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Evaluation of Hydrated Lime Filler in Asphalt Mixtures

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Abstract

Mineral filler is one of important materials and affecting on properties and quality of asphalt mixtures .There are different types of mineral filler depended on cost and quality , the matter encourages us to achieve this study to evaluate hydrated lime filler effects on properties of asphalt mixes related with strength and durability. Conventional asphaltic concrete mixtures with Portland cement and soft sandstone fillers and mixtures modified with hydrated lime were evaluated for their fundamental engineering properties as defined by Marshall properties , index of retained strength , indirect tensile strength , permanent deformation characteristics , and fatigue resistance .A typical dense graded mixture employed in construction of surface course pavement in Iraq in accordance with *SCRB* specifications was used .The materials used in this study included mineral aggregate materials (coarse and fine sizes) were originally obtained from *Najaf Sea* quarries and two grades of asphalt cements produced from Daurah refinery which are D47 and D66 . The physical properties , stiffness modulus and chemical composition are evaluated for the recovered asphalt cement from prepared asphalt mixes containing various filler types .The paper results indicated that the addition of hydrated lime as mineral filler improved the permanent deformation characteristics and fatigue life and the use of hydrated lime will decrease the moisture susceptibility of the asphalt mixtures.

Key word: Hydrated Lime, Mineral Filler, Chemical Composition, Retained Strength Index, Indirect Tensile Strength, Indirect Tensile Creep, Indirect Tensile Fatigue, Rutting Distress, Absolute viscosity, Stiffness Modulus.

Introduction

Permanent deformation, fatigue and moisture damage are common distresses found in asphalt pavements today. In many cases , mineral fillers will increase the mixture stiffness. In Iraq , the performance of asphalt pavements has deteriorated over the last decade . Heavy axle loads coupled with the hot climate and poor drainage systems in middle part of Iraq are major contributing factors to the development of severe pavement distresses such as permanent deformation and loss of structure because of moisture damage. The use of lime to reduce moisture sensitivity has been promoted by FHWA for many years (Shah,1963).

The structure of hydrated lime consists of different size fractions. The larger size fraction performs as a filler and increases the stiffness of the asphalt mixture. The smaller size fraction increases asphalt film thickness enhancing viscosity of the asphalt , and improving the asphalt cohesion and stiffness. Adhesion between the aggregate and asphalt increases (Dickinson ,1984) , resulting in decreased mixture segregation.

The water sensitivity of asphalt mixes treated with hydrated lime and antistrip agents was evaluated previously (Kennedy et.al.,1982 and Kennedy et. al. , 1991). Results from these tests depended on the actual combinations of aggregate , asphalt and additives. However, among the antistrip agents, hydrated lime was most effective in increasing the tensile strength and in improving the water sensitivity of the mixture.

This paper presents the results of a comparative study conducted on various asphalt mixes with three different mineral filler types to determine if the use of hydrated lime as a mineral filler leads to any improvement in the fundamental engineering properties. In addition, effect of hydrated lime on physical properties and chemical composition of asphalt cement has been investigated in this study.

Materials

Asphalt cement

The two grades of asphalt cement used in this work included: (40-50) and(60-70) penetration grade asphalt from Daurah refinery .The different physical properties of asphalt cement are evaluated according to ASTM standards including absolute viscosity (D2171) , standard penetration (D5),ductility (D113), specific gravity (D70) , solubility in trichloroethylene (D2042) and thin-film oven test (D1754). The chemical composition of the asphalt cement is determined by the modified precipitation method of Rostler (ASTM D 4124) , in which the asphalt is separated into four fractions (Rostler and Rostler ,1981) as shown in Table 1.

The physical properties and chemical composition of the two asphalt types (D47 and D66) as well as State Commission of Roads and Bridges , *SCRB* (SCRB, 2003)specifications are presented in Table 2 .

Aggregate and Mineral Filler Properties

Mineral aggregate materials (coarse and fine sizes) were originally obtained from *Najaf Sea* quarries. The aggregate properties are listed in Table 3.

Three different types of mineral filler were used as mineral filler in preparation of various asphalt mixes because these types were available in a large quantity during study period. The hydrated lime filler was obtained from Karbala’a factory. The Portland cement filler was brought from Kufa cement factory . The soft sandstone powder filler was obtained from Najaf Sea quarries**.** The physical properties of the mineral filler types are shown in Table 4.

Asphalt Concrete Mixtures

The asphalt concrete mixtures are prepared using crushed gravel and sand with three different mineral fillers and two asphalt cement types . The mid limits of the 12.5 mm nominal maximum size dense gradation in accordance with SCRB (SCRB, 2003) specification requirements are used in preparing six asphalt mixtures (two asphalt cements and three mineral fillers) as reported in Table 5. The six asphalt mixture types included in this study are coded as shown in Table 6 .

The optimum asphalt contents (O.A.C) of various asphalt mixtures which were determined from standard Marshall mix design in accordance with ASTM D1559 (ASTM,2003) are reported in Table 7 . Also, Marshall properties at (O.A.C) and SCRB (SCRB ,2003) specifications for asphalt mixes used in the construction of surface course are presented in Table 7.

Fundamental Test Procedure

Four fundamental tests were conducted to characterize the six mixtures and determining the effects of the hydrated lime mineral filler on the properties of asphalt mixes. Three specimens were prepared and the average results are reported for all tests .A brief description of each test is given below:

Index of Retained Strength Test

Index of retained strength test is used to evaluate moisture damage of asphalt pavement in accordance with method ASTM D1075 **(ASTM ,2003)**. It is one of tests required by ***SCRB*** **(SCRB , 2003)** specifications to be performed on asphalt mixes used in surface course in addition to Marshall tests. This test is intended to measure the loss of cohesion resulting from the action of water on compacted bituminous mixtures containing penetration grade asphalt. A set of six cylindrical specimens 4 in (101.6mm) in diameter by 4 in (101.6mm) in height was prepared for each asphalt mixtures in according with the procedure described in the standard method of test for compressive strength of bituminous mixtures of ASTM D1074 **(ASTM ,2003).**

Indirect Tensile Strength Test

The indirect tensile strength at 25°C is evaluated for cylindrical specimens (101.6mm diameter × 63.5 mm height) in accordance with ASTM D4123 **(ASTM,2003).**

Indirect Tensile Creep Test

At testing temperature of 40 °C , a compressive stress of 0.138 Mpa (20 psi) was applied on the Marshall specimen (101.6mm diameter × 63.5 mm height). The loading times include (3,5,10,100, and 1000 seconds) and rest periods are (2,2,2,4,and 8 minutes). The total permanent strains, ε_P (in/in) at the end of each rest period were measured. In last loading time (1000 seconds), the creep deformations were measured after 3, 6, 10, 30, 60,100, 300, 600, and 1000 seconds durations. The creep compliance, C (t), at each of these loading durations is calculated as follows:

$$C(t)=\epsilon(t)/\sigma_o \qquad \ldots (1)$$

Where:

C(t)= Creep compliance at (1/Mpa),

ϵ(t)=Vertical strain at loading duration t (mm/mm), and

σ_o = Applied stress (Mpa) .

Indirect Tensile Fatigue Test

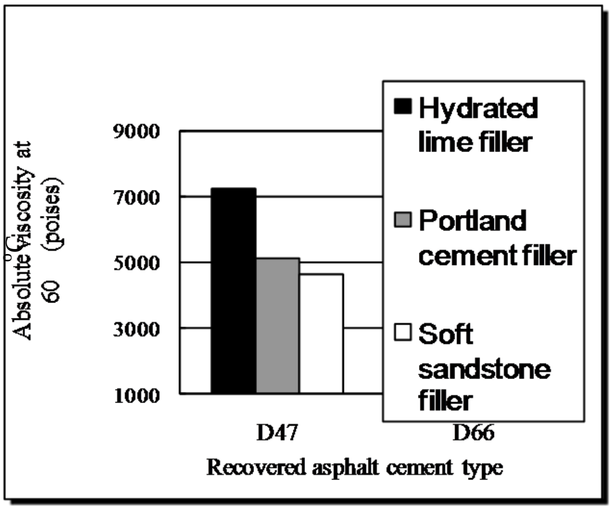
To determine the fatigue resistance of the asphalt concrete samples, this test was conducted at 25°C temperature by using the machine manufactured by the researcher in the highway laboratory in College of Engineering in Kufa University . The (10 %) of the test failure load obtained from indirect tensile test was used as the peak value of the cyclic load with loading duration of 0.10 second followed by a rest period of 0.90 second was applied to the test specimen **(Loulizi et.al.,2002)** .The number of cycles were monitored through the duration of test and the test was terminated when the specimen reached to failure.

4. Discussion of Test Results

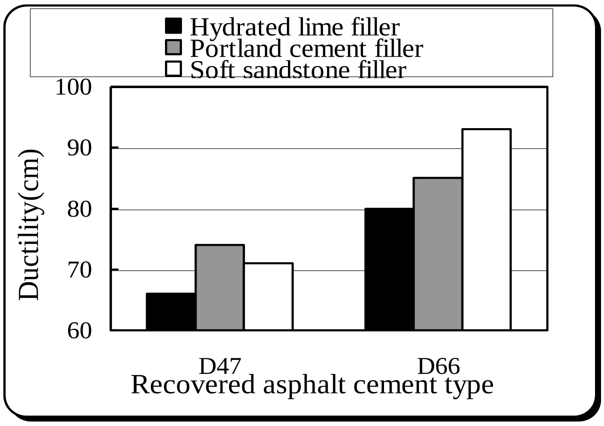
The test results obtained from experimental work will be discussed in the following sections

Effect of Mineral Filler Type on Asphalt Cement Properties and Chemical Composition

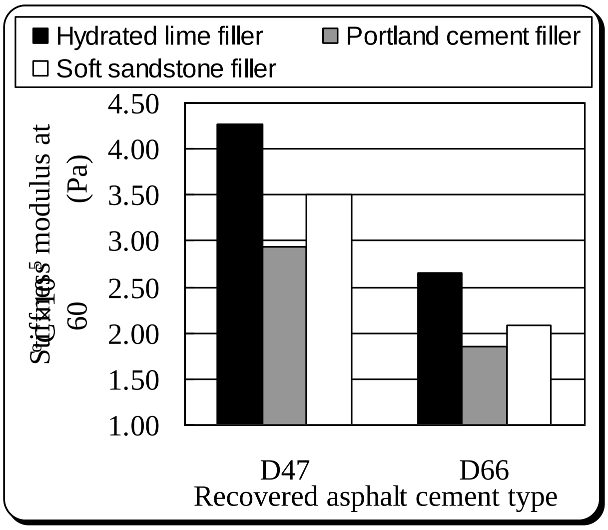
To evaluate the effect of mineral filler type on the physical properties and chemical composition of asphalt cement , there is need to recovery the asphalt from asphalt mixture specimens .Extraction test was achieved by using a solvent in accordance with the method standardized in ASTM D 2172 **(ASTM , 2003)** to quantitative separation of the aggregate and asphalt cement . The asphalt was then recovered from asphalt-solvent solution (extract) in accordance with the method described in ASTM D1856 **(ASTM ,2003)**. The stiffness modulus values of recovered asphalt cement types at temperature of 60 °C and a loading time of 0.02 second were determined by using Shell nomographs **(Bonnaure et. al. ,1977)** .Three properties of the recovered asphalt cement are evaluated : absolute viscosity , ductility and stiffness modulus .The effect of mineral filler type on these properties are shown in **Fig.1**.



(a) Absolute viscosity



(b) Ductility



(c) Stiffness modulus

Fig. (1) Effect of mineral filler type on asphalt cement properties

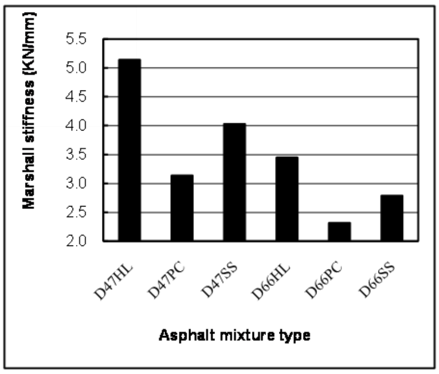
It can be noticed that recovered asphalt cement from mixes containing hydrated lime as a filler exhibits high absolute viscosity and stiffness values and has low tensile properties represented by low ductility values when compared with other asphalt types.

The chemical composition parameter, Gaestel Index (IG) defined as the ratio of (Asphaltenes and saturates) fractions to (Naphthene Aromatics and Polar Aromatics) fractions which is related with asphalt durability **(Ishai I. ,1995).** High values of (IG) refers to reduction in the asphalt durability and asphalt exhibits brittle and hardening behavior. The Chemical fractions and Gaestel index values of original and recovered asphalt cement types are reported in **Table 8**.

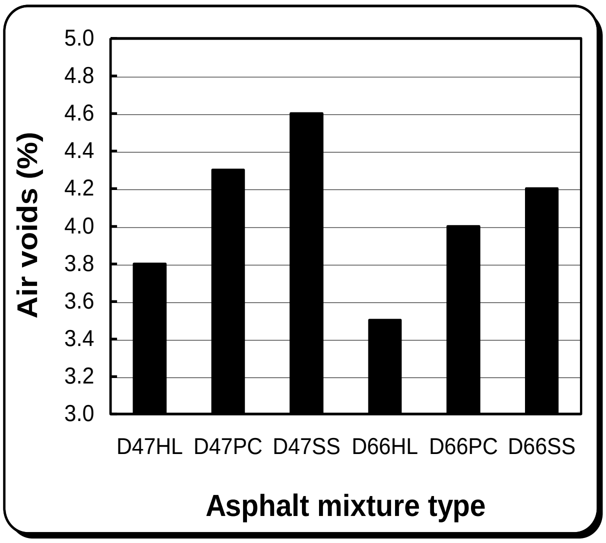
The asphalt cement considers durable if the range of (IG) values lie within a range of about (0.4-1.2) **(Ishai I. ,1995).** It may be seen from **Table 8** that all asphalt cement types fall within this range and have good durability.

Effect of Mineral Filler Type on Marshall Stiffness and Air Voids

Marshall stiffness (KN/mm) , which is calculated as the ratio between Marshall stability and corresponding Marshall flow at optimum asphalt content, represents the combination of stability and flow in single value .Marshall stiffness gives the indication about the resistance of asphalt mixture to plastic flow resulted from loading. High values of Marshall stiffness means the asphalt mixtures have considerable resistance to permanent deformation in case these mixes will be used in construction of pavement. It is well known that percentage of air voids is related to durability of asphalt mixture. The role of mineral filler type in increasing or decreasing of air voids is necessary to be investigation. The effect of mineral filler type on Marshall stiffness and air voids is shown in **Fig. 2**.



(a) Marshall stiffness



(b) Air voids

Fig.(2) Effect of mineral filler type on Marshall stiffness and air voids of asphalt mixes

It can be seen from figure that using hydrated lime as a mineral filler increases the mixture stiffness and improving the it durability represented by low air voids percent in comparison with using other mineral filler types.

Effect of Mineral Filler Type on Index of Retained Strength

The moisture damage of asphalt concrete mixtures had produced serious distress , reduced performance and increased maintenance for asphalt pavements. ***SCRB* (SCRB ,2003)** specifications require this distress to be checked by performing the index of retained strength percent test . ***Fig. 3*** indicates effect of mineral filler type on index of retained strength percent of asphalt mixes

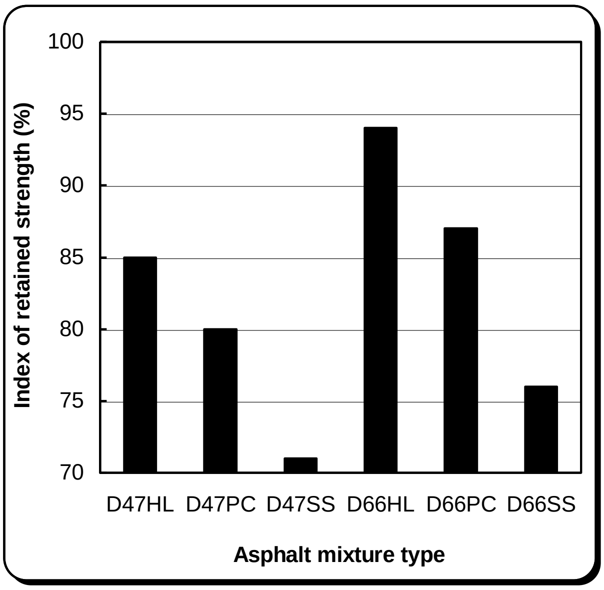


Fig. (3) Effect of mineral filler type on index of retained strength percent of asphalt mixes

SCRB (SCRB, 2003) specifications require the minimum percentage of index of retained strength as 70 % for asphalt mixtures used in a construction of surface course pavement . It can be noticed from **Fig. 3** that all asphalt mixtures have index of retained strength percent above minimum percentage From test results illustrated in Figure , it can be seen that asphalt mixtures prepared from hydrated lime filler has high resistance to moisture damage because they exhibit high percentages of index of retained strength in comparison with other asphalt mixtures.

Effect of Mineral Filler Type on Indirect Tensile Strength (ITS)

Fig. 4 presents the indirect tensile strength (ITS) test results. In this test , high tensile strength at failure is desirable property for stiff mixtures. For the ITS test performed at 25^{o}C , the addition of hydrated lime increases the strength for D47HL and D66HL asphalt mixtures. This may be due to the fact that at intermediate temperatures the combined viscosity of the asphalt and minus 0.075 material decreases more in mixtures with other mineral filler types , causing the mixture to lose more of its strength. In other words , the using of the lime filler improved the indirect tensile strength for two asphalt mixtures.

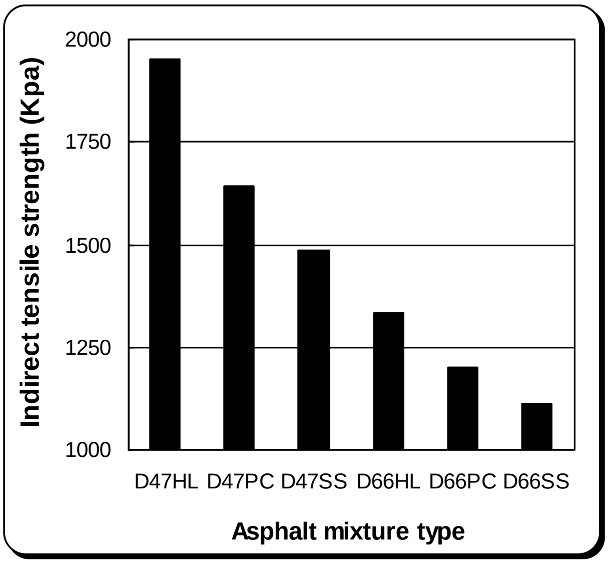


Fig. (4) Effect of mineral filler type on indirect tensile strength of asphalt mixes

Effect of Mineral Filler Type on Rutting Distress

One of the main types of structural distress which may affect the performance of asphalt concrete pavements is permanent deformation , also known as rutting . Rutting develops with an increasing number of axle load applications. Rutting is caused by a combination of densification and shear related deformation and may occur in any course of a pavement structure. VESYS 5W software program is short for Visco - Elastic Pavement System Analysis Program (Kenis et. al. ,1982) and (FHWA , 2003) . It is necessary to mention that the rut depth computed by the

VESYS 5W program is the summation of the permanent deformation values of all courses .Therefore , the VESYS 5W software program requires the input of material properties of the courses ,the course thicknesses ,traffic data ,and environmental conditions. These input data will be described in the following articles:

Material Properties

To obtain input parameters required for the ***VESYS 5W*** software , an average curve of creep compliance C (t) versus time is constructed on a log-log graph and extrapolated backward to obtain values of C (t) at 0.1 and 0.30 seconds . The total permanent strain versus incremental time of loading is plotted on a log-log graph and the best-fit line is obtained .The intersection of the line with the vertical axis is denoted by i and the slope by s . The permanent deformation properties μ and α are determined as follows:

$$\mu = is/\varepsilon \quad \textbf{... (2)}$$

$$\alpha = 1-s \quad \textbf{... (3)}$$

Where ε is the recovered strain which was obtained from resilient modulus test

The parameters (α and μ) obtained from the incremental static creep test performed on asphalt mixture are used as input into the ***VESYS 5W*** software to estimate the rut depth of a specific pavement structure using properties of different asphalt mixtures.

Resilient modulus values, Alpha (α) and Gnu (μ) parameters for binder, base, subbase and subgrade courses are taken as a default values [Fujie **and Tom (2002)]** and **[Mohammed and Michael (1999)]** while corresponding values for the surface course were determined from laboratory tests. Average resilient modulus values (Mpa) of various asphalt mixtures which were obtained by conducting the resilient modulus test on three Marshall specimens for different asphalt mixes. The specimens were tested at 25, 40 and 60 ^{o}C temperatures according to a modified ASTM D4123 **(ASTM,2003)**.

The conventional flexible pavement structures are layered systems , and consist of a surface course , binder course , base course ,subbase course and subgrade . The selected pavement structure consists of five courses with material properties and thicknesses are reported in **Table 9**. The variability coefficients of the course properties were taken as 10, 10, 15, 15 and 20 % for the surface, binder, base, subbase and subgrade courses respectively.

Traffic Loading

Initially an equivalent 80 KN (18 Kip) single axle load (ESAL) with dual tires was adopted . Traffic loading is assumed to be one million ESAL at end of first year of pavement service life . The dual tires are spaced 13.57 inch (34.5 cm) apart with tire pressure of 80 psi (552 KPa) and radius contact area of 4.25 inch (10.8 cm).Tire contact area depends on contact pressure .Thus , the contact pressure was assumed equal to the tire pressure (no effect of tire wall) . The use of ESAL is based on the results of experiments that have been shown that the effect of any load on the performance of a pavement can be represented in terms of the number of single applications of (ESAL). Annual growth rate is assumed to be 10 percent.

Environmental Conditions

Many environmental conditions influence the performance of the flexible pavement. The only environmental effect that is included in the developed model is the temperature of the asphalt course. Changes in the temperature of the asphalt course affect the elastic and viscous properties of the asphalt. Three temperatures (25 ,40 and 60 ^{o}C) were used in estimation of rut depth within selected pavement structure.

Rut Depth Values

The system rutting formulation treats the pavement system as a whole and first calculates an equivalent set of pavement system permanent deformation parameters (α_{sys} and μ_{sys}) which are determined as functions of load repetitions by least square regression analysis .***VESYS 5W*** software program is applied to estimate rut depth in selected pavement structure by using resilient modulus values , three testing temperatures **. Fig. 5** below presents the rut depth values of various asphalt mixtures at end of 10 years of analysis time.

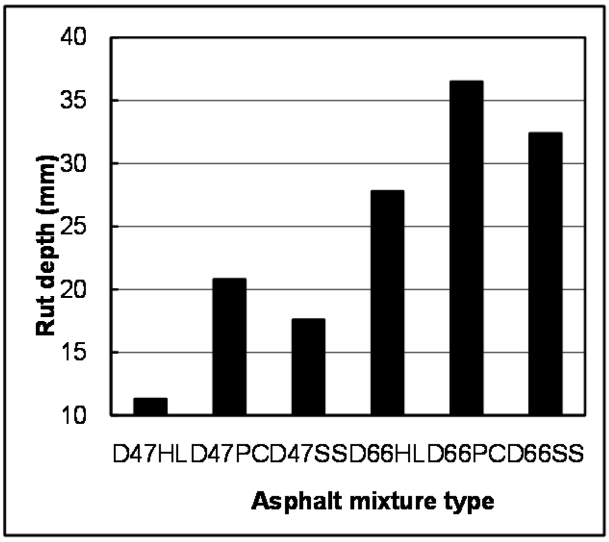


Fig. (5) Effect of mineral filler type on rut depth values of asphalt mixes

When comparing the rut depth results showed in **Fig. 5** , it is noted that the addition of hydrated lime improved the performance indicators with low rut depth values .

Effect of Mineral Filler Type on Indirect Tensile Fatigue Test Results

Fatigue cracks are caused by repeated traffic loading and it occurs in asphalt pavements when repeated stress or strain having a maximum value generally less than the ultimate strength of the material **(Yoder and** Witczak **,1975)** . The results of the indirect tensile fatigue test are presented in **Fig. 6** . While evaluating the fatigue resistance of asphalt concrete mixes , the number of cycles to failure are used as performance indicators.A high number of cycles to failure are the desired properties.

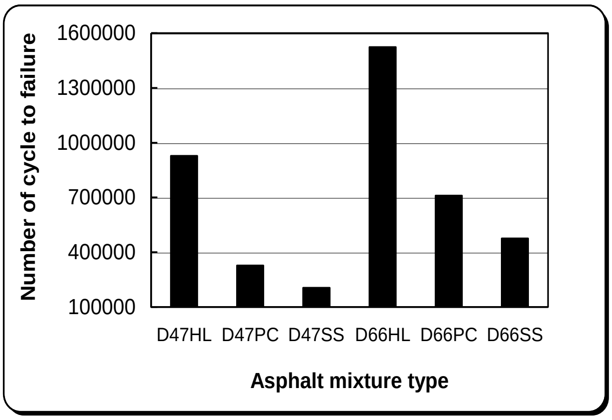


Fig. 6: Effect of mineral filler type on number of cycle to failure of asphalt mixes

The results of the fatigue test indicate that the addition of hydrated lime as a filler increased the fatigue resistance of the mixes. The D66HL mixture was the mix that showed the highest endurance to the repeated cyclic loading of the fatigue test.

5. Conclusions

Within the limitations of materials and test procedures used in this work, the following are concluded:

1. The smaller size fractions of hydrated lime enhancing the absolute viscosity , and improving the asphalt durability and stiffness of the recovered asphalt from asphalt concrete mixture containing hydrated lime as a filler.
2. The hydrated lime is effective in increasing the moisture damage resistance of the mixture, thereby providing pavements that are highly strip resistance.
3. The asphalt mixes with hydrated lime showed improved stiffening and durability properties when incorporated into the mixture.
4. The tensile strength are highest for the asphalt concrete mixes containing hydrated lime fillers than mixes designed with other mineral filler types.
5. The research results revealed that the hydrated lime fillers can have an effect on the rutting susceptibility and fatigue life of flexible pavements , and the use of hydrated lime can improve resistance of the mixes to rutting and fatigue cracking distresses.

Table 1: Chemical composition of asphalt cement

Fraction	Chemical Reactivity
Asphaltenes – A	Low
Polar Aromatics –PA	High
Napthene Aromatics -NA	High
Saturates -S	Low

Table 2 : The physical properties chemical composition of asphalt cement types

Property	Daurah (40-50)	Daurah (60-70)	***SCRB*** specifications	
			(40-50)	(60-70)
Standard Penetration ,1/10 mm	47	66	40-50	60-70
Absolute viscosity at 60 °C, poises	2033	1340	------	--------
Ductility (25 °C , 5 cm/min),cm	>100	>100	=>100	=>100
Specific gravity at 25°C	1.035	1.03	-------	--------
Solubility in trichloroethylene ,%	99.72	99.9	>99	>99
Mass loss , %	0.35	0.58	<0.75	<0.80
Residue from Thin film oven test -Retained penetration,% of original -Ductility (25 °C,5 cm /min.), cm	 65 75	 61 92	 >55 >25	 >52 >50
Chemical Composition , %				
Asphaltenes – A	20.03	18.31		
Polar Aromatics –PA	35.42	37.08		
Napthene Aromatics -NA	24.20	25.37		
Saturates -S	20.35	19.24		

Table 3 : Coarse and fine aggregate properties

Property	Value	Test method	Specification source	Specification requirements
	Coarse aggregate			
Sieve size (mm)	12.5 to 2.36		***SCRB***	------------
Bulk specific gravity	2.632	ASTM C127	---------	-------------
Percent wear, Los Angeles (%)	19.2	ASTM C535	***SCRB***	Not more than 30 %
% Crushed pieces (One face)	96	----------	***SCRB***	At least 90% by weight of material
Soundness, total weight loss percent	3	ASTM C88	***SCRB***	Not more than 12 %
	Fine aggregate			
Sieve size (mm)	2.36 to 0.075		***SCRB***	---------
Bulk specific gravity	2.676	ASTM C128	-------	--------
Soundness , total weight loss percent	4.6	ASTM C88	***SCRB***	Not more than 12 %

Table 4: Physical properties of mineral filler types

Property	**Test method**	**Result**
Hydrated lime		
Passing sieve No. 200, %	---------------	100
Specific gravity	ASTM C128	2.785
Plasticity index	AASHTO T90	1.5
Portland cement		
Passing sieve No. 200, %	---------------	96
Specific gravity	ASTM C128	3.15
Surface area (m^2/Kg)		357.82
Soft sandstone		
Specific gravity	ASTM C128	2.653
Plasticity index	AASHTO T90	3.2

Table 5: Selected gradation of aggregate

Sieve size (mm)	19	12.5	9.5	4.75	2.36	0.30	0.075
% Passing	100	95	83	59	43	13	7

Table 6: The code for the six asphalt mixture types

Asphalt mixture code	Description
D47HL	Daurah 47 pen.asphalt with hydrated lime filler
D47PC	Daurah 47 pen.asphalt with Portland cement filler
D47SS	Daurah 47 pen.asphalt with soft sandstone filler
D66HL	Daurah 66 pen.asphalt with hydrated lime filler
D66PC	Daurah 66 pen.asphalt with Portland cement filler
D66SS	Daurah 66 pen.asphalt with soft sandstone filler

Table 7 : Marshall properties of different asphalt mixture types at optimum asphalt content

Property	Asphalt mixture type						***SCRB*** specifications
	D47HL	D47PC	D47SS	D66HL	D66PC	D66SS	
Marshall stability (KN)	14.4	11.3	12.9	10.7	8.6	9.5	Min. 8 KN
Marshall flow(mm)	2.8	3.6	3.2	3.1	3.7	3.4	2-4 mm
Voids in total mix (%)	3.8	4.3	4.6	3.5	4.0	4.2	3-5 %
Voids in mineral aggregate (%)	15.7	16.6	16.9	14.8	15.1	15.9	Min. 14
Voids filled with asphalt (%)	75.8	74.1	72.8	76.4	73.5	73.6	65-85 %
Optimum asphalt content (%)	5.36	4.9	5.03	5.20	4.7	5.48	4-6 %

Table 8: Chemical fractions and Gaestel index values of original and recovered asphalt cement types

Asphalt cement	Original D47	Original D66	Recovered asphalt cement types					
			D47HL	D47PC	D47SS	D66HL	D66PC	D66SS
% A	20.03	18.31	26.29	23.77	22.61	23.24	21.48	20.07
% P.A.	35.42	37.08	22.45	33.65	22.92	20.19	38.56	36.41
% N.A.	24.20	25.37	31.80	22.61	34.44	38.35	21.59	24.83
% S	20.35	19.24	19.46	19.97	20.03	18.22	18.37	18.69
IG	0.68	0.60	0.84	0.78	0.74	0.71	0.66	0.63

Table 9: Material properties of pavement structure courses

Material properties	Surface	Binder	Base	Subbase	Subgrade
Resilient modulus (psi)	Variable	143000	66000	10000	5000
Poisson’s ratio	0.35	0.35	0.35	0.40	0.45
Thickness (cm)	5	8	15	25	infinity
Permanent deformation properties					
Alpha (α)	Variable	0.66	0.65	0.88	0.77
Gnu (μ)	Variable	0.12	0.15	0.03	0.04

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تقييم الجير المطفأ كمادة مالئة في الخلطات الاسفلتية

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الخــلاصــة:

المادة المالئة المعدنية هي احد المواد المهمة والمؤثرة على خواص ونوعية الخلطات الإسفلتية، وتوجد هناك أنواع مختلفة من المواد المالئة متباينة فيما بينها من ناحية الكلفة والنوعية، الامر الذي شجع على إجراء هذه الدراسة لتقييم تأثيرات الجير المطفأ على خواص الخلطات الإسفلتية من حيث مقاومة الأحمال و متانة . تم تحضير الخلطات الإسفلتية التقليدية باستخدام اسمنت بورتلاند و حجر رملي مطحون كمادة المالئة و أخرى معدلة الجير المطفأ لتقيم خواصها الهندسية الأساسيةِ كما هي مُعَرَّفة من قبل خواص مارشال، دليل المقاومة المسترجعة، مقاومة الشدّ الغير مباشر، خصائص التشوه دائمي، ومقاومة الكلل.تم استخدام التدرج الكثيف المثالي لتحضير الخلطة و المستخدم في انشاء الطبقة السطحية في العراق بموجب مواصفات *(SCRB)*. المواد ألمستعملة في هذه الدراسة تضمنت مواد ركام معدنية (مقاسات خشنة وناعمة) تم الحصول عليها من مقالع بحر نجف و نوعان من الإسفلت المنتج من مصفى الدورة وهما D66, D47. تم تقييم الخواص الفيزيائية ومعامل الصلادة و التركيب الكيمياوي للإسفلت المستعادة من الخلطات الإسفلتية المحضرة و التي تحتوي على المواد المالئة المختلفة . أظهرت نتائج البحث بأنّ إضافةَ الجير المطفأ كمادة مالئة حَسّنَ خصائص التشوهِ الدائمي وعمر الكلل وكذلك استعمال الجير المطفأ يقلل من حساسية الرطوبة للخلطات الإسفلتية.