate the effect of three types of mineral fillers on the characteristics of the HMA with a standard asphalt binder (40-50). Based on the outcomes of this study, the following conclusions can also be obtained:

- The results of the research showed that the RHA can be used as mineral filler to replace the conventional mineral filler (lime dust). These results revealed that the best characteristics can be obtained with replacement ratio of 25% RHA and 75% lime dust, since the Marshall stability was increased by 13% compared with reference mix. Other percentages of replacement up to 100% RHA can give satisfactory results according to the requirement of SCRB.

- Using RHA as a mineral filler can withstand heavy traffic loads enhance longevity of pavement, reduce environmental problems, improving the performance characteristics of mixtures and pavement performance.

- The results of study also showed that the asphalt mixtures containing a 25 percent OPC and 75 percent LM provided the best results in term of mechanical characteristics as MS increase approximately 6.8% more than those for conventional HMA. However, the other percentages of replacement also give satisfactory results according to the requirement of SCRB.

- The mineral filler consists of 25% RHA and 75% LM gives the best results since, it shows 21.5% and 32.5% higher for ITS and Marshall stability values respectively than that of reference mix.

This analysis was a preparatory laboratory study of the influence of the mineral filler on the characteristics of HMA mixes. More advanced and extensive further studies are suggested to integrate the results from this study into the real HMA mix design.

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