Study the Effect of Polyethylene on Physical Properties of Asphaltic Cement

Taher M.A. Al-ani
Engineering College
Anbar University

الخلاصة :-

لتحسين خواص الاسفلت الاسمنتي يتم استخدام مواد مضافة مثل الكبريت، المطاط، الكاربون، البوليمرات،...الخ لهذا الغرض. في هذا البحث استخدم البولي اثيلين واطيء الكثافة (LDPE) بنسب مختلفة (٠%، ١%، ٣%، ٥%، ٧%) من وزن الاسفلت. بعد ذلك تم تقيم تاثير هذا المضاف على الاسفلت بواسطة فحوصات فيزياوية هي فحص الاختراق (ASTM-D5) و فحص اللدونة (ASTM D-2398) وفحص اللزوجة الحركية (ASTM D-2170) . استحدم العامل (P.V.N) (pentration vescosity number) لتقيم حساسية التاثر الحراري لمادة الاسفلت الاسمنتي اضافة الى ذلك تم حتساب معامل الجسائة لمادة الاسفلت الاسمنتي باستخدام مخطط فاندر بول (van der pole's nomograph). الدراسة بينت ان مادة البولي اثيلين واطيء الكثافة (LDPE) تزيد من صلابة الاسفلت عند مختلف النسب ماعدى النسبة (١%) كذلك تقلل من حساسية الاسفلت للتاثر الحراري بصورة عامة.

Abstract :-

For improving the properties of asphaltic cement several materials such as sulfur, rubber, carbon black, polymers….etc. are used for this purposes. In this study low density Polyethylene (LDPE) used at different percentage (0%, 1%, 3%, 5% and 7%) by weight of the asphaltic cement and then the changes in the properties are evaluated by pentration test (ASTM D-5), softening point test (ASTM D-2398), and Kinematics viscosity test (ASTM D-2170). Temperature susceptibility was evaluated by using Penetration vescosity number (P.V.N). In addition to that stiffness modulus of asphalt cement was predectied by using van der pole's nomograph.

The study showed that the LDPE increase the hardening of asphalt cement at different percentage except at (1%), and decrease the susceptibility of asphaltic cement to temperature.

Introduction:-

Asphalt pavement have been used successfully over many decades it is evident that such pavement will be used extensively in the years to come.

Asphaltic cement additive is a material which would normally be added to and/or mixed asphalt before mix production or during mix production to improve the properties and/or performance of the resultant binder and/or the mix, or where on aged binders is involved as in recycling , to improve or restore the original properties of the aged binder(1).

Polymer-modified binders have been found to improve several properties of paving mixes such as temperature susceptibility, fatigue life, and resistance to permanent deformation (2).

Reclaimed rubber obtained from used tiers, polyethylene in the form of low density (LDPE), styrene-butadiene-styrene copolymer, latex are used for modification of asphaltic cement and test sections were found to perform satisfactorily (3).

The aim of this paper was to study the effect of low density polyethylene (LDPE) on the physical properties of asphaltic cement which producing from Daurah refinery with grade (40-50) for different percent of added (0%, 1%, 3%, 5% and 7%). For this purposes the changes in the physical properties are evaluated by investigating the following tests penetration test at $25C^0$, softening point , kinematic viscosity at 135 C^0. Stiffness modulus of asphaltic cement was predicted by van-der- pole nomograph and penetration viscosity number (PVN) was used for evaluating temperature susceptibility.

2.Review of Literatuve :-

It can be expected that asphalt mixtures compounded with polymers will a longer service life, show lower tendency towards permanent dimensional changes, have greater elasticity less sensitive to variations in temperature and greater elasticity, vibration caused by traffic(4).

The interaction between bitumen and any given polymer system is complex. The morphology of the polymer appears to swell and take up a much larger volume fraction than it’s weight fraction would indicate. The greater the degree of compatibility the closer to a bitumen matrix is achieved and the more polymer like is the behavior(5).

A polymer is a large molecule construction from many smaller structural unites called monomers , coralently bonded together in any conceivable pattern. In certain cases it is more accurate to call the structural or repeat unite a monomer residue because atoms are eliminated from the simple monomeric unite during some polymerization processes(6).

It is well known that some polymer modified asphalt mixes by providing high rigidity it is said that they have same drawbacks regarding homogeneousness of mixture, execution of work, and performance (7).

Mahabir Panda and Mayajit Mazumdar (8) were used reclaimed low density polyethylene (LDPE) from carry bags of goods for modification asphalt mixture performance as fatigue life, resilient modulus, resistance to moisture susceptibility in addition to marshal characteristics.

David, Anderson, Maurer, and other (9) were studied and evaluated several section of road constructed by asphalt concrete and modified asphalt cement by LDPE, Ethylene vinyl acetate, Polymer fibers, SB-reacted, Gilsonite and SBS 4141. study showed there are different performance in the modification type according to SHRP (Strategy Highway Research program).

Wlodyslaw Milkowski (10) used polyethylene as an additive to achieve asphalt concrete of much higher stability and lower thermal susceptibility. Adding polyethylene "PE" in small percent reduce penetration, raised the softening point and increased the shear strength of asphalt joints.

Lee, Morrison and Hesp (11) found that the additive of polyethylene and chlorinated polyethylene to asphalt binders does significantly increase their low temperature fracture toughness and fracture energy.

Larsen, Wohlk and Andersen (12) determine whether bitumen modification can increase pavement life. The asphalt was modified by oxidation, chemecrete, wax, SBR "Styrene-Butadiene-Rubber" , BR"Butadiene-Rubber" or SBS "Styrene-Butadiene-Styrene", which are used as modifiers in sprayed sealing and asphalt cement wearing coarse. They found, compared with the base, the modifier creates an improve in internal cohesion, less temperature susceptibility and increase the ductility.

Dunning, Schulz and Grawron (13) found that polymer system could be used to part stripping trance to asphalt concrete by coating the aggregate prior to drying, and they found that polymer decrease the temperature susceptibility of the resilient modulus of the mix.

Ogino, Ohame and Kouzuki (7) used the epoxy resin modified asphalt concrete pavements as one of the counter measure to prevent plastic flow.

Nahas, et.al (14) selected a series of ethylene copolymers to increase high temperature stiffness without losing low temperature flexibility when blended with asphalt.

King et.al (15) shown that SBS "Styrene-Butadiene-Styrene" modifiers reduce the low temperature stiffness at some constant low temperature, the elastomers modified product will generally withstand greater tensile strains before fracturing.

Asal Naume (5) shown that using of 1.25% of PVC "Polyvinyl Chloride" caused increasing stability and decreasing susceptibility to temperature and shown lower stiffness modulus, less permanent strain and lower susceptibility to low temperature cracking when compared with zero PVC mixture.

3.Materials and Tests :-

1. Asphalt Cement:-

One binder of asphaltic cement was tested, it is from Daurah Refinery with a grade of (40-50) penetration. The physical properties of this type are illustrated in table (1)

Table (1). Physical Properties of Asphalt Cement.

Test	Unit	Daurah (40-50)
Pentration @ 25 C^o	**0.1 mm**	**49**
Ductility @ 25 C^o	**Centimeter**	**+100**
Softening Point	**C^o**	**52**
Flash Point	**C^o**	**351**
Specific Gravity	**---**	**1.033**
Kinematic Viscosity	**cst.**	**461**

2. Additive:-

Low density polyethylene (LDPE) was used with asphalt binder , it is available in the local market as a particles size (3x3) mm.

LDPE was added to binder at different percent (0% ,1% ,3% ,5% and 7%). The method of adding LDPE to binder depending to temperature (160 to 200) C^0 and stirrer (3000 r/min) for 20 minute (8). in this study to avoid high temperature of adding, the LDPE was grinding to small particles less then (0.2 mm) and added to binder at (140 C^0) with stirrer (3000 r/min).

3. Testing Asphalt Cement:-

To study the effect of LDPE on the physical properties of asphalt cement, the following tests are performanced:-

1- Penetration test at 25 C^o ASTM (D-5) (18).

2- Softening point test (ASTM D-2398) (18).

3- Kinematics viscosity test(ASTM D-2170) at temperature of test (135C^o) (18).

4. Result and Discussions :

The data of study “effect of Polyethylene” after addeding on asphalt cement are evaluated laboratory and are arranged in table (2).

Table (2).Physical Properties of Daurah (40-50) With LDPE.

No.	% LDPE	Physical Properties			P.V.N	Stiffness Binder (N/Cm^2)	
		Penetration @ 25 C°	Softening Point C°	Kinematics Viscosity (cst)		@ -5 C°	@ 60 C°
1.	0%	49	52	461	0.77	١٥	$3*10^{-5}$
2.	1%	61	47	378	0.85	١٠	$8*10^{-6}$
3.	3%	48	53	464	0.78	١٩	$4*10^{-5}$
4.	5%	40	58	509	0.83	٣٨	$7*10^{-5}$
5.	7%	36	60	551	0.84	٥٢	$9*10^{-5}$

Figure (1) shows the effect of LDPE percentage on the grade of asphaltic cement by penetration test at 25 C°. The penetration decrease with increasing the LDPE percentage except at (1%) where increase penetration grade.

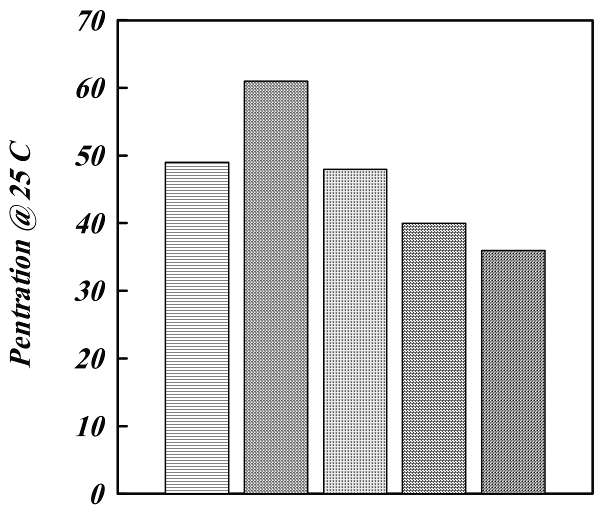
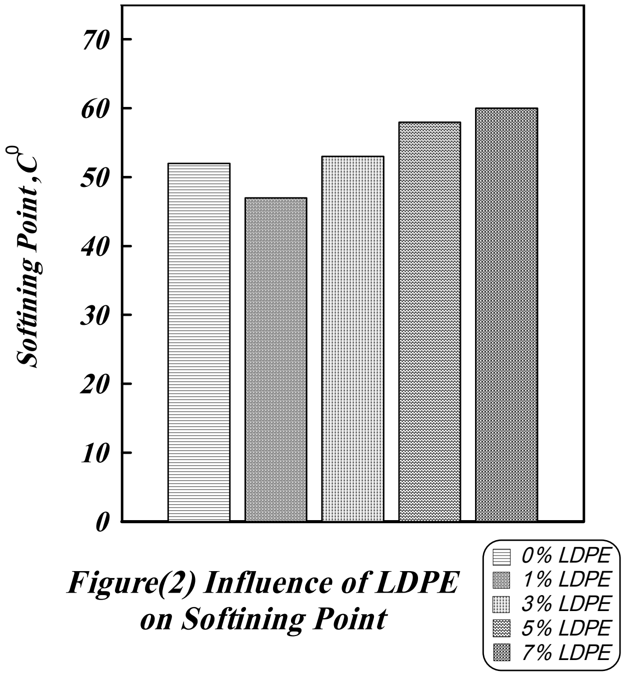


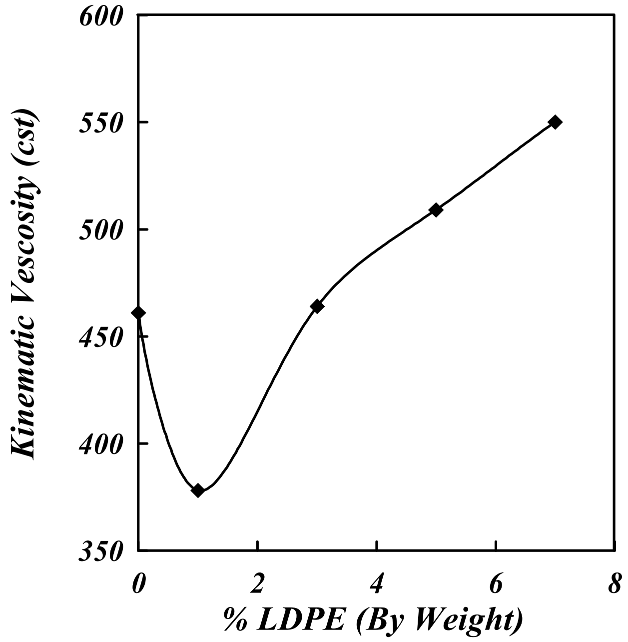
Figure (1) Influence of LDPE on Pentration @ 25 C

Figure (2) shows the effect of LDPE percentage on the softening point of asphalt cement .The softening point values increase with increasing the LDPE percentage except at (1%) where decrease the softening point.



Figure(2) Influence of LDPE on Softining Point

Figure (3) shows the effect of LDPE percentage on the kinematics viscosity of asphalt cement .The viscosity increasing with increasing the LDPE percentage except at (1%) where decrease the viscosity. From figures (1, 2 and 3) appear that the asphaltic cement become more hard with increasing LDPE percentage except at (1%) where the asphalt cement become more soft comparing with other percentages.



Figure(3) Influence of LDPE on Kinematic Vescosity

For evaluating temperature susceptibility of asphalt cement the study has been depended on Penetration Viscosity Number parameter (P.V.N) (16).

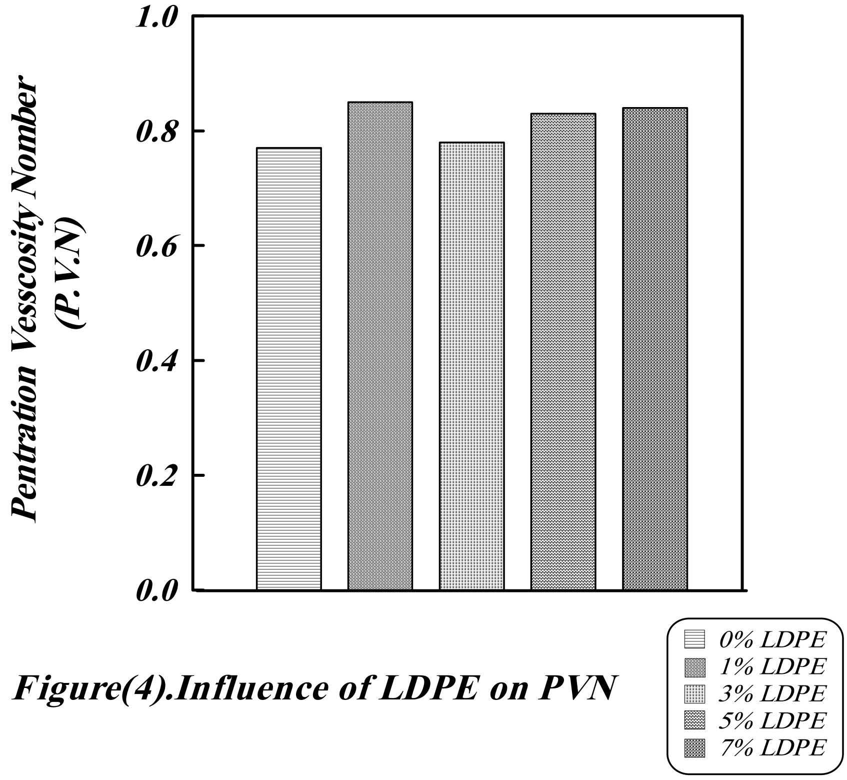
P.V.N= [(4.2588-0. 796*Log P- Log ŋ) /(0.7951-0.1858 Log P]*1.5…………(1)

Where:- P = penetration at 25 ^{0}C, 100gm,5sec

ŋ = kinematics viscosity at 135^{0}C (centistokes)

Higher values of (P.V.N) indicate lower temperature susceptible (P.V.N).

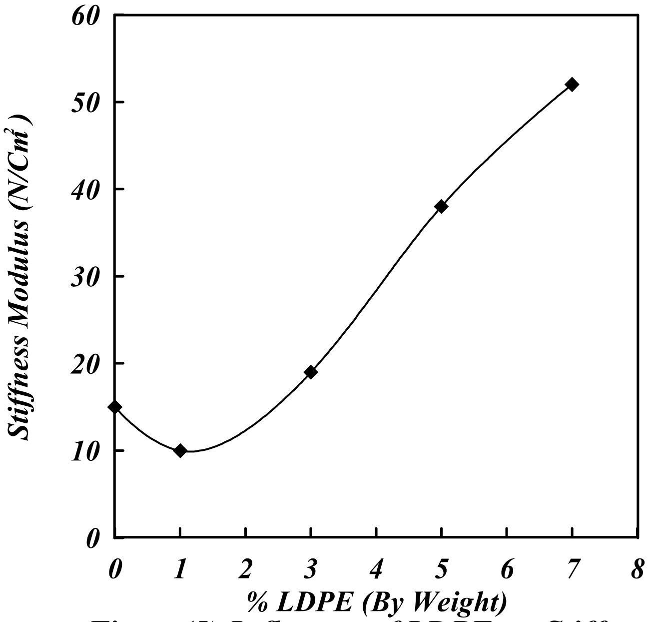
Figure (4) shows the effect of LDPE percentage on the PVN. The susceptibility of asphaltic cement to temperature decrease with increasing LDPE percentage and at (1%) lower suscptiblety comparing with other percentages.



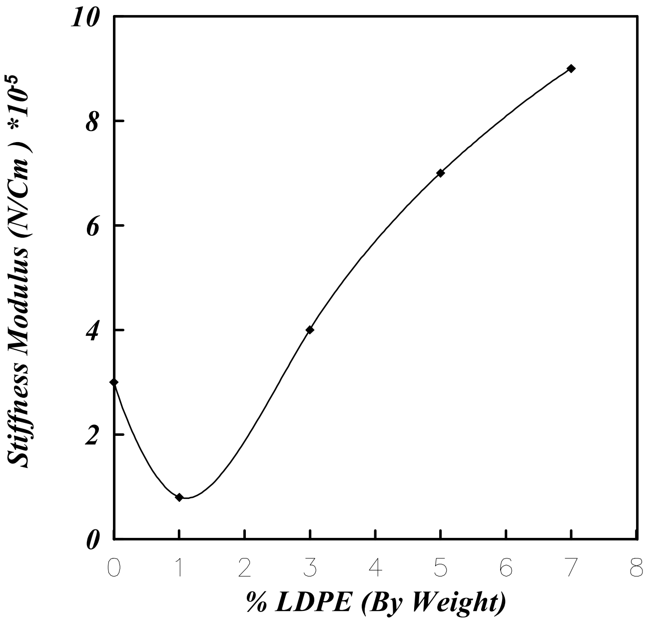
Figure(4).Influence of LDPE on PVN

Study was depended service temperature at (60 C^o) for hot climatic at summer and (-5 C^o) for cold climatic at winter for predicting stiffness modulus of asphalt cement by using van der pole's nomograph (17).

Figure (5) and (6) show the effect of LDPE percentage on the stiffness modulus of asphalt cement at low temperature (-5C^o) and high temperature (60C^o) respectively. Stiffness of asphalt cement increase with increasing LDPE percentage except at (1%) where the stiffness become lower comparing with other percentages.



Figure(5) Influence of LDPE on Stiffness of Binder at Low Temperatur (-5 C)



Figure(6) Influence of LDPE on Stiffness of Binder at High Temperatur (10 C)

5. Conclusion and Recommendations

1. Increasing the LDPE percentage causing the asphaltic cement more hard except at (1%) the asphalt cement becomes more soft.

2. Increasing the LDPE percentage decreasing the susceptibility of asphalt cement for temperature and at (1%) of LDPE the asphaltic cement lower susceptibility.
3. Increasing the LDPE percentage increase the stiffness binder of the asphalt cement except at (1%) the asphalt cement becomes lower stiffness.
4. Study the effect of aging on Asphalt modified by LDPE.
5. study the effect of LDPE on performance of asphalt mixture for determining the best percentage.
6. Study the effect of recycled – Polyethylene on performance of asphalt mixture.

6.References

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