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Study the Effect of Epoxy Additives on Some Physical Properties of Asphalt Cement

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ABSTRACT

In the series of study on the asphalt cement to improve properties of asphalt cement several polymers materials are used for this purpose. In this study Epoxy used at different percentage by weight (1, 2, 4 and 6) %. Epoxy was added in three cases, pure Epoxy and the other two cases were mixing of Catalyst-Epoxy by weight in the two ratio (1:3) and (1:4).The effect of additives on the asphalt cement properties are evaluated by penetration test (ASTM D-5)(10), softening point test (ASTM D-2398)(10), and Kinematics viscosity test (ASTM D-2170)(10). Temperature susceptibility of asphalt cement was evaluated by using Penetration viscosity number (PVN). The study shows that Epoxy, 1:3 Epoxy and 1:4 Epoxy additives have more effect on the physical properties of asphalt cement and make asphalt softer than original asphalt cement, the additives reduced the temperature susceptibility, but Epoxy have more reduction in the susceptibility of asphalt cement compared with 1:3 Epoxy and 1:4.

Introduction:-

Polymer-modified binders have been found to improve several properties of paving mixes such as temperature susceptibility, fatigue life, and resistance to permanent deformation [(1)].

There have been many investigations on polymer modified asphalt binders as counter measure to prevent plastic flow [(2)]. Modification of bitumen with polymers decreased it's temperature susceptibility chiefly by increasing its ring and ball softening point, increased its cohesion and modified its rheological characteristics [(3)]. The purposes of modification is to increase the viscosity at the high temperature, increase the flexibility and elasticity of binders at the low temperature, improve the adhesion to aggregates and improve high thermo-stability and aging resistance [(4)].

The aim of this paper was to study the effect of Epoxy on the physical properties of asphalt cement produced from Daurah refinery with grade (40-50) with different percentage of weight (1, 2, 4 and 6)% . The effect of additives on asphalt cement was evaluated by investigating the following tests penetration, softening point and, kinematic viscosity. Temperature susceptibility of asphalt cement was evaluated by penetration viscosity number (PVN).

Dunning, et.al [(1)] found that polymer system could be used to impart stripping resistance to asphalt concrete by coating the aggregate prior to drying, and they found that polymer decreased the temperature susceptibility of the resilient modulus of the mix.

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 [(2)].

It can be expected that asphalt mixtures compound with polymers give a longer service life, shown lower tendency towards permanent dimensional changes, has greater elasticity, less sensitive to variations in temperature and greater elasticity, vibration caused be traffic[(5)].

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[(6)].

Lee et.al [(7)] found that the additive of polyethylene and chlorinated polyethylene to asphalt

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binders does significantly increase their low temperature fracture toughness and fracture energy.

Reclaimed rubber obtained from used tiers, polyethylene in the form of low density (LDPE), styrene-butadiene-styrene copolymer, latex are used for modification of asphalt cement and test sections were found to perform satisfactorily [7].

Naume [8] concluded that using 1.25% of Polyvinyl Chloride (PVC) caused increasing stability and decreasing susceptibility to temperature and shows lower stiffness modulus, less permanent strain and lower susceptibility to low temperature cracking when compared with zero PVC mixture.

King et.al [9] show that Styrene-Butadiene (SB) modifiers reduced the low temperature stiffness at some constant low temperature; the elastomers modified product will generally withstand greater tensile strains before fracturing.

Materials and Tests :-

Asphalt Cement:-

One binder of asphalt 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)

Additive:-

Epoxy which is used with asphalt binder as an additive, it is available in the local market. Epoxy was added to asphalt binder by weight at different percentage (1, 2, 4 and 6)% and, the addition of epoxy was in three cases, pure epoxy without catalyst, and two cases with catalyst. The ratios of Catalyst-Epoxy were 1:3 and 1:4. The epoxy and catalyst are thick at normal temperature therefore, the fluidity increased by heating the epoxy and catalyst in closed containers and in water at temperature (80)^{0}C for (15) minute.

For preparing sample of Catalyst-Epoxy, using about (20 gm) of catalyst with (60 gm) of epoxy for (1:3) ratio and (15gm) of catalyst with (60 gm) of epoxy for (1:4) ratio to the epoxy and mixing it by stirrer at temperature (80^{0}C) for (10) minute. The heating should be indirect by heating the water which contain the container of mixing to (80^{0}C). After that samples of asphalt are heating to (140^{0}C) and adding the additives to asphalt for the different percentage of study (1 ,2 ,4 and 6)% and mixing by stirrer for (15 minute). Asphalt samples with pure epoxy as an additive are prepared by heating epoxy as previous method and adding to hot asphalt binder (140^{0}C) and mixing by stirrer for (15 minute). Properties of Epoxy and Catalyst are shown in Table (2).

Testing Asphalt Cement:-

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

1- Penetration test at 25 ^{o}C ASTM (D-5).
2- Softening point test (ASTM D-2398).
3- Kinematics viscosity tests (ASTM D-2170) at temperature of test (135 ^{o}C).

All test of this study are conducted in the road laboratory in civil engineering of Anbar University.

4.Result and Discussions :

figure (1) show the microscopy picture (1:500) for the pure asphalt and asphalt with additives at (6%) percentage of additives.

The effect of the Epoxy and Catalyst-Epoxy on asphalt cement are evaluated in the Road laboratory of Engineering College-Anbar University. These data are shown in Tables (3-5).

The presentations of the results are in the following figures.

Figure (2) and figure (3) show the effect of additives percentage on the grade of asphalt cement by penetration test at (25^{o}C). The epoxy make the asphalt more soft as shown by penetration value, while 1:3 Catalyst-Epoxy make asphalt hard at (1%) but, with increasing content becomes more soft but, near the original value and has the same behavior of epoxy additive effect. 1:4 Catalyst-Epoxy make asphalt more soft at (1%) additive and, after that increase the hardening of asphalt and becomes near the original grade.

Figure (4) show the effect of Epoxy percentage on softening point of asphalt cement. In general the additives reduced the softening point of asphalt cement but, 1:3 Catalyst-Epoxy increased the softening point after (1%) added while, Epoxy and 1:4 Epoxy has the same behavior but, 1:4 Catalyst-Epoxy indicate more effect.

Figure (5) shows the effect of Epoxy additives at different percentage. At percentage of adding (1%) and (2%) the softening point decrease gradually while at (4%) and (6%) 1:3 Epoxy becomes more hard and near to the original asphalt value.

Figure (6) shows the effect of Epoxy percentage on Kinematic viscosity at (135^{o}C).

Increasing Epoxy content reduce kinematic viscosity while, 1:3 Catalyst-Epoxy and 1:4 Catalyst-Epoxy reduce the viscosity until (1%) and after that limit the viscosity increase gradually but remain near original value.

Figure (7) shows the effect of Epoxy on Kinematic viscosity at (135 ^{o}C) for different percentage. With increasing Epoxy there are reducing in the viscosity and, in the same percentage the changing in viscosity is random.

For evaluating temperature susceptibility of asphalt cement with Epoxy the study has been depended on Penetration Viscosity Number parameter (P.V.N) [8].

P.V.N= [(4.2588-0.796*Log P-Log η) /(0.7951-0.1858 Log P]*1.5……(8)

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 (8) and figure (9) show the effect of Epoxy percentage on the PVN. Increasing Epoxy content reduce the temperature susceptible of asphalt cement to temperature. 1:3 Catalyst-Epoxy and 1:4 Catalyst-Epoxy reduce the temperature susceptibility of asphalt cement until (1%) but after this limit the susceptibility increase but less than susceptibility of original asphalt.

Conclusion and Recommendations

1. The study shows that the Epoxy, 1:3 Epoxy and 1:4 Epoxy additives have more effect on the physical properties of asphalt cement and make asphalt softer than original asphalt cement.
2. Epoxy, 1:3 Epoxy and 1:4 Epoxy additives reduced the temperature susceptibility, but Epoxy have more reducing in the susceptibility of asphalt cement compared with 1:3 Epoxy and 1:4.

- Study the effect of Epoxy on the chemical composition of asphalt cement before and after aging..
- Study the effect of Epoxy on the performance of asphalt mixture before and after aging..

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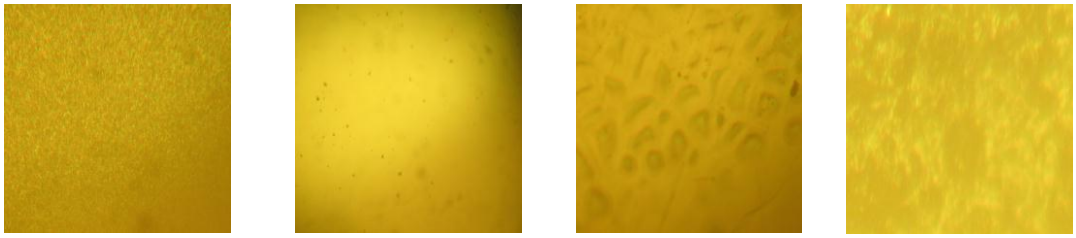

(a) (b) (c) (d)

Figure(1). Microscopy Picture for (a) Asphalt Cement, (b) Asphalt with Epoxy only, (c) Asphalt with 1:3 Catalyst- Epoxy, (d) Asphalt with 1:4 Catalyst- Epoxy.

Table (1). Physical Properties of Asphalt Cement.

Test	*Unite*	*Daurah (40-50)*
Penetration @ 25 ^{0}C	**0.1 mm**	**40**
Ductility @ 25 ^{0}C	**Centimeter**	**+100**
Softening Point	**^{0}C**	**55**
Flash Point	**^{0}C**	**329**
Specific Gravity	**---**	**1.033**
Kinematic Viscosity	**cst.**	**247**

Table (2). Properties of Epoxy and Catalyst .

Specific Gravity	**1.03 gm/cm^3**
Color of Epoxy	**White**
Color of Catalyst	**yellow**
Origin	**Jordan**

Table (3).Physical Properties of Penetration Test for Daurah (40-50) With Epoxy and Catalyst-Epoxy Additives.

No	**% additive**	**Penetration test @ 25 C^o**		
		Asphalt with Epoxy	**Asphalt with 1:3 Catalyst-Epoxy**	**Asphalt with 1:4 Catalyst-Epoxy**
1	**1**	٤١	٣٤	٤٥
2	**2**	٤٤	٣٩	٤٣
3	**4**	٤٦	٤٢	٤٠
4	**6**	٥٥	٤٣	٣٩

Table (4) Physical Properties of Softening Point Test for Daurah (40-50) With Epoxy and Catalyst-Epoxy Additives.

No	**% additive**	**Softening Point Test**		
		Asphalt with Epoxy	**Asphalt with 1:3 Catalyst-Epoxy**	**Asphalt with 1:4 Catalyst-Epoxy**
1	**1**	٥٣	٤٦	٤٥
2	**2**	٤٨	٤٨	٤٣
3	**4**	٤٧	٥١	٤٠
4	**6**	٤٥	٥٤	٣٩

Table (5)Physical Properties of Kinematic Viscosity Test for Daurah (40-50) With Epoxy and Catalyst-Epoxy Additives.

No	**% additive**	**Kinematic Viscosity Test @ 135 ^{o}C.**		
		Asphalt with Epoxy	**Asphalt with 1:3 Catalyst-Epoxy**	**Asphalt with 1:4 Catalyst-Epoxy**
1	**1**	٢٣٤	٢٤٤	٢٠٣
2	**2**	٢٠٠	٢٢٣	٢١٨
3	**4**	١٨٨	٢٢٠	٢٣٧
4	**6**	١٥٣	٢٢٧	٢٥١

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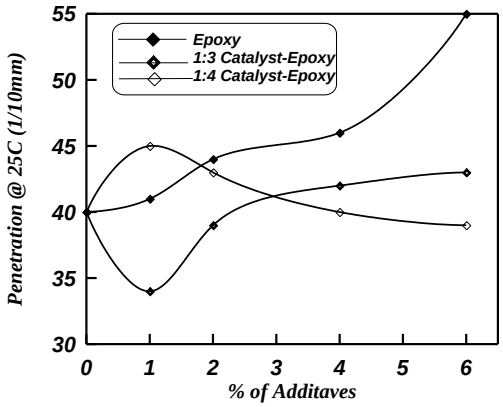


Figure(2).Effect of Epoxy and Catalyst-Epoxy on Penetration @ 25C

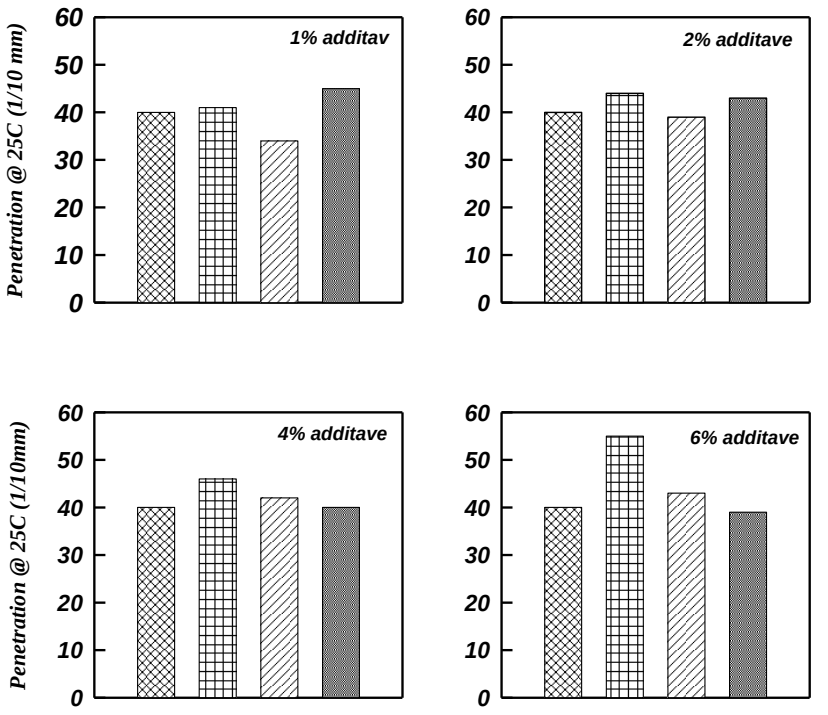
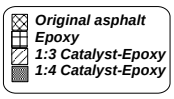
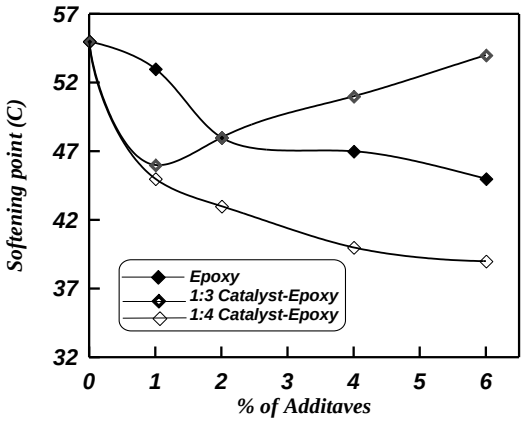


Figure (3) Effect of Epoxy and Catalyst-Epoxy on Penetration at (25C) For Different Percent of Additives





Figure(4) Effect of Epoxy and Catalyst-Epoxy on Softening Point

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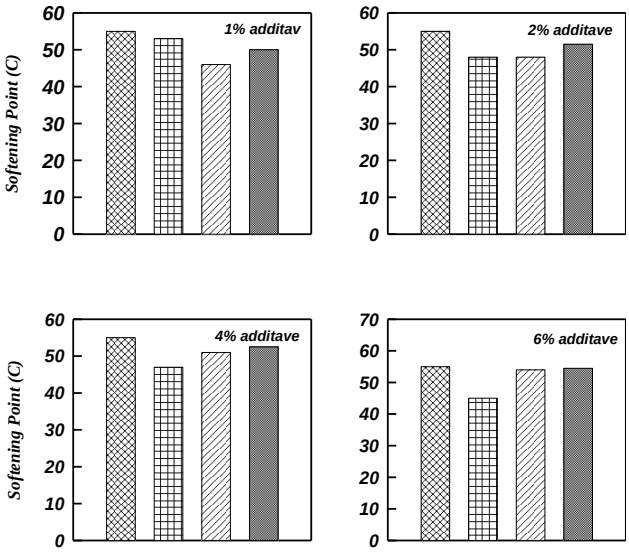
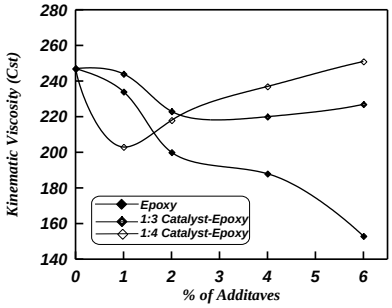


Figure (5) Effect of Epoxy and Catalyst-Epoxy on Softening Point For Different Percent of Additives



Figure(6) Effect of Epoxy and Catalyst-Epoxy on Kinematic Viscosity @ 135C

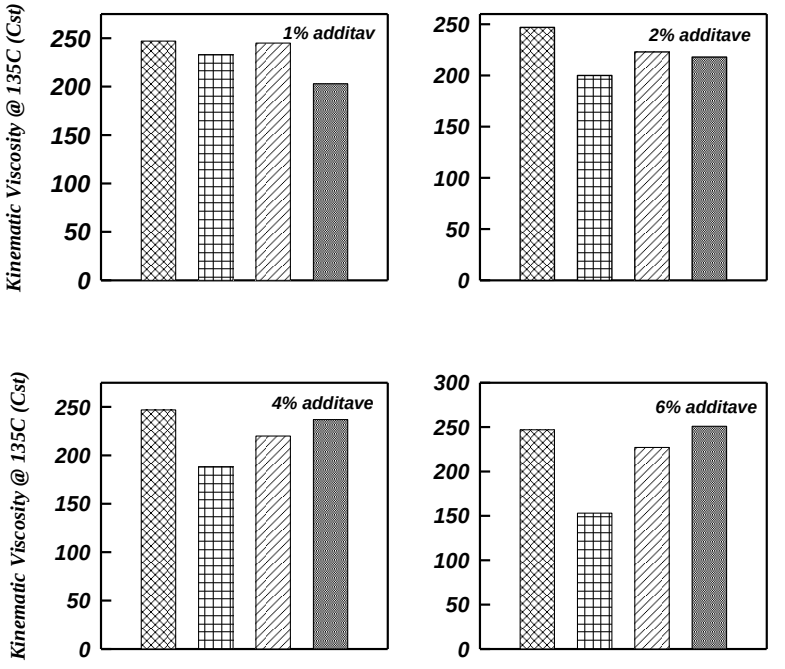


Figure (7) Effect of Epoxy and Catalyst-Epoxy on Kinematic Viscosity at (135C) For Different Percent of Additives

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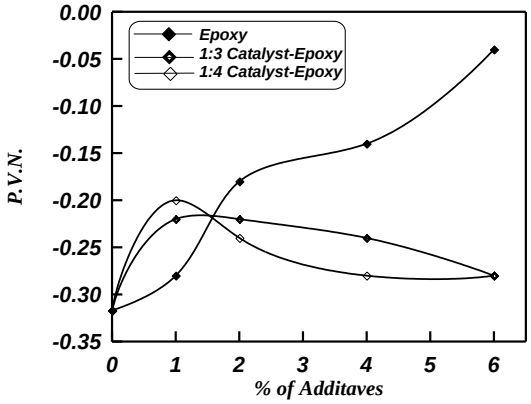

Figure(8) Effect of Epoxy and Catalyst-Epoxy on P.V.N.

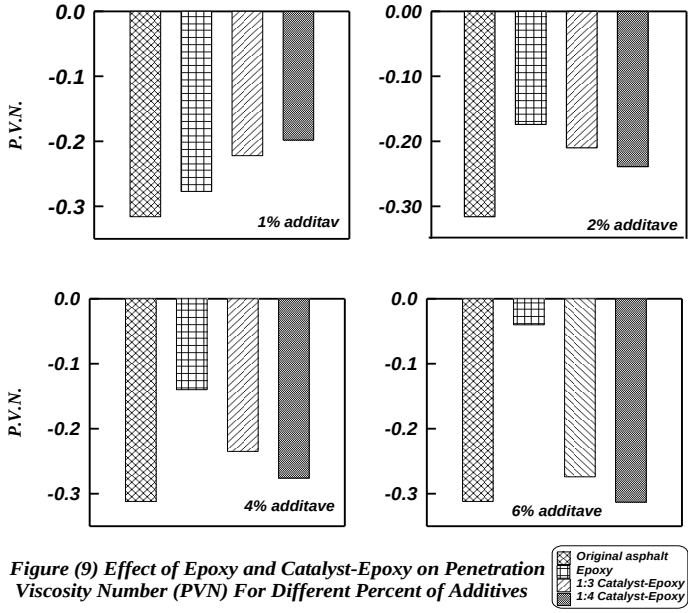

Figure (9) Effect of Epoxy and Catalyst-Epoxy on Penetration Viscosity Number (PVN) For Different Percent of Additives

دراسة تاثير الايبوكسي على بعض خواص الاسفلت الاسمنتي.

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الخلاصة:-

في سلسلة الدراسات التي أجريت على تحسين خواص المواد الإسفلتية استخدمت مواد البوليمرات لهذا الغرض . هذه الدراسة استخدمت مادة الايبوكسي مع الإسفلت في عدد من نسب الإضافة كنسبة وزنية وهي (١و ٢و ٤و ٦) %. أضيف الايبوكسي إلى الإسفلت في ثلاث حالات هي ايبوكسي بصورة خالصة وايبوكسي مع مصلد بنسبة خلط (مصلد – ايبوكسي) كنسب وزنية وهي (٣:١) و (٤:١). لتقيم تأثير هذه المواد المضافة استخدمت بعض الفحوصات الفيزيائية منها فحص الاختراق (Penetration Test ASTM D-5)(10) وفحص نقطة السيولة (Softening Point Test ASTM D-2398)(10) وفحص اللزوجة الحركية (Kinematic Viscosity Test ASTM D-2170)(10). بالإضافة إلى ذلك قيم التحسس الحراري (Temperature Susceptibility) بواسطة استخدام العامل (Penetration Viscosity Number) (PVN). الدراسة بينت أن الايبوكسي الخالص والمصلد مع الايبوكسي (٣:١) و (٤:١) اثرت بشكل واضح على الخواص الفيزيائية وجعلته اكثر ليونة مقارنه مع الإسفلت الأصلي. كما وان الدراسة قد بينت ان المادة المضافة قللت حساسية الإسفلت الى الحرارة وان هذا التأثير كان اكثر وضوحا مع الايبوكسي الخالص مقارنة مع المصلد و الايبوكسي (٣:١) و(٤:١).