Evaluating Marination Effect of Diluted Zycotherm on Hot Mix Asphalt

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***Abstract*—Sinceasphalt concrete undergo different failure problems at different temperature and moisture conditions and for years many scientists and researchers used different kinds of materials and variety of methods for improving the properties of asphalt concrete made with either basalt or limestone. So it became necessary to provide the best possible way to get rid of these failure problems. In this study diluted zycotherm nanomaterial at three different percentages by weight of aggregate used with two aggregate types, basalt and limestone, and asphalt concrete made with the marinated aggregate and later the properties of asphalt concrete were investigated after the marination. Indirect tensile strength test and retained stability test results were used to evaluate the marinating effect. As a result zycotherm dilution by weight of aggregate has changed the properties of asphalt mixture and improved to a great extent. From the results it can be concluded that rutting and fatigue problems decreased with a great range.**

***Keywords*—diluted zycotherm, marinated aggregate, indirect tensile strength test**

I. INTRODUCTION

Highways and pavements fail due to different and variety of reasons and those reasons that play a vital role in the failure of highways and especially pavements constructed with hot mix asphalts can be listed as:

- Failure due to the bottom layers base, sub base or subgrade;
- Failure due to the asphalt layers

As in most of the countries, Moisture and temperature has the greatest influence regarding the failures due to the asphalt layers, and can be considered as the major causes of pavement failure.

Water and temperature causes de bonding between liquid asphalt and the aggregate and this becomes the major threat to the durability of the asphalt concrete.

Different admixtures have been proposed by the researchers to increase the bond between liquid asphalt and aggregate in order that the asphalt will be much more durable and can sustain much more loads. A research used cement dust as the filler to investigate the stripping potential of the mixture due to moisture and compared with thetraditional lime stone filler and *Accelerated moisture damage program was established to evaluate the mixture resistance to moisture damage*, and it was seen that moisture damage from the asphalt concrete mixture can be greatly reduced and decelerated by the aid of the usage of cement dust [1].

Since asphalt possess a complex chemical composition, researchers have been trying to use different polymers, nanomaterial, crumb rubbers and other admixtureswithin asphalt for improving the properties of asphalt concrete, as an example Cortizo et al. used styrene butadiene styrene (SBS)[2], Zhang et al; Zhang et al. used styrene butadiene rubber (SBR)[3], Yildirim used ethylene glycidyl acrylate (EGA) terpolymer[4], Shen et al.used crumb rubber[5], some researchers have used waste materials as asphalt modifiers, such as waste fiber, waste tire rubber, waste plastic and tall oil pitch [6]-[7]-[8].

Since nanomaterial is a promising and creative technique in the material industry, there are some other researchers used nanomaterial as a modifier for improving and optimizing the properties of hot mix asphalt as; Carbon Nano fiber [9], raw single wall nanotube [10], nonmodified Nano clay (NMN) and polymer modified Nano clay (PMN) [11].

Also Nano silica has been used as asphalt modifier due to its potentially beneficial properties as (huge surface area, strong adsorption, good dispersal ability, high chemical purity and excellent stability) and it was found that it can improve the properties of asphalt to a great extent[12].

II. MATERIALS

A. Asphalt and aggregate

The asphalt (bitumen binder) used in this research was the 50/70 penetration grade, which is more suitable for hot weather such that of Iraqi Kurdistan weather conditions. Their properties were determined through some conventional t ests including penetration, softening point, specific gravity, ductility, thin film oven test and rolling thin film oven tes

Table I: The properties of bitumen used for this research

Tests	Units	Test Methods	50/70 Grade Bitumen	Specification

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Penetration	0.1 mm	TSEN 1426	61.0	50-70
Softening Point	^{0}C	TSEN 1427	50.4	46-54
Frasss Max.	^{0}C	TSEN 12593	-12	-8
Flash Point min.	^{0}C	TSEN ISO12592	332	230
Specific Gravity ($d_{25/25}$)	g/cm^3	TSEN 15326+A1	1.021	-
Thin Film Heating Loss (Mass Change) Max.	%	TSEN 12607-2	0.3	0.5
RTFOT (Thin Film Oven Test) Max.	%	TSEN 12607-1	0.5	-

Two types of aggregate used for investigation purpose, basalt and limestone, and they were taken from two different sources and the physical properties and the gradation detail are given in the table (2).

Table II: Physical Properties Of Basalt And Limestone

Tests	Units	Test Methods	Results Limestone	Results Basalt	Specification
					Wear Type 1
Abrasion loss (loss angeles) max.	%	TS EN 1097-2	22	12.0	30
Abrasion max.	%	TS EN 1097-6	0.61	1.53	2
Magnesium sulphate freezing loss max.	%	TS EN 1367-2	4.2	6.61	16
flatness index	%	TS 9582 EN 933-3	14	20	20
Peeling strength, min.	%	KTS 2006	65-75	30-40	50
bulk spesific gravity of coarse aggregate	g/cm^3	TS EN 1097-6	2.699	2.891	-
apparent specific gravity of coarse aggregate	g/cm^3	TS EN 1097-6	2.744	2.974	-
bulk spesific gravity of fine aggregate	g/cm^3	TS EN 1097-6	2.65	2.812	-
apparent specific gravity of fine aggregate	g/cm^3	TS EN 1097-6	2.725	2.918	-
apparent specific gravity of filler	g/cm^3	TS EN 1097-7	2.779	2.94	-

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B. *Aggregate Gradation*

Aggregate gradation is one of the most important factors for design of bituminous mixtures; it affects the HMA performance in many respects including stiffness, durability, stability, permeability, and workability, resistance to rutting and fatigue cracking and frictional resistance. Specification for wearing course selected and detail of the gradation is tabulated down in table (3).

Table III: Agrregate gradation and specification limits

Sieve Opening		% Passing		Design Limit
Inch	mm	Min	Max	% Passing
3/4"	19.1	100	---	100
1/2"	12.7	83	100	92
3/8"	9.52	70	90	80
No.4	4.76	40	55	48
No.10	2	25	38	32
No.40	0.425	10	20	15
No.80	0.18	6	15	11
No.200	0.075	4	10	8

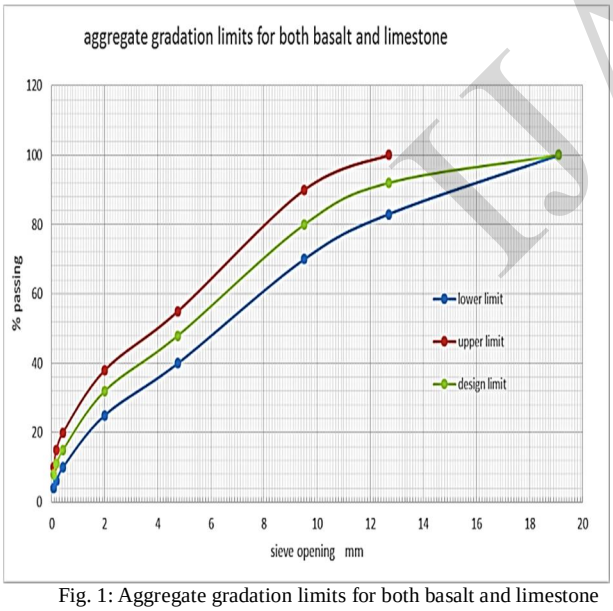


Fig. 1: Aggregate gradation limits for both basalt and limestone

C. Zycotherm Nanomaterial

Zycotherm Nano material is used for modifying hot mix asphalt concrete and offers a wide range of benefits, due to the unique properties of Alkyl Siloxane Nano layer produced [13].

The typical specification of zycotherm is listed herein under:
Active ingredient: Organosilane compound
Solid content: 65% ± 2%
Appearance: clear pale yellow liquid
Flash point: >80˚C
Solubility in water: soluble

D. Aggregate Marination With Zycotherm Dilution

Zycotherm diluted in water at 1:400 means one part of zycotherm diluted in 400 parts of water. The mixture sprinkled over the aggregate, mixed and left it to dry. Both aggregate type limestone and basalt marinated with this dilution at 3 different percentages (1%, 3%, and 5%) by weight of aggregate. After this marinated aggregates heated up to 170'C and bituminous mixtures produced with the marinated aggregate, retained stability and indirect tensile strength was measured and compared with control samples (sample produced with 0% zycotherm dilution at the same condition of mixtures that contain zycotherm dilution).

III. EXPERIMENTAL WORKS

A. Marshall Test

It is conducted to determine the optimum bitumen content for both aggregate types and also to determine the strength and flow parameter change with the addition of zycotherm. Optimum bitumen content is determined with preparing 3 sets of HMA samples prepared at 3.5%, 4%, 4.5%, 5% and 5.5% bitumen content and compacting samples with 75 blow with standard hammer. The optimum content is determined at 4% air void. For limestone, the optimum content is found to be 4.67% and for basalt is 5.03%.

B. Indirect tensile strength test (ITS)

It is used for determining the structural properties of a bituminous mixture. It is also aimed to evaluate the moisture susceptibility of bituminous mixtures, and this can be shown with the reduction in the loss of indirect tensile strength after conditioning samples in water at 60 □C.

Indirect tensile strength is calculated with this formula [15]

1. $St=2P/\pi dt$

Whereas
(St): is the indirect tensile strength,
(P): is the maximum applied load,
(d): is the specimen diameter,
(t): is the specimen height.

The test is performed by preparing the marshal samples of 100 mm diameter and 63.5 mm height, at optimum bitumen content and compacting each side of the specimen with(50

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blows for limestone and 60 blows for basalt) to get an air void content of 7%±1%.

C. Retained Stability Index (RSI)

It is performed by preparing the standard marshal samples (of 100 mm diameter and 63.5mm height) at optimum bitumen content by applying 75 blows on each side for both limestone and basalt aggregates.

Three specimens are selected as a control and tested without moisture conditioning and the three more are selected to be conditioned by keeping them in water bath maintained at 60 °C for 24 hours. The marshal stability and flow of compacted specimens is determined after conditioning them with standard marshal testing machine. The retained stability is expressed as the stability after conditioning samples in water maintained at 60 °C for 24 hours divided by the stability under standard conditions multiplied by 100 according to [14] and [15].

IV. RESULTS AND DISCUSSION

At the beginning control samples prepared for both aggregate types at optimum bitumen content for both types separately. And later on samples prepared from the aggregate marinated with zycotherm dilution at 1%, 3% and 5% by weight of aggregate.

The results for the retained stability index for limestone can be seen from figure (2); from there we can see an increase in the RSI from 65% to 96% at 3% zycotherm dilution content, which is an indicator for increasing the resistance of mixture to moisture damage up to 30%.

The result of RSI for basalt can be seen form figure (3), from there also there is an increase from 67% to 99% at 3% dilution content. We can say that almost the same amount increased 30% at 3% zycotherm dilution content.

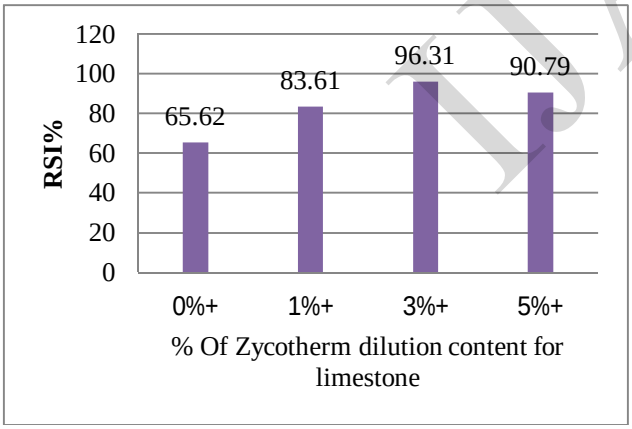


Fig. 2: Zycotherm dilution content versus RSI % for limestone

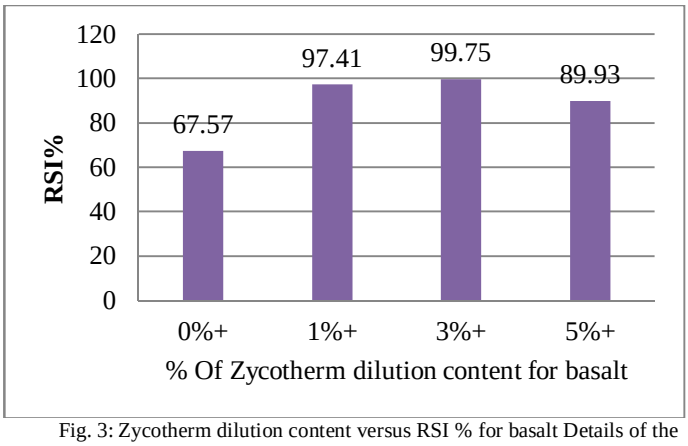


Fig. 3: Zycotherm dilution content versus RSI % for basalt Details of the indirect tensile test results are given below.

From figure (4) limestone results and from figure (5) basalt test results are given. The same fact for RSI is revealed for ITS. At 3% zycotherm dilution content there is approximately 15% increase for limestone and 10% increase for basalt. Since indirect tensile strength is a measure for structural properties of asphalt concrete and also a measure for moisture susceptibility of the mixture, so we can say by increasing 3% zycotherm dilution content to both aggregate types we have increased the response of asphalt mixture to water by approximately 15%.

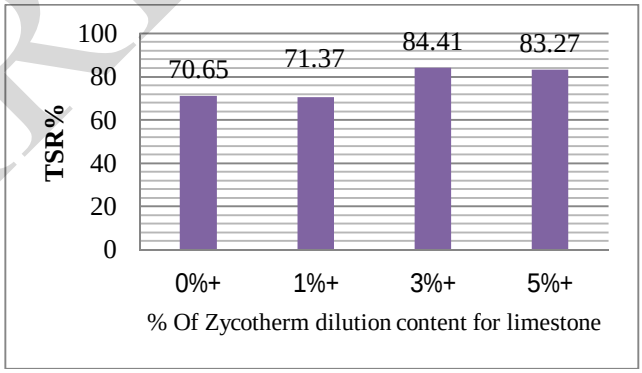


Fig. 4: Zycotherm dilution content versus TSR % for limestone

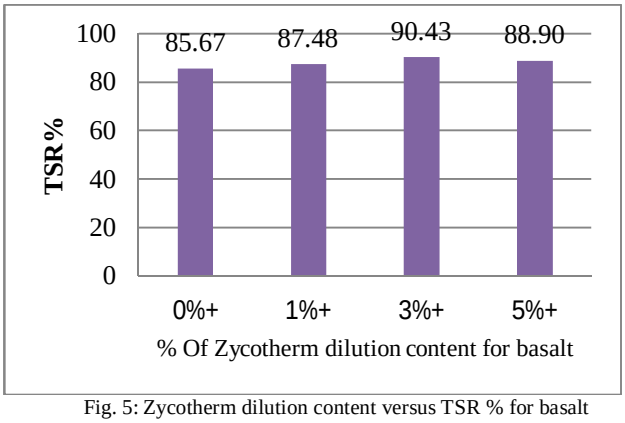


Fig. 5: Zycotherm dilution content versus TSR % for basalt

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V. CONCLUSION

We have done this research mainly to check whether diluted zycotherm can be used directly with aggregates or not? While hot mix asphalt concrete is produced with it, and to find out the optimum amount of zycotherm dilution. Three tests were done to investigate the marinating effect of zycotherm Nano material on two types of aggregates, basalt and limestone, since zycotherm contain silanol group which is believed to react with the silicon available on the surface of aggregate and converts the hydrophilic (water loving) layer of the surface of aggregate to a hydrophobic (water-hating) layer. By this way at the same time reinforces the bond between aggregate and bitumen.

From the test results obtained we can say that using 3% zycotherm dilution by weight of aggregate will increase the retained stability of hot mix asphalt by 30% for both aggregate types, which is an indicator for water or moisture susceptibility. From this result we can say if we omit water or moisture by 30% it means we have increased the life of pavement by that range.

And also using 3% zycotherm dilution by weight of aggregate will increase the indirect tensile strength or tensile strength ratio (TSR) by 15 % for both aggregate types approximately.

From the above results it can be concluded that using 3% zycotherm dilution by weight of aggregate will improve and enhance the properties of hot mix asphalt concrete to a great extent and rutting and fatigue problems which mostly arise from moisture exposure and existence inside the asphalt will be decreased.

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