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Laboratory Investigation of Reclaimed Asphalt MixturesContaining Cyclogen and Vacuum Bottom Rejuvenators

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ABSTRACT

The use of reclaimed asphalt pavement (RAP) to create recycled asphalt mixture is attracting great interest because of landfill space decrease and natural resources saving. Also, incorporating rejuvenators is an efective method to promote the utilization of RAP materials in hot mix asphalt (HMA) production. The main goal of this study was to evaluate the efect of Cyclogen and vacuum bottom (VB) rejuvenators on the performance of RAP mixtures against moisture sensitivity, rutting resistance, and tensile strength. In this regard, mixtures were constructed with diferent RAP contents (0, 35, and 70% by asphalt mix weight) and virgin aggregates. Furthermore, three contents of Cyclogen (0, 5, and 10%) and VB (0, 15, and 30%) by the weight of RAP binder were used. The laboratory test results revealed that RAP materials enhanced the indirect tensile strength, rutting resistance, and moisture sensitivity of asphalt samples. Moreover, increasing RAP content improved the rutting resistance and permanent deformations of asphalt samples. The addition of RAP also enhanced the resilient modulus and tensile strength of asphalt samples; this increase was subject to RAP content applied. Furthermore, the efect of rejuvenators on the performance characteristics of RAP mixtures showed that adding VB and Cyclogen decreased tensile strength, resilient modulus, and strain creep and increased the moisture sensitivity of RAP mixtures.

1. Introduction

Analysis of pavements and their constituents is highly im- portant due to a better understanding of their performances under diferent conditions [1, 2]. The behavior of asphalt pavement has a complex system that is faced with several layers of diferent materials with varying combinations of traffic loads and environmental conditions [3–5]. The asphalt pavement industry is constantly looking for solutions to improve pavement performance, increase construction effi- ciency, conserve resources, and advance environmental stewardship. Reclaimed asphalt pavement (RAP) has received much attention recently due to its increased application in hot mix asphalt (HMA) pavements. According to high demand, clean and sustainable characteristics, high cost, low life-cycle aging, and absence of enough natural resources of bituminous materials, researchers have presented the utilization of RAP materials in HMA as an economic and environmental method [6–8]. RAP is the outcome of grinding and crushing of aged laying pavement [9, 10].

Previous studies showed that although the end of the life cycle of HMA was reached, the asphalt binder and aggregates obtained from the old HMA were still worth [11], but the aging of asphalt binder was the major impediment to the in- corporation of the high content of RAP materials in the asphalt mixture [12, 13]. The aging of asphalt binder results in pavement distresses, including pavement ravelling, fatigue failures, and reflective cracks in the structure of pavements [14–18]. The methods used for incorporating RAP in new asphalt mixtures can be divided into four methods. These procedures are hot recycling at asphalt plants, full-depth reclamation, hot in-situ recycling, and cold in-situ recycling [19, 20]

Using a great amount of RAP in the pavement is efficient by adding rejuvenating or softening agents. Rejuvenators restore the ratio of asphaltene to maltenes as components of asphalt binder, while the softening agents decrease the viscosity of asphalt binders. Also, the use of rejuvenators helps to produce sustainable infrastructure that can have clean air and reduce air pollution caused by the low energy consumption of asphalt production [21–23]. Shen et al. investigated the efect of rejuvenating agents, including a rejuvenator and a softening agent (softer binder), on as- phalt samples, including various amounts of RAP. According to their results, the mixtures containing the re- juvenator had more significant strength amounts and less rutting depth than samples containing the softer binder. Also, the results of the tensile strength ratio (TSR) for re- juvenated samples were diferent from those constructed by the softening agent [24]. Hajj et al. evaluated the impact of RAP content (0, 15, and 30%) on the mechanical properties of asphalt mixtures. It was revealed that the addition of RAP to a mixture resulted in acceptable moisture resistance. However, a reduction in the unconditioned and conditioned tensile strength was observed. Also, the addition of RAP to a mixture resulted in equivalent or better rutting resistance and fatigue behavior compared to the virgin mixture [25]. Ameri and Behnood evaluated the efectiveness of steel slag as a substitute for virgin aggregates on the mechanical properties of asphalt pavement containing RAP. The results showed that the use of steel slag enhanced Marshall stability, resilient modulus, tensile strength, and resistance to mois- ture damage and permanent deformation of mixtures [26]. Moghadas Nejad et al. presented an experimental study to characterize the permanent deformation of warm mix as- phalt containing 0%, 15%, 30%, 50%, and 60% RAP. It was found that replacing upto 60% of the virgin aggregate with RAP improved the rutting properties of asphalt mixtures. Also, the minimum permissible TSR of 70% was satisfied by replacing upto 50% of the virgin aggregate with RAP, however, the mixtures with 60% RAP had a TSR of less than 70% [27]. Fakhri and Hosseini described a laboratory efort to study glass fiber modified warm mix asphalt mixtures with 0, 20, 40, and 50% RAP contents to enhance the resistance of mixtures to rutting and moisture susceptibility. The results showed the improving efect of glass fiber and RAP contents on the performance of warm mix asphalt mixtures [28]. Faramarzi et al. examined the mechanical properties of asphalt mixtures containing RAP materials. Results in- dicated that the addition of RAP in asphalt mixtures im- proved the moisture and rutting behavior and considerably lower compressive strength compared to portland cement concrete (PCC) [29]. Hussein conducted a study to address the main issues related to the rejuvenation of asphalt mixtures with high levels of RAP materials. They illustrated that when a high level of RAP in HMA is used, rejuvenating agents must be employed. They also paid special attention to how the binder is structured and chemically composed, the nature and dose selection of the rejuvenator, as well as the difusion, blending efficiency, homogeneity, time, and temperature mixing [30]. Al-Safar et al. applied maltene as a rejuvenator to investigate several measurements regarding

stripping failure in RAP mixtures. The experimental results revealed that the ideal percentages of maltene, which should be added to 30% and 50% aged asphalt, were 8% and 16%, respectively.

Also, all the rejuvenated samples exhibited better results than virgin asphalt [31]. Al-Safar et al., in another research, explored the performance and durability of RAP mixtures and assessed if the proposed rejuvenators are indeed viable for pavements. Results indicated that most rejuvenators could restore the physical properties of aged asphalt. In addition, the negative impact of rejuvenating agents could be minimized by including additives, such as polymers and fibers [32].

Some studies have been conducted to examine the efect of Cyclogen on the moisture damage, rutting resistance, and resilient modulus of asphalt mixtures. Tran et al. investigated the impact of Cyclogen rejuvenator on the rutting and moisture performances of asphalt mixtures containing RAP materials. They revealed that the use of rejuvenator slightly increased TSR values. Moreover, the results indicated that RAP mixtures containing Cyclogen had better rutting resistance in comparison with the control mixture [33]. However, in similar research, Mogawer concluded that RAP mixtures containing Cyclogen rejuvenator degraded the rutting resistances of RAP mixtures [34]. Moniri explored the resilient modulus, moisture susceptibility and rutting resistance of RAP mixtures containing Cyclogen rejuvenator. They indicated that these fea- tures improved by increasing RAP content in mixtures containing Cyclogen compared to HMA mixtures [35]. Ziari et al. also revealed similar results and showed that the resilient modulus, rutting resistance, and indirect tensile strength (ITS) of Cyclogen rejuvenated mixtures containing RAP materials were higher than the control mixture [36]. Ziari, in another research, examined the efects of Cyclogen rejuvenator on asphalt mixtures containing 50% RAP material using dynamic creep, resilient modulus, low-temperature fracture energy, and ITS tests. Results showed that the use of rejuvenator led to an increase in the flow number, resilient modulus, and tensile strength of RAP mixtures compared to HMA mixture [37]. Moniri et al. investigated the efect of Cyclogen as a rejuvenator and glass fiber on the cracking behavior of recycled asphalt mixtures. For this aim, the fracture energy and critical value of J-integral of semicircular bending asphalt specimens in terms of RAP content, fiber content and testing temperature were examined. The results indicated that the fracture energy and J- integral value of asphalt mixtures declined by increasing RAP content at intermediate temperatures. However, the reduction in fracture energy and J-integral value could be compensated using glass fiber [38].

According to the previous studies, there is no research to investigate the efect of vacuum bottom (VB) on various performances of RAP mixtures, such as moisture sensitivity, rutting resistance, and tensile strength. Moreover, the re- lationships between the properties of the rejuvenated asphalt binder and the recycling asphalt mixture need to be de- veloped further. So, the principal goal of the study was to evaluate the impact of Cyclogen and VB as rejuvenators and softening agents with diferent amounts on the mixture characteristics relative to moisture sensitivity, rutting re- sistance, and tensile strength behavior of RAP mixtures.

2. Materials and Methods

Materials. The asphalt binder applied in producing HMA and RAP mixtures was provided by Jey Oil Refinery with a 60–70 penetration grade (PG 64-22). In addition, the Cyclogen and vacuum bottom (VB) as rejuvenators and softening agents were used in RAP mixtures at diferent amounts. In this regard, samples were constructed with diferent RAP contents (0, 35, and 70% by asphalt mix weight) and virgin aggregates. The percentage of used RAP in this research was based on previous studies to evaluate the efect of diferent percentages of RAP content on the be- havior of asphalt mixtures [38–42]. Furthermore, three various contents of Cyclogen (0, 5, and 10% by the weight of RAP binder) and VB (0, 15, and 30% by the weight of

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RAP binder) were used. The properties of the applied asphalt binder, VB, and Cyclogen are demonstrated in Table 1.

In this research, the only portion of the RAP stockpile after fractioning that passed the 9.5 mm sieve in the labo- ratory was used [43, 44]. To specify the binder content of RAP materials, the ignition oven was used based on AASHTO T308, determining HMA asphalt binder amount using the ignition method. The RAP was sieved into two fractions. The passing RAP through a 1.25 cm sieve and the remaining RAP on sieve #4 (4.75 mm) was referred to as +#4 RAP, and the passing RAP through sieve #4 was referred to as #4 RAP [24, 44]. The aggregate gradation and binder amount were analyzed based on two types. ASTM D3515 proposed the average amounts of three typical gradations for

determine elastic characteristics. In order to investigate the efect of RAP and rejuvenators on the resilient modulus of asphalt mixtures, the tensile resilient modulus was tested at 25°C and 700 N by the use of the haversine load pulse with a 0.9 s rest period and a 0.1 s load time in the loading fre- quency of 1 Hz [52, 53].

2.2.2. ITS Test. AASHTO T283 is the most common test to examine the moisture sensitivity of HMA, which correlates well with field results [54]. ITS test is constituted of loading a cylindrical sample with vertical compressive loads applied on the diametric plane. Failure is typically the output of fracture along the loaded plane. In order to consider the samples as conditioned, a 13 to 67 kPa pressure vacuum was used to saturate samples to a 70–80% level. The vacuum samples were held in a freezer for 16 hours at 18°C, then kept in a water bath for 24 hours at 60°C. The indirect tensile strength (ITS) value of asphalt samples was measured according to the following equation [55]:

$$\text{ITS} = \frac{2000P}{\pi t D}, \quad (1)$$

where P is the rupture force (kN), D is *the* sample diameter (m), and t is the sample thickness (m).

Moreover, the wet-to-dry tensile strength ratio (TSR) to investigate the moisture sensitivity of samples was calculated based on the following equation:

$$\text{TSR} = \frac{\text{ITS}_{wet}}{\text{ITS}_{dry}}, \quad (2)$$

selecting the gradation of HMA mixtures [45]. The gradation of RAP samples contained 35% RAP material remaining on sieve #4 and 70% RAP material passing through sieve #4. The aggregate gradation was based on ASTM standard which the maximum and nominal sizes are 1.9 cm and 1.25 cm, re- spectively. The structure of gradation is illustrated in Fig- ure 1. Moreover, the physical characteristics of aggregates are displayed in Table 2.

For the mix design of RAP mixtures, the virgin aggre- gates were heated to 175°C for 2 h, RAP materials were dried at 60°C for two days, and heated aggregates were added during the mixing process at 150°C for two *h* before the asphalt binder [46]. The neat binder was heated to 135°C and applied to mix the control mixture. RAP materials and virgin aggregates were then mixed with the asphalt binder for 1 minute in a bucket mixer. Then, each rejuvenator was added directly to the mixing of heated aggregates and binder immediately before mixing for each fabricated sample, and they were mixed in a bucket mixer with the rejuvenator for 5 minutes, regarding previous studies [35, 47–49]. The air voids amount of final HMA and RAP mixtures for the moisture sensitivity and

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rutting performance was 7 ± 0.5%.

Methods

Resilient Modulus Test. In this study, the indirect tensile resilient modulus was performed according to ASTM D7369 standard to measure the resilient modulus of HMA and RAP mixtures [50, 51]. This method is the most common form of stress-strain measurement used to

in which ITS_{wet} and ITS_{dry} (kPa) are the mean value of ITS under wet and dry conditions, respectively [56].

Dynamic Creep Test. The dynamic creep test was con- ducted in this research to investigate the rutting perfor- mance of recycled asphalt mixtures containing diferent rejuvenators. Cyclic stress of 2100 kPa with 0.1 s loading and

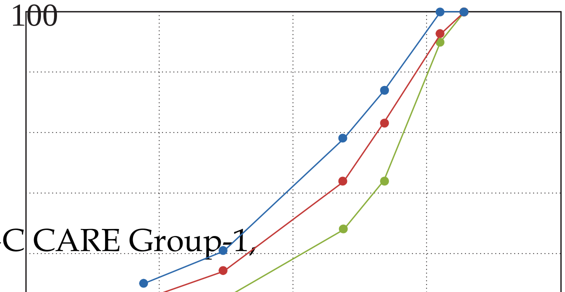
0.9 s rest period at a temperature of 50°C with 50 preloading cycles and 5 main loading cycles was applied on the spec- imens with three replicates, and the resulted axial strain was measured according to the National Cooperative Highway Research Program (NCHRP) Project 9–19 [35–37].

3. Results and Discussion

Resilient Modulus. The resilient modulus results of as- phalt mixtures with RAP and rejuvenating agents are in- dicated in Figure 2. As can be seen, adding RAP increased the resilient modulus of asphalt mixtures, and this increase was subject to RAP content used so that the addition of 35% and 70% RAP contents improved the resilient modulus of asphalt samples by 104% and 192%, respectively. In fact, the utilization of RAP materials increased the stifness of asphalt binder, and so, the resilient modulus of asphalt mixtures. Investigation of the efect of rejuvenators on the resilient modulus of RAP mixtures revealed that adding the re- juvenators resulted in a decrease in the resilient modulus of

TaBlE 1: Asphalt binder, VB, and Cyclogen properties.

Properties	Test methods	Asphalt binders 60–70	VB	Cyclogen
Penetration @ 25°C (0.1 mm)	ASTM D5	63	295	—
Softening point (°C)	ASTM D36	49	39	—
Flash point (°C)	ASTM D-92	310	>250	>220
Ductility at 25°C (cm)	ASTM D113	>100	>100	>100
Specific gravity (g/cm^3)	ASTM D70	1.045	—	0.98–1.02



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Percent passing (%)

80

60

40

20

0

0.01 0.1 1 10 100

Sieve size (mm)

Lower limit Aggregate gradation Upper limit

Figure 1: Applied gradation of aggregates.

observed from the results that the use of rejuvenators de- creased the stifness of RAP binder. Moreover, 30% VB and 10% Cyclogen performed better in restoring the stifness efect of RAP binder for 35% and 70% RAP mixtures, re- spectively. Also, increasing rejuvenators reduced the re- silient modulus of all RAP mixtures. The increment in the percentage of rejuvenators results in a soft mix, and con- sequently, a lower value of resilient modulus is observed [57].

The results of this research regarding the resilient modulus of mixtures are in accordance with the results of the study conducted by Moniri et al., which indicated that the resilient modulus of RAP mixtures containing Cyclogen was increased compared to HMA mixture, and by increasing the amount of RAP material, the resilient modulus was also raised [35]. Similar results were presented by Ziari et al., who revealed that the resilient modulus of Cyclogen rejuvenated mixtures containing RAP materials was higher than the control mixture, and all recycled mixtures had higher re- silient modulus than the virgin HMA, in compliance with the findings of this research [36].

Table 2: Physical characteristics of aggregates.

Characteristics	Standard	Result	Regulation limit
Specific gravity of coarse aggregates (gr/cm^3)			
Apparent	ASTM	2.69	—
Efective	C127	2.64	—
Bulk		2.61	—
Specific gravity of fine aggregates (gr/cm^3)			
Apparent	ASTM	2.68	—

Moisture Sensitivity. Figure 3 shows the normalized ITS values of asphalt mixtures with diferent RAP and re- juvenator contents. The results showed that the addition of RAP caused an increase in the tensile strength of asphalt mixtures in dry and wet samples. An increase in RAP contents by 35% and 70% enhanced the average ITS values

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Efective
C128
2.63 —
1.43 and 2.12 times compared to HMA mixtures, re-
Bulk 2.61 —

spectively. In addition, the use of rejuvenators resulted in
Specific gravity of filler (gr/cm^3)
Flat and elongated particles(%)
ASTMD854 ASTMD5821

2.55 —

94 Minimum 10

a reduction in ITS of RAP mixtures. Moreover, adding rejuvenators decreased ITS values of recycled asphalt mix- tures. It can be concluded that the addition of VB and

Water absorption (%) ASTM C127 Needle and flake particles ASTM

.8 Maximum 2 D4791

9 Maximum 15
Cyclogen reduced stifness in RAP binder, so ITS values of RAP mixtures were reduced.

Table 3 presents the list of mixture ID, ITS in wet and dryconditions, and TSR of asphalt test specimens. Based on the
Sodium sulfate soundness
(%)ASTM C88 7 Maximum 15
results of TSR values, adding RAP materials resulted in anincrement in TSR values, and hence, improved the per-
Los Angeles abrasion (%) ASTM C131 22.3 Maximum 30

RAP mixtures so that for 35% RAP mixtures with 5% and 10% Cyclogen, the resilient modulus decreased by 3.4% and 20.7%, respectively. In addition, the impact of 15% and 30% VB on the resilient modulus showed that the resilient modulus reduced by 23.2% and 34.8%, respectively. Furthermore, the resilient modulus of 70% RAP mixture was decreased by 16.7% for mixtures designed with 5% Cyclogen and 36.5% for mixtures containing 10% Cyclogen. It can be
formance of asphalt mixtures against moisture sensitivity. This increment can be mainly due to the strong bonding between the aged binder of RAP material and aggregates [58]. In other words, some proportion of aged asphalt of RAP material participates in the remixing process, and the remaining proportion of aged asphalt forms a layer that coats RAP aggregate particles. This performance results in a layered structure for RAP-containing asphalt mixtures, and the resultant layered structure could improve the moisture performance of asphalt mixtures [59, 60].

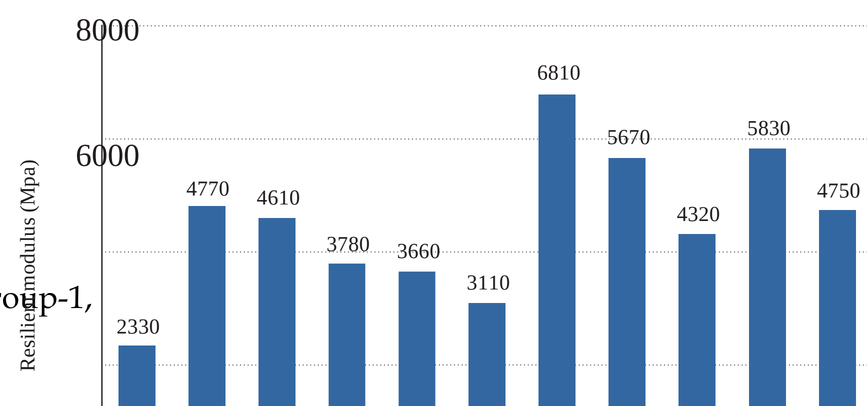

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FIgurE 2: Efect of RAP and rejuvenating agents on the resilient modulus of asphalt mixtures.

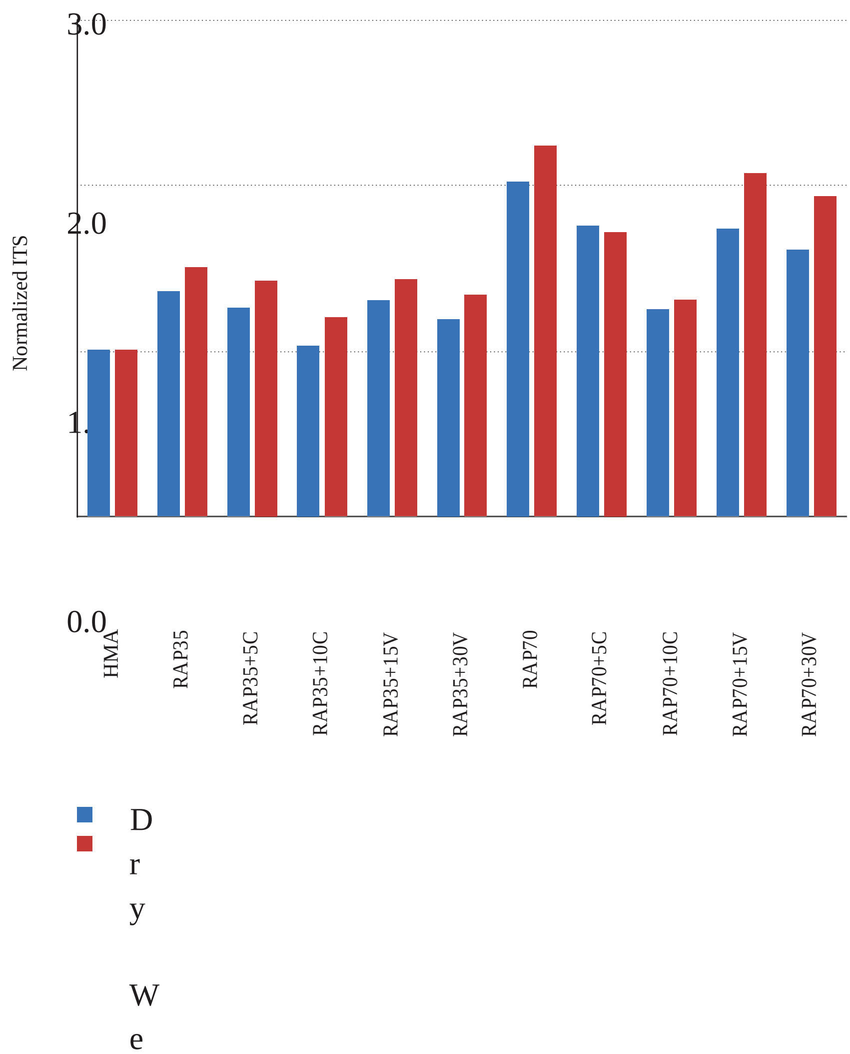

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FIGURE 3: Efect of RAP and rejuvenating agents on the normalized ITS of asphalt mixtures.

Investigation of the efect of rejuvenators on the moisture sensitivity of the 35% RAP mixture showed that adding VB and Cyclogen to RAP mixtures did not significantly afect TSR values. The addition of VB increased TSR values in samples containing 70% RAP, hence improving the co-hesiveness and adhesiveness of asphalt samples.

The results of moisture sensitivity in this study are consistent with the finding of Tran et al., which indicated that the use of Cyclogen rejuvenator increased TSR values in asphalt mixtures containing RAP materials [33]. Similar re-sults have been illustrated in the study of Moniri et al., which

also indicated that the moisture resistance of asphalt mixtures improved by increasing RAP content in mixtures containing Cyclogen [35]. Also, Ziari et al. indicated that the indirect tensile strength of Cyclogen mixtures containing RAP ma- terials was improved compared to the control mixture [36].

Rutting Resistance. Figure 4 shows the creep strain ε for the asphalt mixtures at 450 kPa( ) stress and a temperature of 50°C. The creep curve is divided into three stages: the first indicates the decelerated creepstage, the second represents

TABLE 3: Efect of Cyclogen and VB contents on the moisture resistance of HMA and RAP mixtures.

Mixture IDs	RAP (%)	Cyclogen (%)	VB (%)	ITS_{dry} (kPa)	ITS_{wet} (kPa)	TSR (%)
HMA	—	—	—	592	402	75
RAP35	35	—	—	808	665	82
RAP35 + 5C	35	5	—	741	632	85
RAP35 + 10C	35	10	—	614	532	87
RAP35 + 15V	35	—	15	772	634	82
RAP35 + 30V	35	—	30	705	590	84
RAP70	70	—	—	1192	989	83
RAP70 + 5C	70	5	—	1040	789	76
RAP70 + 10C	70	10	—	741	579	78

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RAP70 + 15V	70 88	—	15	1031	912
RAP70 + 30V	70 89	—	30	950	854

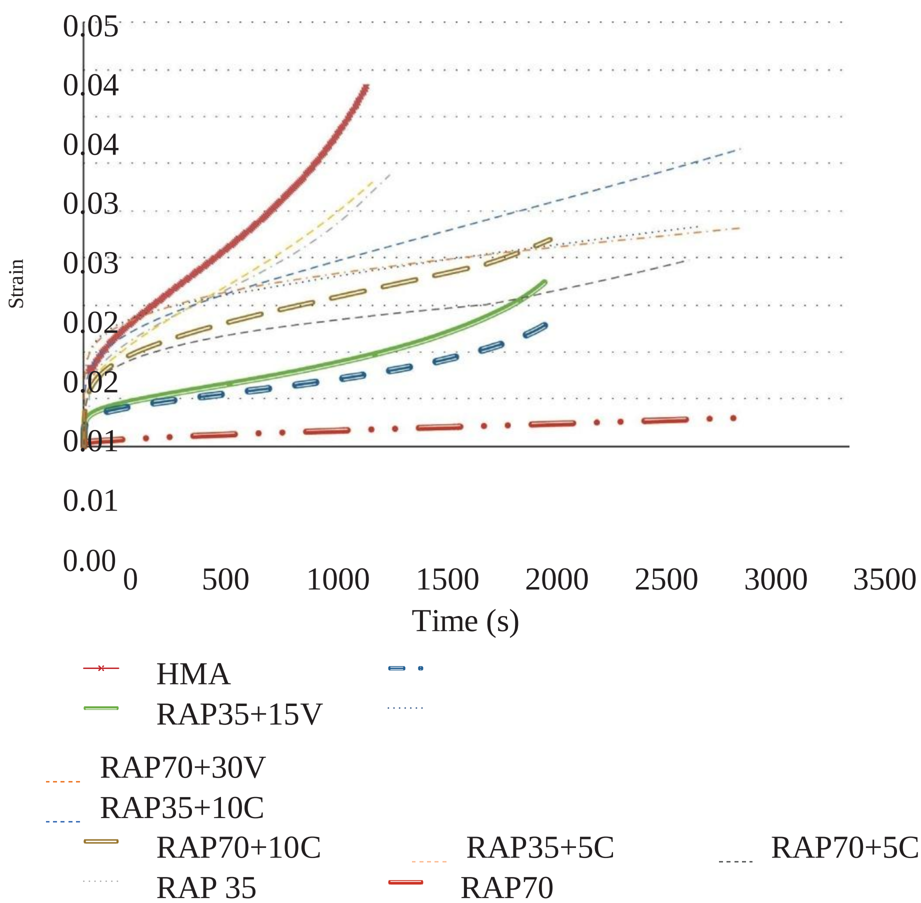

FigurE 4: Creep curve for HMA and RAP mixtures with diferent amounts of rejuvenating agents.

the equi-velocity creep stage, and the third shows the accelerated creep stage. According to Figure 4, RAP mixtures showed better rutting resistance compared to HMA mixture. Increasing RAP contents from 35% to 70% significantly enhanced the rutting resistance of asphalt mixtures. This could be due to the stifening efect of aging on recycled asphalt mixtures [35]. Evaluation of the impact of re- juvenators on the strain of RAP mixtures represented that VB and Cyclogen rejuvenators degraded the rutting re- sistance, which may be due to the fact that the addition of rejuvenators led to an increment in the softening of asphalt binder and hence an increase in the quantity of creep strain of RAP mixtures [24]. However, VB and Cyclogen re- juvenators improved the rutting resistance of RAP mixtures compared to HMA mixture with a virgin binder. It can also be seen that the positive efect of RAP material was much more than the negative efect of rejuvenators on the rutting resistance of mixtures, therefore, increasing the amount of RAP material enhanced the rutting

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resistance even when theaged binder of RAP material was restored by rejuvenators [35].

The rutting performance results of this research are inaccordance with the results of Tran et al. that indicated theapplication of Cyclogen rejuvenator in RAP mixtures re-duced the rutting resistance [33]. In another researchconducted by Moniri, the results showed that the rutting resistance of asphalt mixtures increased by increasing theamount of RAP material in the mixtures containingCyclogen in compliance with the findings of this research[35]. Ziari et al. also represented similar results and con-cluded that the rutting resistance of RAP mixtures con-taining Cyclogen was higher than the control mixture, in linewith the findings in this study [36]. Mogawer also concludedthat the used rejuvenator degraded the rutting resistance ofRAP mixtures which confirms the results of this study [34].Figure 5 represents the efect of RAP amounts and re-juvenator types and contents on the normalized strain ofasphalt mixtures. Based on the results, it was revealed thatincreasing RAP content to 35% resulted in a minor decreasein permanent deformation. In comparison, a significantdecrease was observed when RAP content was changed froma low level (35% RAP) to a high level (70% RAP). Increasing

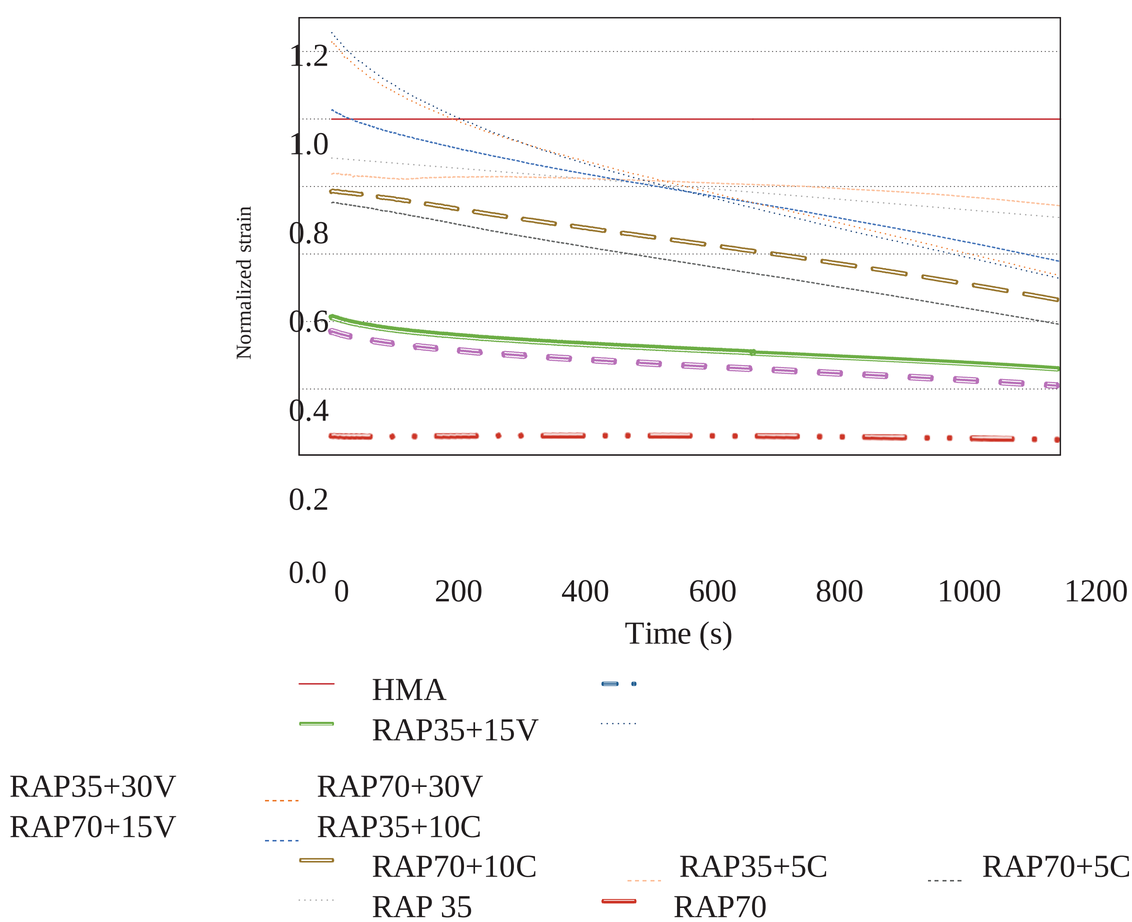

FIgurE 5: Efect of RAP and rejuvenating agents on the normalized strain of asphalt mixtures.

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the content of RAP materials by 35% in the base asphalt mixture decreased strain by an average of 10%, while the strain of 70% RAP mixture was decreased by an average of90%.

It is worth noting that if RAP material is added alone, due to the increase in asphalt binder stifness, the fatigue performance and low-temperature resistance will also be afected, and rejuvenators can improve such behavior by changing the asphalt binder's softening point, in addition to improving the rutting and moisture performances [35–37]. Also, according to various studies [61–63], it was found that low percentages of RAP can show less weakness in fatigue and low-temperature performances. Therefore, if the goal is to improve pavement resistance against all these damages (i.e., moisture, rutting, fatigue, and low-temperature cracking), 35% RAP along with rejuvenator can be used, which the results of this study showed an improvement in the studied resistances compared to HMA. However, the higher values of RAP can have a better performance againstmoisture and rutting.

4. Conclusion

In this research, the impact of Cyclogen and VB rejuvenators in reclaimed asphalt mixtures was examined on the moisture sensitivity, rutting resistance, and tensile strength of asphalt mixtures. It was indicated that

(i) The resilient modulus test showed that the re- sistance was increased using RAP materials com- pared with HMA mixture. However, the use of rejuvenators in RAP mixtures decreased the re-silient modulus.

(ii) ITS test results showed that the use of RAP materials increased tensile strength, and this improvement

was enhanced by increasing RAP in asphalt mix- tures. Also, rejuvenators resulted in a decrease in thetensile strength of RAP mixtures.

(iii) Moisture sensitivity results indicated that adding RAP to mixtures enhanced TSR values. The highestvalue was observed in high-content RAP mixtures containing VB.

(iv) The addition of RAP materials decreased the per- manent deformation, hence improving the rutting performance. However, the use of VB and Cyclogen resulted in an increase in the quantity of creep strainof RAP mixtures.

(v) It was revealed that the optimum rejuvenator dosage for the resilient modulus and ITS tests was 15% VB in mixtures containing 70% RAP. However, 30% VB in 35% RAP mixtures indicated the highestrutting resistance.

(vi) For future work and analysis, we will deal with some statistical analysis and machine learning methods [64–75]. Moreover, deep learning and optimization algorithms can be applied to obtain the optimal additive content [76, 77]. Various nanomaterials can be applied to be incorporated with the proposed approach [78–93]. In addition, other failures in RAP mixtures containing rejuvenators can be in- vestigated in future studies [94–96]. RAP could also lead to poor fatigue and low-temperature proper- ties, which can be investigated in future studies using Cyclogen and VB rejuvenators [97, 98].

Data Availability

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The data used to support the findings of this study areavailable from the corresponding author upon request.

Disclosure

In this study, Iranian governmental organizations have not been partners and sponsors, and this study is purely studious.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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