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Characterication Of Modified Asphalt Mixtures With Asphalt Cement With Road Bond En-1

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Abstract: *The objective of this study is to evaluate the effect of adding Road bond EN-1 to the asphalt cement and their asphalt mixtures properties, and the long term performance.*
The variables considered are the effect of adding different ratios of EN-1 to suej 60/70 Asphalt cement properties . The added ratios are 0.3, 0.4 and 0.57 by weight for 60/70 A.C.
For asphalt mixtures, the variables considered are the effect of the above modified asphalt cement on Marshall Properties.
The results of this study indicate that the addition of EN-1 to suez A.C and its asphalt mixtures at all ratios improved all properties. The addition of EN-1 to seuz A.C improves its thermal characteristics by increasing its penetration index. Increasing the percentages of EN-1 increases stability and Marshall Stiffness and decreased the flow of Asphalt concrete mixtures.
Key Words:*Road bond EN-1 ,penetration Index , Rutting* **.**

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I. Introduction

With the rapid growth of traffic particularly of heavy vehicle consequently, roads come to the end life earlier. Distress signs take the form of severe rutting of the road , cracking and disintegration of surface materials . Road authorities are looking for materials for maintenance and rehabilitation , which capable of giving better performance over longer period (1).

The characteristics of asphalt and asphalt mixtures may be improved by means of using additives such as fly ash (2) , carbon black (3) , sulfur (4) , lime (5) wood fibers (6) , rubber (7) and polymers (8).

The objective for this study is to evaluate the effect of adding Road bond EN-1 material on properties of the Asphalt cement and their concrete mixtures and comparing these modified properties with the unmodified properties of the conventional asphalt cements and their asphalt concrete mixtures .

II. Materials and Method

The materials used in this study composed of aggregate, bituminous and road bond EN-1 .Crushed siliceous limestone aggregates supplied from El-suez quarry. The basic engineering properties are presented in table 1 . siliceous sand obtained from El-suez used as fine aggregate , its bulk specific gravity is 2.65 . lime powder filer of bulk specific gravity used as mineral filler .

The asphalt cement used in this study, was obtained from Suez plant . Its penetration grade is 60/70 and has a specific gravity of 1.040. The properties of the asphalt cement are presented in Figure 1. The asphalt cement achieved the Egyptian requirements for all tests which are 60-70 for penetration and 45 to 55 ºC for softening point, 250 ºC minmum for flash point and 320 centstoke minmum for viscostity.

Road bond EN-1 is an American material and used for improving the asphalt mixtures properties . It is a chemical material which produced from food residuals. , . The physical and mechnical properties of the Road bond EN-1 are provided in Table 3.

Table 1 Engineering properties of coarse Aggregate :

Test No	Test	ERBA Test Standard	Result
1	Bulk specific gravity	T-108	2.436
2	Bulk specific gravity Saturated surface dry	T-108	2.51 2.63
3	Apparent specific gravity	T-108	3.0
4	Water absorption (%)	T-108	0.25
5	Water Disintegration %		24
6	Los Angelos abrasion (LAA)%	T-106	

Table physical properties of the Asphalt Cement

Test	AASHTO Designation No.	Results	Specification Limits
Penetration, 0.1 mm	T-49	65	60-70
Softening point, Cº	T-53	53	45-55
Flash point, Cº	T-204	270	≥ 250
Kinematic viscosity, cst	T-201	347	≥ 320

Table 3 Physical properties for Road bond EN-1

Status	Liquid
Colour	Black
Density	1-6 kg/liter
Temperature susceptibility	Less temp.susceptible
Effect on Enviroment	No effect

Experimental Testing Program was divided into two phases. The first phase is the tests that conducted on the modified asphalt binder. Tests were penetration ,softening point , flash point and kinematic viscosity. Second phaseis the tests that performed on the modified asphalt mixture which are marshall test, rutting test and loss of stability test.

Different percentages of the EN-1 was trialled. The percentages were 0%, 0.3% , 0.4% and 0.5% by the weight of the asphalt binder. The unmodified binder was separated into quart containers for specimen production. Then the unmodified binder was heat to 175 ºC and afterthat the EN-1 modifier was added and mixing with the appropriate amount of EN-1. The mixing continue for 10 minutes with a hand held drill and paint mixer attachment. The mixing container was placed on a hot plate to maintain a 175 ºC.

A conventional wearing surface (4C) asphalt job mix formula (JMF) mixture was designed by Marshall method (ASTM D 6927-06). The grading curve of the mixture

compared with the upper and lower limits is provided in Figure 1. Marshall mixture properties are presented in Table 2.

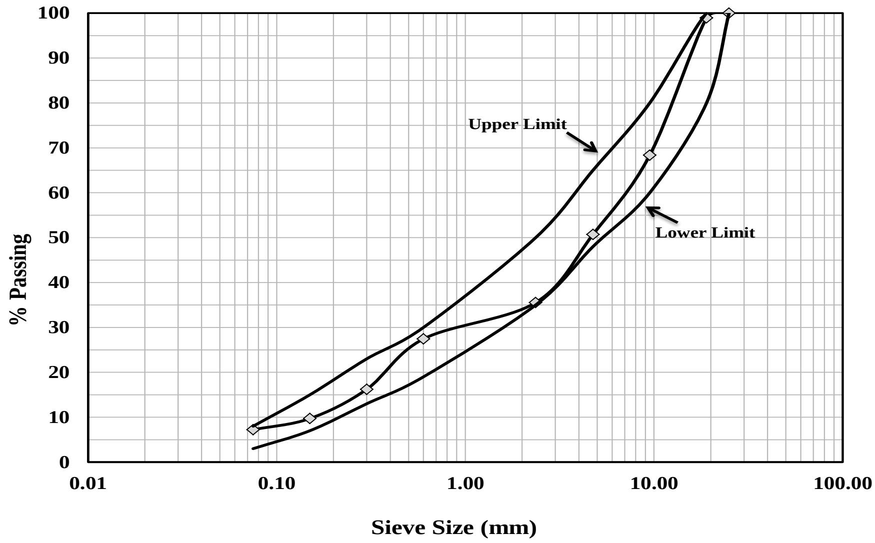

Figure 1 Gradation curve for the wearing surface asphalt mixture

Table 2 Conventional Asphalt Mixture Properties

Property	Design	Minimum	Maximum
Marshall Bulk Density (t/m^3)	*2.305*	-----	-----
Stability (kg)	*1023*	*800*	-----
Flow (mm)	*2.9*	*2*	*4*
Air Voids (AV) %	*4.6*	*3*	*5*
Voids in Mineral Aggregates (VMA) %	*16.3*	*13*	-----
AC	*5.0*	-----	-----

III. Results and Analysis

Modified Asphalt Cement Properties :

Figure 2 presents the testing results for the modified asphalt cement compared with the unmodified binder. It can be seen from the figure that the pentration decreases with the increase of EN-1 and becomes out of the Egyptian standards. An improvement was recorded for the softening points and the kinematic viscosity values with the addition of the EN-1. However, no singnificance was observed for the flash point value.The maximum rate of increase was recorded at 0.4% and 0.5% for the viscosity and softening point, respectively.

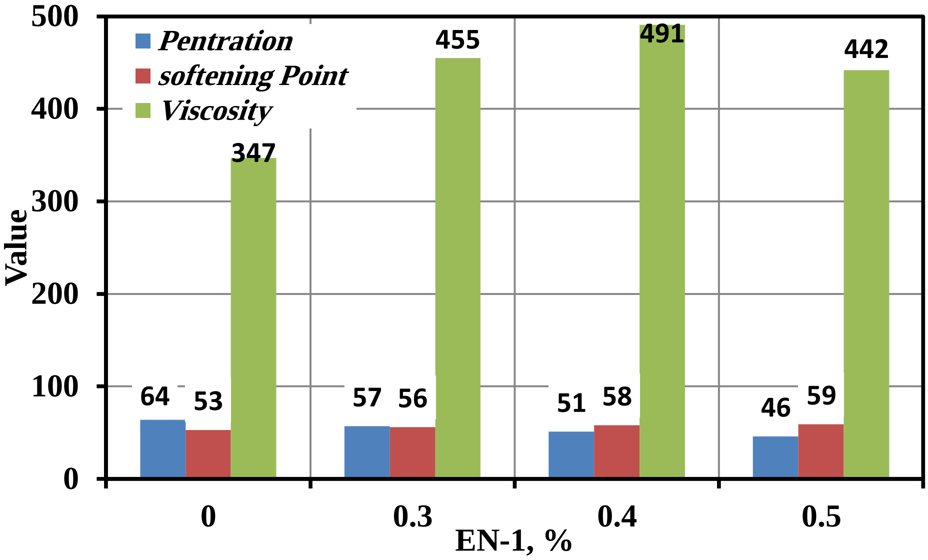

Figure 2 Physical properties of A.C Modified with Road bond EN-1

3.1 Modified Asphalt Mixtures

The modified mixtures were prepared after determining the optimum binder content. The conventional mixture was modified using EN-1 ranging from 0.3% to 0.5% by the weight of the binder. Three samples were prepared for each percentage.

Figures 3, 4 and 5 demenstrated the relationship between the percentage of EN-1 against Marshall, bulk specific gravity and air voids, repectively. It can be noted the addition of EN-1 increases the mixture stablity. The percentage of 0.5% EN-1 has improved the stability by 30%. The air voids decreases with the increase of the EN-1 percentage in the mixture which caused a slightly increase in the bulk specific gravity of the mixture. The flow values decreases with the high percentage of the EN-1 in the asphalt mixture (ranged from 2.88 mm at 0% to 2.75 mm at 0.5%). Also same behavior was observed for the voids in mineral aggregates (VMA) percentage (ranged from 16.3% at 0% to 14.5% at 0.5%)

Table (6) mashall properties for the investigated mixtures .

EN-1/A.C %	O.A.C (%)	Unit weight g /cm3 (1b/ft3)	Stability (1b)	Flow (0.01in)	A.V	V.M.A	Marshall stiffer
0	5.0	2.305 (143.9)	2250	11.5	4.60	16.3	7821
0.3	5.0	2.31(144.22)	2380	11.4	4.40	15.5	8351
0.4	5.0	2.314 (144.47)	2541	11.2	3.75	14.5	9075
0.5	5.0	2.312 (144.34)	2875	11.0	3.70	14.5	10459

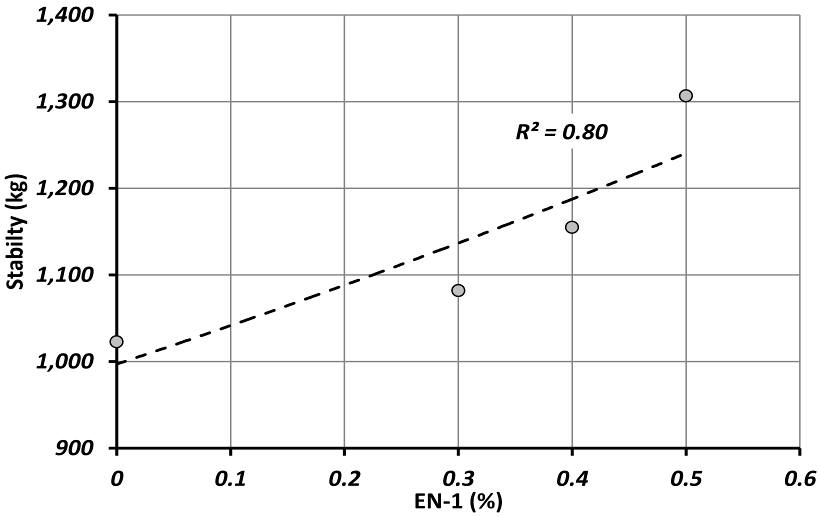

Figure 3 Marshall stability for modified mixture with different percentage of EN-1

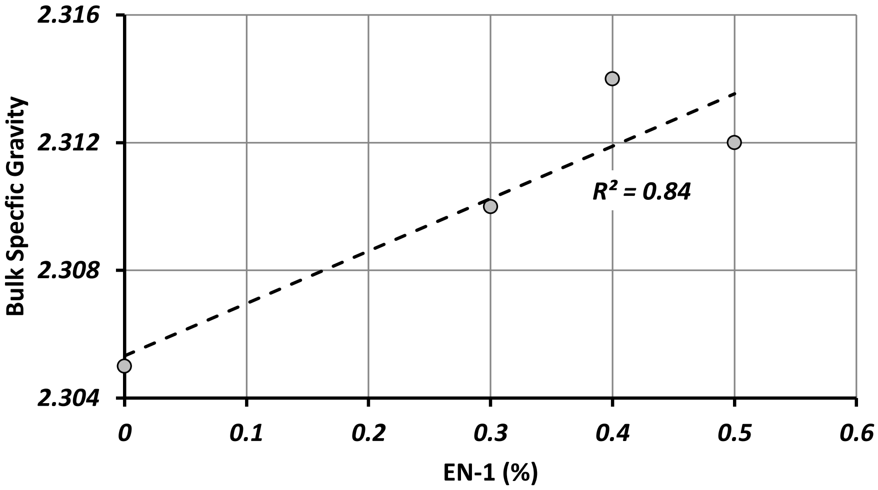

Figure 4 Bulk specific gravity for modified mixture with different percentage of EN-1

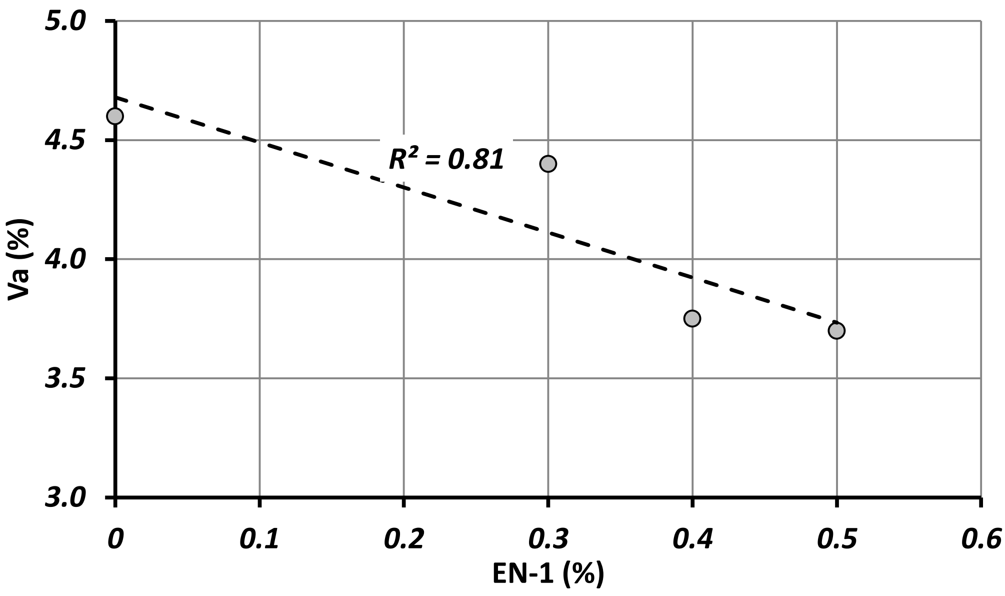

Figure 5 Air voids for modified mixture with different percentage of EN-1

Two tests were conducted on the asphalt mixtures of the first group and on the best EN-1 ratio to suez 60/70 asphalt cement in the second group from the analysis of phase I , these tests are the loss of stability and wheel tracking test . To achieve both of wheel tracking test and loss of stability test (9) some considered variables were selected . these variables are the soaking for 24 hrs at 160 º C for loss of stability test & the temperatures 25º C and 60 º C at 6.25 kg /cm^2 stress level for wheel tracking test .

This phase presents the results of different asphalt mixture produced by asphalt cement at different EN-1/A.C ratios . This phase includes marshall test results , rutting test results and loss of stability test results . Marshall test results :

IV. Marshall stiffness results

The values of marshall stiffness that are shown in table (6) are calculated by using this equation (10)
SM (psi)= marshall stability (1b) (marshall flow to specimen height) for 60/70 asphalt mixtures the increase of EN-1 /A.C ratio by 0.3 ,0.4 and 0.5 % increases the marshall stiffness value by 6.7 , 15.96 and 33.6 % respectively.
Evaluation of asphalt mixtures deformation resistance using rutting test.

Rutting Results:-

Specimens of Sues 60/70 asphalt mixture at EN-1/A.C = 0 , 0.3 , 0.4 and 0.5 were used in rutting test according to the temperature of the test . the testing temperature were 25 and 60Cº , these temperatures represents the laboratory temperature and the maximum temperature of the asphalt concrete surface in summer . All specimens were tested in wheel tracking machine under a constant repeated stress equal to 6.25 kg /cm^3 (90psi) and also were cured for three days before testing. The rutting depth deformation was recorded with time .
The rutting stiffness of the mixture was determined by using the equation which was developed by J.F.Hill (11) for the wheel tracking test as follows :-

Sr mix = (Ƶ ×

Where Srmix : rutting stiffness modulus of mixture in kg /cm^2
Ƶ equal to 0.5 for wheel tracking machine where the asphalt layer rested on a steel base plate .
:- contact stress at the surface of the specimen in the rutting test (6.25 kg/cm^2)
HO: intial thickness of specimen in the rutting test (5cm) and
RD:- Rutting depth (cm) for the wheel tracking machine with rigid steel plate .

Table (8) Rutting results for different paving mixtures at temperature 25Cº, curing time 3 days and contact stress 6.25 kg/cm^2

Time (min)	Dial guage reading (0.005 in) 60/70 +EN-1/A.C %			Rutting depth deformation (mm) A.C60/70EN-1/A.C%			Rutting stiffness kg/cm2 60/70 +EN-1 A.C%		
	0	0.3	0.4	0	0.3	0.4	0	0.3	0.4
1	0	0	0	0	0	0	∞	∞	∞
2	0	0	0	0	0	0	∞	∞	∞
3	0	0	0	0	0	0	∞	∞	∞
4	0	0	0	0	0	0	∞	∞	∞
5	0	0	0	0	0	0	∞	∞	∞
10	0	0	0	0	0	0	∞	∞	∞
15	0	0	0	0	0	0	∞	∞	∞
20	0.2	0	0	0.025	0	0	6250	∞	∞
25	0.3	0.1	0	0.038	0.013	0	4112	12019	∞
30	0.45	0.25	0	0.057	0.032	0	2741	4882	∞
35	0.55	0.35	0	0.070	0.044	0	2232	3551	∞ 12019
40	0.70	0.55	0.1	0.089	0.070	0.013	1756	2232	8224
45	0.90	0.65	0.15	0.114	0.083	0.019	1371	1883	6793
50	1.10	0.85	0.18	0.140	0.108	0.023	1116	1447	6250
55	1.15	1.00	0.20	0.146	0.127	0.025	1070	1230	4883
60	1.55	1.10	0.25	0.197	0.140	0.032	793	1116	

Table (9) summary results of rutting depth ,rutting stiffness (at 25 Cº after 45 min) and rate of tracking depth for different asphalt mixtures .

Rutting depth (mm)			Rutting stiffness, (kg/cm^2)			Rate of tracking depth (mm/hr)		
60/70 +EN-1 /A.C %			60/70 +EN-1 /A.C %			60/70 +EN-1 /A.C %		
0	0.3	0.4	0	0.3	0.4	0	0.3	0.4
0.114	0.083	0.019	1371	1883	8224	0.176	0.156	0.076

The rate of tracking in the rutting depth was expressed in mm/hr by using the following formula :-
ROT: 4(RD45-RD30 Where ., ROT : rate of tracking mm/hour , RD45: Rutting depth after 45 min ., (mm) and RD30 : Rutting depth after 30 min ., (mm).

The results of these tests are given in table (8). Table (9) shows the values of the rutting depth and the rutting stiffness at25 º C after 45 min and also the rate of tracking depth for different asphalt mixtures .

At 25 º C , the increases of EN-1/A.C ratio from 0% to 0.3% and 0.4% for 60/70 asphalt mixture decreases the rutting depth and increases the rutting stiffness by factor of 1.4 and 6 respectively .

The rutting depth of 60/70 asphalt mixture is more than 6 time the rutting depth of 6-/70 asphalt mixtures at EN-1/A.C = 0.4% . While the rutting depth of 60/70 asphalt mixture at EN-1/A.C =0.3% is less than the rutting depth of 60/70 asphalt mixture by a factor of 1.40.

Table (9) indicates that the increase of EN-1 /A.C ratio from 0% to 0.3% and 0.4% for 60/70 asphalt mixtures decreases the rate of tracking by a factor of 1.13 and 2.32 respectively .

The rutting depth increases with increases the loading time for different asphalt mixtures .

The 60/70 asphalt mixture at EN-1/A.C =0.4% shows the best resistance to permanent deformation, i.e the lowest rutting depth along the all loading times, followed by 60/70 at EN-1/ A.C = 0.3% and 60/70 asphalt mixtures respectively . The addition of EN-1 by eight of asphalt to 60/70 asphalt mixture results in shifting the rutting time from 20 to 25 minutes at EN-1/A.C =0.3% and from 20 to 40 minutes at EN-1/A.C =0.4% at25 º C .The rutting stiffness of the mixtures decreases with increases the loading time for different asphalt mixtures . the 60/70 asphalt mixtures at EN-1 /A.C =0.4% shows the highest rutting stiffness modulus , followed by 60 /70 at EN-1/A.C =0.3% and 60/70 asphalt mixtures respectively .

V. Conclusion And Recommendations

The analysis of test results led to the following conclusions and recommendation :

1. The addition of EN-1 to suez 60/70 A.C reduces the penetration, increase the kinematic viscosity and softening point.
2. Increasing the percentages of EN-1 increases stability and marshall stiffness and decreases the flow of suez asphalt concrete mixtures.
3. The suez 60/70 asphalt mixture at 0.4 % EN-1 by weight to asphalt shows that the best resistance to permenant deformation and increasing the percentage of EN-1 decreaces the optimum asphalt content.
4. It is recommended to study the chemical behavior of EN-1 and asphalt cement mixture in relation of physical and mechanical properties and the fatigue resistance of the modified mixes, also construct a field test section using EN-1 to predict the performance of the modified mixtures under different traffic and environmental conditions.

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