VOLUME-7, ISSUE-1, JANUARY-2018 • PRINT ISSN No 2277 - 8160

Original Research Paper

Engineering

EFFECT OF POLYMERS ON PERMANENT DEFORMATION OF FLEXIBLE PAVEMEN

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ABSTRACT The lasting misshapening of adaptable asphalt speak to major issue in hot atmosphere district. Various endeavors are dedicated to relieve this misery, for example, adjusting black-top cover by polymers. The present examination show the impact of using four kinds of polymers to lessen the lasting misshapening, these polymers are Polyethylene Wax (PEW), Styrene Butadiene Rubber (SBR), Ethylene Propylene Dien Monomer (EPDM) and Ethylene Vinyl Acetate (EVA). The readied blends made out of 4.9 % of 40/50 black-top folio, 12.5 mm ostensible total most extreme size and limestone clean as filler. The perpetual and versatile strains have been recorded when the tube shaped examples, 101.6 mm in distance across and 203.2 mm in stature, tried by rehashed stacking framework. The fundamental conclusions display that SBR and EPDM with a similar focus (15 % by weight of black-top fastener) lessened the perpetual distortion by 30.20 % and 30.46 % separately. In spite of the fact that, the PEW and EVA lessened lasting distortion by bring down esteems, 13.24 % and 17.35 % individually, however the incremental level of their activity are higher. The impacts of testing temperature and feeling of anxiety on changeless misshapening were examined. Straight relapse demonstrate was set up to associate the estimations of changeless twisting and the flexible modulus of black-top blends.

KEYWORDS : asphalt pavement, permanent deformation, polymers, resilient modulus

1. INTRODUCTION

For the most part, polymer changed black-top cover are turned out to be more broad in street development to meet the present high activity stacking. Moreover, numerous endeavors are committed toward altering black-top blends by different kinds of polymers to improve the protection of black-top clearing to high and low temperatures results, permitting decrease in like manner disappointment components as rutting and splitting.

Lasting twisting named as rutting is a standout amongst the most significant load-related trouble writes influencing the execution of black-top solid asphalt, Alavi, et al., 2011.

In light of extensive overview completed by Federal Highway Administration in 1998, rutting was thought to be the main positioning pain components in adaptable asphalt, trailed by weariness splitting and afterward by warm breaking , FHWA, 1998.

The examination led by Pardhan, 1995, delineated that rutting normally shows up as longitudinal sadness in the wheel way joined by little changes to the side. Kaloush, 2001, uncovered that redundant activity of overwhelming movement loads caused a gathering of perpetual misshapenings in black-top asphalt.

A broad work in this field has been done by Sousa, et al., 1991, they revealed that perpetual disfigurement communicated by rutting involved a noteworthy worry for no less than two reasons; grooves trap water and hydroplaning which speak to danger especially for traveler autos, and trenches that create top to bottom influence directing progressively to end up noticeably troublesome, prompting real wellbeing concerns. Mirzahosseini, et al., 2011, and numerous different analysts derived that rutting diminishes the helpful administration life of the asphalt and by influencing vehicle dealing with attributes; it makes genuine perils for thruway clients, therefore, it can diminish seepage limit of asphalt structure bringing about aggregation of water. Another negative impact of perpetual misshapening as pronounced by Bahuguna, 2003, is the diminishment of asphalt thickness, which supports the event of asphalt disappointments through weariness splitting.

2. MATERIALS AND METHODS OF TESTING

2.1 Asphalt Mixtures

Basically, all of black-top blends materials were steadily brought from locally surely understood sources. Concerning the black-top bond folio, it was initially brought from Al-Daurah refinery and has 40/50 infiltration review, which is prescribed to be utilized as a part of hot area. The basic test outcomes are compressed in Table 1.

With respect to partition, the traditional hotspot for the coarse total was Al-Nibaee quarry while Karbala area was the exporter for both of waterway sand and limestone tidy that was hireling as mineral filler. For proper creation of thick black-top blends, as far as possible degree choice is assent with the suggested esteems offered by SCRB R/9, 2003. It was built up to utilize the 12.5 mm ostensible total greatest size, which is reasonable for wearing course asphalt.

The exhibit of accessible portrayals of totals and mineral filler are recorded in Tables 2 and 3 separately while the degree way choice and strainer examination are compressed in Table 4 and depicted in Fig.1.

2.2 Polymers

The SBR and EPDM polymers have been brought from Babylon Tires Factory in Al-Najaf region, while the wellspring of the PEW and EVA polymers was the State Company for the Petrochemical Businesses in Basra. Fig.2 show tests of these polymers. In light of past investigations said in writing audit, the amount of polymers mixed with black-top bond hold steady by three classes with various fixations, in this manner, the PEW and EVA have been included by 2, 4 and 6 percent of black-top concrete weight and for SBR and EPDM the percent ended up plainly 5,10 and 15. The predetermined percent of polymer was blended with toluene in a jar (500 ml vol.) by the proportion of 1gm/1 ml and set in air for around 24 hours. This strategy expanded the polymers absorption and swelling and in addition diminished the season of blending. The homogenous slurry was added to the warmed black-top and blended utilizing an electrical stirrer at 1200 r.p.m for one hour at around 180 oC. The principal period of black-top blend planning included: washing, drying, isolating and recombined the totals particles with limestone clean to get the required degree. In this manner, both of totals and black-top changed concrete were warmed to reasonable blending temperature, for this situation, the blending temperature was moderately high (160 oC, because of the nearness of polymers substances) . The folio content was held consistent by 4.9 percent of aggregate blend weight all through the shaping of black-top blends examples. Each tube shaped testing example has measurements of 101.6 mm in distance across and 203.2 mm in tallness, which required around 3800 g of black-top blend crude materials. The examples were compacted by twofold plunger strategy with a heap of 16600 kg. The heap was connected to each finish of the example for one moment. At long last, the example was painstakingly exchanged to a smooth and level surface, permitted to cool by standing it overnight at room temperature and after that expelled from the shape utilizing a water driven extractor. The examples were then numbered and putting in testing chamber for two hours at the coveted temperature as appeared in Fig.3. The hub rehashed stack test was directed utilizing the Pneumatic Repeated Load System , Albayati, A.H, 2006. In this test, tedious compressive stacking was connected to the example and the hub disfigurement was measured under the distinctive stacking redundancies. Compressive stacking was connected as rectangular wave with a steady stacking recurrence of 60 cycles for every moment including 0.1 sec stacking time and 0.9 sec rest period. The examination is initiated by use of rehashed hub stress and recording the vertical misshapening. Endless supply of test after 3000 load reiterations or any number for stack redundancy when the example flopped before (as showed in Fig.4), the account is ended and the example is expelled from the test chamber.

The permanent deformation is expressed as vertical microstrain and calculated by using Eq.(1);

(1)

where;
ε_p = vertical microstrain, mm/mm
ΔH = vertical deformation at the specified load repetition, mm
H = original height of the specimen, 203.2 mm

The resilient modulus of asphalt mixture , **ASTM D-4123**, can be applied as indicator of flexible pavement ability to resist the harmful effects of high axle loading and elevated temperature conditions. According to **Huang, 2003**, the resilient modulus is the elastic modulus based on recoverable strain in repeated load test and can be expressed by Eq.(2);

(2)

where;
M_R = resilient modulus of asphalt mixture, psi
σ_d = deviator stress, which is the axial stress for unconfined compression test, 20 psi
ε_r = recoverable vertical strain corresponding to the 200th repetition of load application.

3. RESULTS AND DISCUSSIONS

3.1 Effect of Temperature on Permanent Deformation and Resilient Modulus

The temperature impacts both of changeless distortion and strong modulus of black-top blend. As exhibited in Fig.5 and Fig.6, expanding the test temperature from 40 oC to 50 oC create an expansion in changeless misshapening by 25.8 % and a lessening in versatile modulus by 40.1 %. These two rates ended up plainly 69.2 % and 64.3 % individually when the temperature raised to 60 oC. This conduct is very comprehended and intelligently acknowledged on the grounds that the firmness of black-top folio is antagonistically influenced by the temperature expanding.

3.2 Effect of Stress Level on Permanent Deformation

A standout amongst the most critical factor that influence the changeless distortion is the anxiety, to put light on this point, the rehashed stack test led at three feelings of anxiety; 10, 20 and 30 psi. The result of the test is depicted in Fig.7, which obviously demonstrates that expanding feeling of anxiety from 10 psi to 20 psi yields blends with higher misshapening esteem by 13.8 %, similarly, the percent of distortion increment achieved 31.8 % as the feeling of anxiety expanded to 30 psi.

3.3 Effect of Polymers on Resilient Modulus

The strong modulus trial of black-top blends have been executed as plot by Huang, 2003 at 40 oC and by applying pressure greatness equivalent to 20 psi, the flexible strain recorded at 200 th No of reiterations. Fig.8 portrays the impact of joining a predefined measure of PEW on the strong modulus, reviewing this figure convey the message that the most extreme flexible modulus happened at 4.0 % polymer content , besides, the aggregate percent of modulus increment achieved 3.74 with an incremental esteem equivalent to 0.62 % for every percent of PEW expansion.

This conduct is very comparable on account of SBR utilization, thus, including SBR with an incentive up to 15 %, raise the flexible modulus by 7.39 % and by an incremental esteem equivalent to 0.49 % for each 1.0 % of included polymer, as unmistakably appeared in Fig.9. This change in versatile modulus is only like the circumstance when the EPDM is go about as added substance, similarly, and inside the scope of polymer dose, the upgrading percent in flexible modulus recorded 0.46 % for each 1.0 % of EPDM option with add up to percent of increment equivalent to 6.92 as showed in Fig.10. The avocation of this similitude derived his validity from the way that both of these polymers lie in a similar polymer classification of elastomer.The impact of mixing black-top fastener with EVA polymer is depicted in Fig.11, which pronounce that, this polymer additionally increment the versatile modulus by aggregate sum of 4.64 % and with incremental greatness of 0.77 %.

3.4 Effect of Polymers on Permanent Deformation

The specific worry of this examination is to explore the part of changing black-top fastener with certain polymers in enhancing black-top blend protection against lasting twisting. The cooperations of trial work giving to achieve this objective are imagined in Figures 12, 13, 14 and 15.

The general comment activated to mind by watching these figures, is that these polymers prevail in the motivation behind lasting twisting lessening, which take after a similar way of different analysts comes about. Great show of PEW sum effect on microstrain greatness can be comprehended by checking Fig.12, as the PEW measurement expanded up to 6.0 %, the aggregate microstrain lessened by 13.24 % with an incremental estimation of 2.20 % for every one percent of PEW dose. Substance of Fig.13 show obviously the connection amongst SBR and microstrain, as appeared; expanding this polymer focus from 0.0 % to 15 % caused a diminishing in microstrain by 30.20 %.The estimation of incremental decrease equivalent to 2.01%. Fig.14 concentrate on the part of EPDM content on microstrain, once more, expanding EPDM esteem up to 15 % diminished the microstrain by aggregate sum of 30.46 % and by 2.03 % of incremental esteem. This likeness in comes about isn't shockingly as specified previously.Fig.15 unequivocal the impact of EVA fixation increment on the microstrain, in this, extending the measure of polymer in blend range up to 6.0 %, bring down the aggregate microstrain esteem by 17.35 % with 2.89 % of incremental decline for every one percent expansion of EVA.

The connection between the versatile modulus of black-top blends and the changeless distortion communicated by microstrain can be found as depicted in Fig.16. By observing this figure, clearly flexible modulus change assume an imperative part in upgrading the protection of black-top blend toward perpetual twisting. To help this feeling, a straight relapse investigation led to the information showed in the specified figure. Thus, the accompanying exact condition has been set up:

$$= 14329 - 3.0\,M_R\,,\quad R^2 = 0.80 \qquad (3)$$

where;
ε_p = vertical microstrain, mm/mm
M_R = resilient modulus of asphalt mixture, psi

4. CONCLUSIONS

It is perpetually discovered that, every one of the four sorts of polymers utilized as a part of this examination prevail with regards to making strides

the capacity of black-top blend to oppose the changeless misshapening, be that as it may, the level of progress differ from one kind to other. though, the SBR and EPDM polymers are sharing roughly a similar estimation of perpetual misshapening diminishment by 30.20 % and 30.46 % individually and at a similar polymer substance of 15 % by weight of black-top folio. On other hand, the PEW and EVA polymers diminish the perpetual disfigurement microstrain by 13.24 % and 17.35 % individually at the 6 % polymer content.

The versatile modulus of black-top blend unmistakably affected by the support of polymers as added substances. At the end of the day, fusing PEW substance into the blend expanded the strong modulus by 3.74 % at 6.0 % substance of PEW. The SBR and EPDM polymers is by all accounts more powerful in this action, their rates of stretched out the flexible modulus raised to 7.39 and 6.92 separately and at correct 15 % of polymer content. The EVA polymer show a change esteem equivalent to 4.64 % at 6.0 % of material substance.

Lifting the test temperature from 40 °C to 50 °C deliver an expansion in changeless misshapening by 25.8 % and a lessening in versatile modulus by 40.1 %. These two rates wound up noticeably 69.2 % and 64.3 % individually when the temperature raised to 60 °C.

Expanding feeling of anxiety from 10 psi to 20 psi yields blends with higher distortion esteem by 13.8 %, similarly, the disfigurement percent of increment achieved 31.8 % as the anxiety expanded to 30 psi.

Basic straight relapse show has been built up to relate the impact of versatile modulus on changeless distortion protection.

NOMENCLATURE

ASTM = american Society for Testing and Materials
EPDM = ethylene Propylene Dien Monomer
EVA = ethylene Vinyl Acetate
ε_p= vertical microstrain, mm/mm
ε_r= recoverable vertical strain corresponding to the 200 th repetition of load application. FHWA=Federal Highway Administration
H = original height of the specimen, 203.2 mm
M_R= resilient modulus of asphalt mixture, psi
σ_d= deviator stress, which is the axial stress in an unconfined compression test, 20 psi
PEW = polyethylene Wax
SBR = styrene Butadiene Rubber
SCRB = state Corporation of Roads and Bridges
ΔH = vertical deformation at the specified load repetition, mm

Table 1. The physical properties of asphalt cement.

Test	Unit	Result	Specification Requirement
Penetration (25 °C, 100 g, 5 sec). ASTM D 5	1/10 mm	42	40-50
Softening Point (Ring & Ball). ASTM D 36	oC	49	…….
Ductility (25 °C, 5 cm/min). ASTM D 113	cm	102	≥ 100
Flash Point (Cleveland open Cup) ASTM D-92	oC	283	≥ 230
Specific Gravity (25 °C). ASTM D-70	…..	1.03	…..

Table 2. The physical properties of aggregates.

Apparent Specific Gravity, ASTM C-127 and C-128	2.54	2.68
Percent Water Absorption, ASTM C-127 and C-128	0.382	0.514

Table 3. The physical properties of limestone dust.

Property	Unit	Result
Specific gravity	-----	2.69
Passing No.200	%	96

Table 4. The Gradation selection of combined aggregate

Sieve Size	Sieve Opening (mm)	Specifications limit (SCRB R/9,2003)	Selected Gradation
3/4	19	100	100
1 2	12.5	90-100	95
3	9.5	76-90	83
No.4	4.75	44-74	59
No.8	2.36	28-58	43
No.50	1.18	5-21	13
No.200	0.075	4-10	7

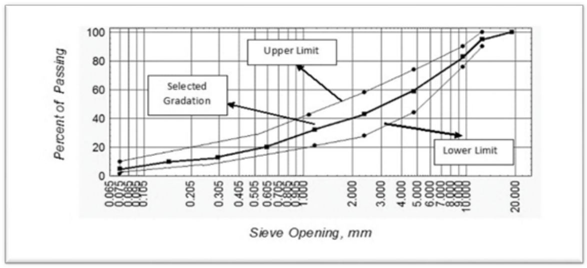

Figure.1 Sieve size analysis of combined aggregates.

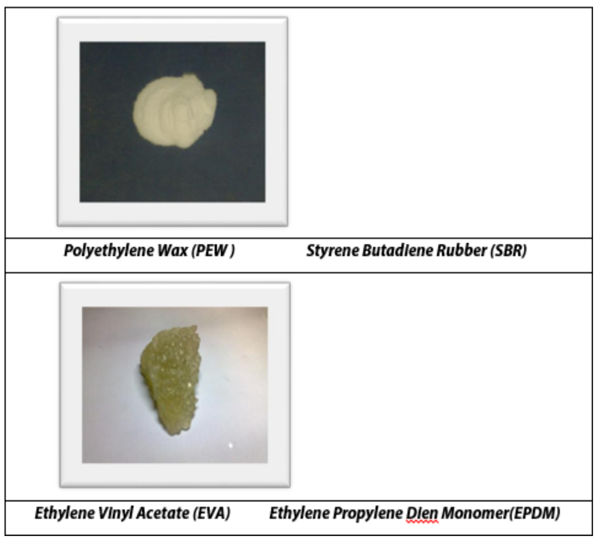

Figure.2 Samples of the polymers.

Figure.3 Specimen in the testing chamber.

Figure.4 Specimen at the end of test.

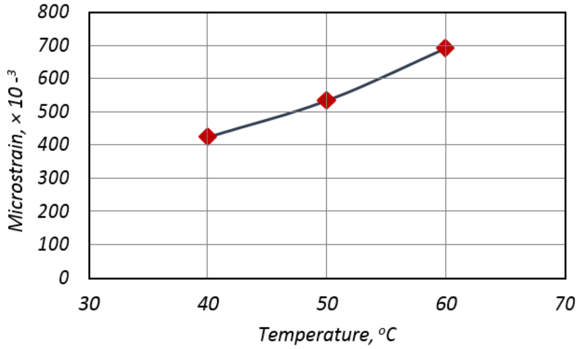

Figure 5. Effect of test temperature on permanent deformation (@ stress level=10 psi, 1000 load repetitions).

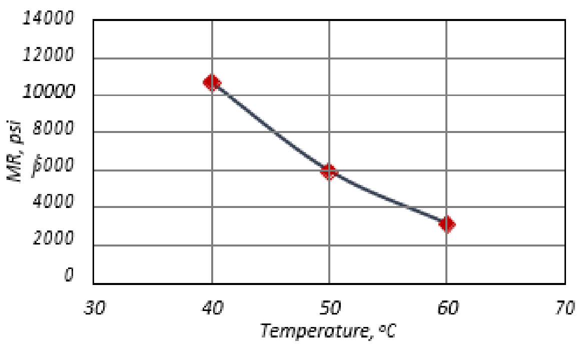

Figure 6. Effect of test temperature on resilient modulus (@ stress level=20 psi, 200 load repetitions, T=40°C).

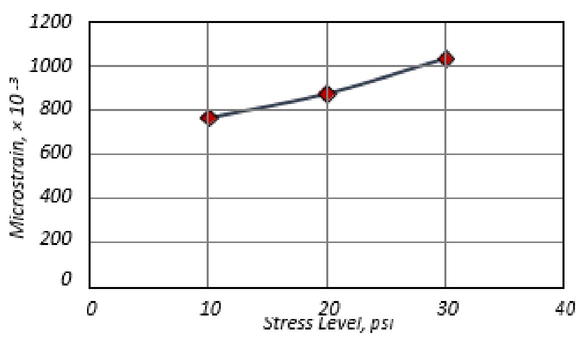

Figure 7. Effect of stress level on permanent deformation (@3000 load repetitions, T=40°C).

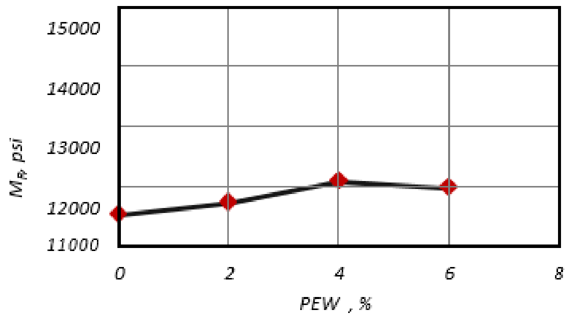

Figure 8. Effect of PEW on resilient modulus (@ stress level= 20 psi, 200 load repetitions, T=40°C).

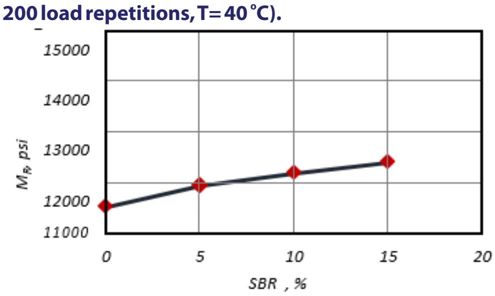

Figure 9. Effect of SBR on resilient modulus (@ stress level= 20 psi, 200 load repetitions, T=40°C).

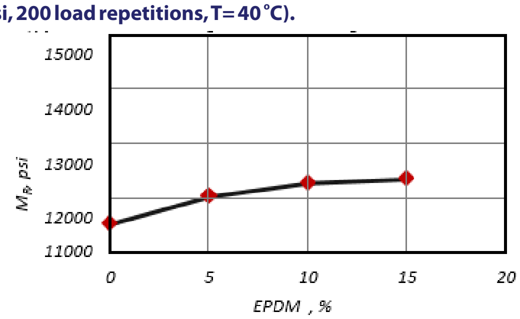

Figure 10. Effect of EPDM on resilient modulus (@ stress level= 20 psi, 200 load repetitions, T=40°C).

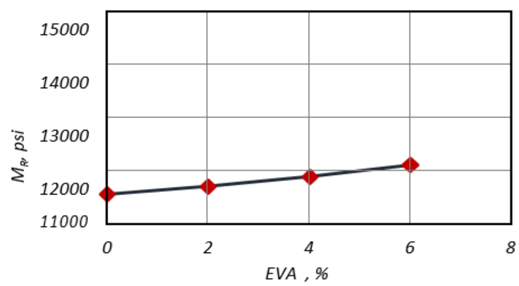

Figure 11. Effect of EVA on resilient modulus (@ stress level= 20 psi, 200 load repetitions, T=40°C).

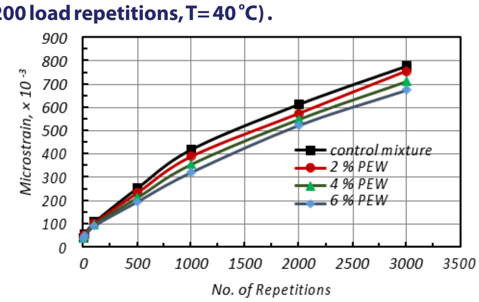

Figure 12. Effect of PEW on permanent deformation (@ stress level= 10 psi, T=40°C).

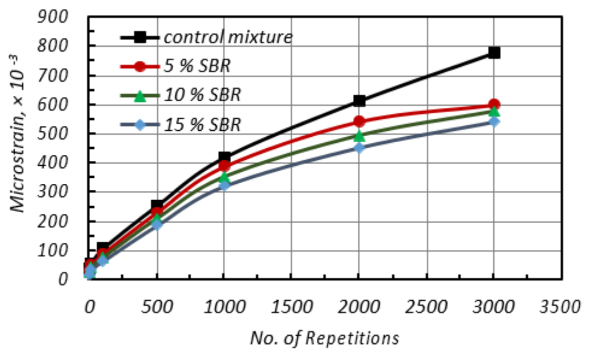

Figure 13. Effect of SBR on permanent deformation (@ stress level= 10 psi, T= 40 °C).

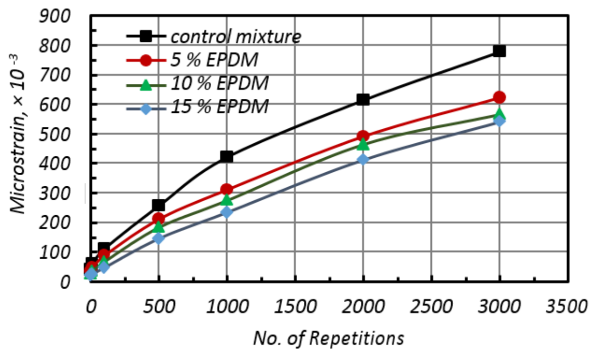

Figure 14. Effect of EPDM on permanent deformation (@ stress level= 10 psi, T= 40 °C).

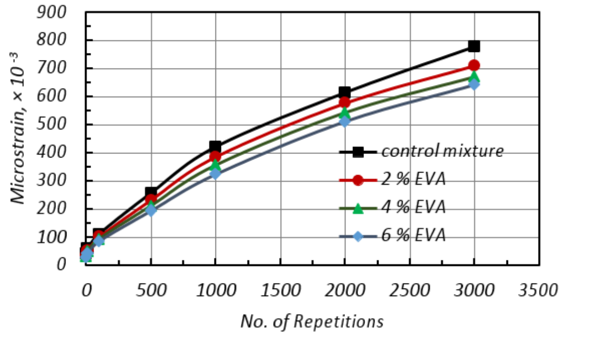

Figure 15. Effect of EVA on permanent deformation (@ stress level= 10 psi, T= 40 °C).

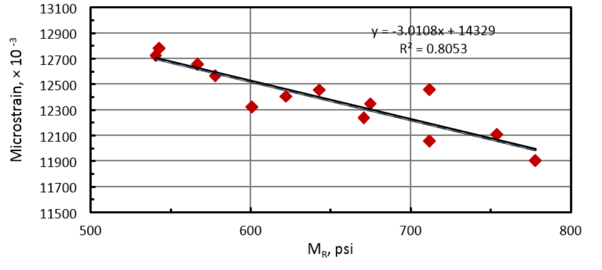

Figure 16. Relationship between permanent deformation and resilient modulus.

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