



## Evaluation of the Correlation Between Performance Parameters of Asphalt Binder and Mixture in the RAP-Containing Asphalt Mixtures

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**ABSTRACT:** In asphalt pavement hot recycling, reclaimed asphalt pavements called “RAP” and aged bitumen extracted from them are known as reclaimed asphalt binder (RAB). In this study, the performance of RAB-containing binder compounds with different percentages of recycled bitumen (0, 25% and 50%) and RAP-containing asphalt mixtures with varying contents of the RAP (0, 25% and 50%) were compared in two conditions (with and without a rejuvenating agent). The main purpose of this study was to evaluate the relationship between bitumen’s performance parameters and asphalt mixture’s performance parameters. Therefore, the correlation between the parameters obtained from the fatigue and the rutting tests of binder compounds (linear amplitude sweep test and multiple stress creep and recovery test, respectively) and parameters obtained from the fatigue and rutting tests of asphalt mixtures (four-point beam fatigue test and dynamic creep test, respectively) were investigated for the first time in RAP-containing asphalt mixtures. The results indicated that the behavior of asphalt mixtures in fatigue and rutting resistance was agreed with the behavior of the binder compounds in the linear amplitude sweep and multiple stress creep and recovery tests. Besides, there were statistically good correlations between the binder’s fatigue life and asphalt mixtures’ fatigue life and relatively good statistical correlations between binder’s rutting resistance and asphalt mixtures’ rutting resistance in the RAP-containing asphalt mixtures.

### 1- Introduction

Performance properties of asphalt mixtures are strongly dependent on the bitumen used in these mixtures [1]. Researchers have found that improving the fatigue or rutting resistance of bitumen plays an important role in enhancing the quality of asphalt mixtures [2, 3]. Based on the previous researches, it was found that there is a research gap for asphalt mixtures containing reclaimed asphalt pavements (RAP) as well as bitumen containing aged bitumen in relation to the correlation between fatigue and rutting resistance parameters of the bitumen and the fatigue and rutting resistance parameters of the asphalt mixtures. For this purpose, in this study, we investigated the relationship between bitumen test results and asphalt mixture test results using asphalt mixtures containing 0, 25 and 50% of RAP in two conditions of with and without the use of the rejuvenating agent.

### 2- Methodology

The purpose of this study was to investigate the relationship between fatigue and rutting parameters of bitumen and fatigue and rutting parameters of asphalt mixtures containing different percentages of RAP. In this study, the fatigue and rutting resistance parameters of bitumen compounds

containing different percentages of reclaimed asphalt binder (RAB) were investigated using linear amplitude sweep (LAS) and multiple stress creep and recovery (MSCR) tests, respectively. Meanwhile, the four-point beam fatigue test and dynamic creep test were also utilized to determine fatigue life and rutting resistance of asphalt mixtures, respectively. The relationship between bitumen performance parameters and performance parameters of asphalt mixtures containing RAP can play an important role in the faster estimation of asphalt mixtures resistance to fatigue and rutting phenomenon in asphalt pavement hot recycling projects. The virgin aggregates used in this study are limestone aggregates and their characteristics are in accordance with Table 1.

**Table 1. characteristics of virgin aggregates**

Property	Value	Standard method
Two fractured faces	92%	ASTM D5821
Abrasion Loss	21.5%	AASHTO T96
Bulk specific gravity	2.6 g/cm <sup>3</sup>	ASTM C127

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The RAP materials were obtained from “Hemmat” highway, Tehran, Iran. The bitumen was extracted from the RAP materials in accordance with ASTM D2172 method and then recovered using the rotatory evaporator (ASTM D5404). The control binder used in this research was 60/70 penetration graded bitumen. In this research study, RAPIOL as a new rejuvenating agent with softening efficiency of 5 [4], the flashpoint of 197 °C, the specific gravity of 0.92 and viscosity at 60 °C of 265 mPa.s was used. Based on the previous study, the optimum amount of the rejuvenator needed to achieve the same performance grade (PG) as the control bitumen was determined 7.5% by the mass of the RAB [5]. In this study, five asphalt binder compounds, including neat bitumen, 25% RAB, 50%RAB, 25%RAB with rejuvenator and 50% RAB with rejuvenator, were investigated. Meanwhile, five asphalt mixtures, including control mixture, 25%RAP, 50%RAP, 25%RAP with rejuvenator and 50%RAP with rejuvenator were evaluated.

### 3- Results and discussion

According to the obtained results in the LAS test, it can be seen that in asphalt binders containing RAB without rejuvenator, the fatigue life of compounds decreases with increasing the percentage of RAB while in asphalt binders containing RAB with rejuvenator, fatigue life increases with increasing the percentage of RAB. The same was true for the four-point beam fatigue test in asphalt mixtures. The results of MSCR test and dynamic creep test in asphalt binder compounds and asphalt mixtures, respectively, showed that the addition of rejuvenating agent did not have a significant negative effect on rutting resistance of binder compounds and asphalt mixtures containing RAP. Therefore, the relationship between fatigue and rutting resistance parameters of binder compounds and fatigue and rutting resistance parameters of asphalt mixtures was investigated. Figures 1 to 3 illustrate the comparison between the fatigue life of the binder compounds used in this study using the LAS test and the fatigue life of asphalt mixtures using a four-point beam fatigue test at different strain levels.

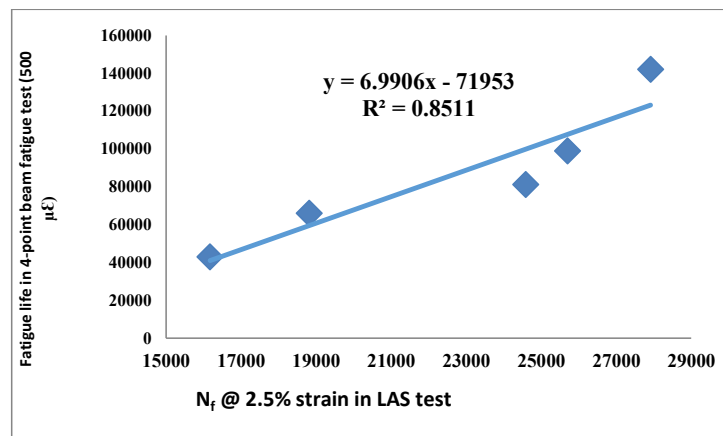


Fig. 1. Correlation between LAS results at 2.5% and 4-point beam fatigue test at 500 $\mu\epsilon$

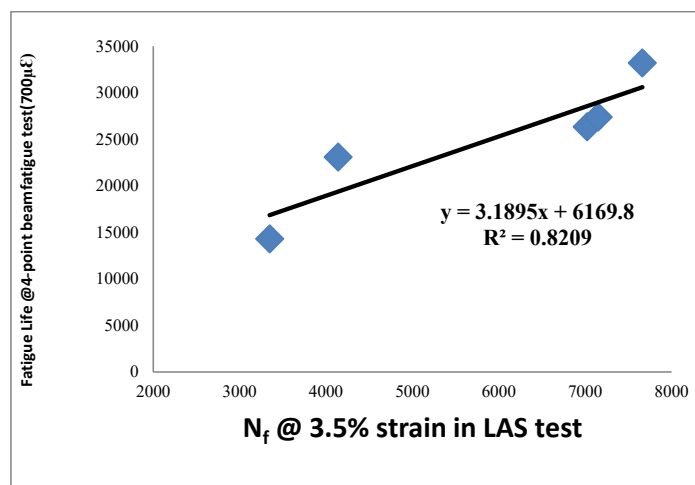


Fig. 2. Correlation between LAS results at 3.5% and 4-point beam fatigue test at 700 $\mu\epsilon$

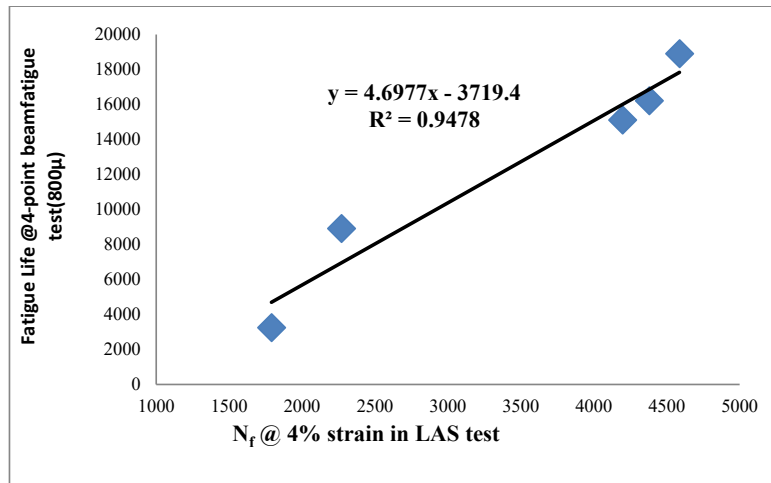


Fig. 3. Correlation between LAS results at 4% and 4-point beam fatigue test at 800µε

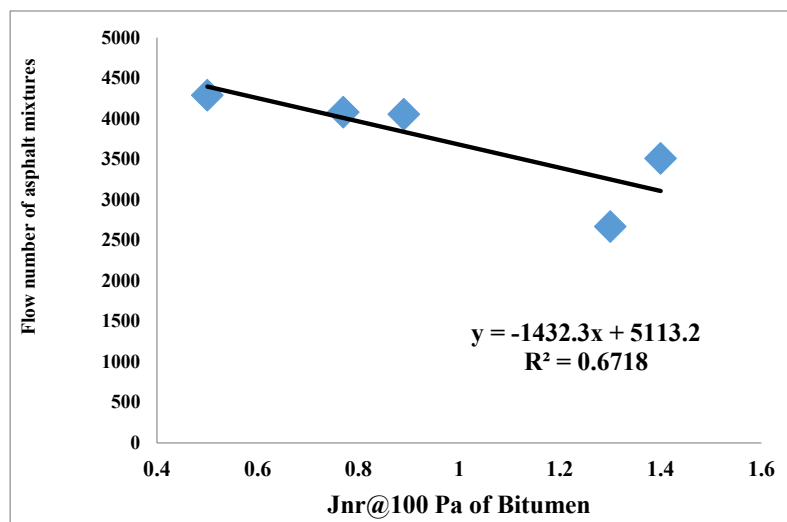


Fig. 4. Correlation between MSCR parameter (J<sub>nr</sub>) at 100 Pa and flow number

As can be seen in Figures 1 to 3, with respect to the high R<sup>2</sup> of regression equations, there is a good statistical relationship between the bitumen fatigue life and the fatigue life of the asphalt mixtures.

Figures 4 and 5 also show the relationship between MSCR test parameters (J<sub>nr</sub> and R) in bitumen and dynamic creep test parameter (flow number) in asphalt mixtures.

As shown in Figures 4 and 5, it can be concluded that there is a good relationship between the J<sub>nr</sub> and R parameters obtained in the MSCR test of binder compounds and the flow number of the asphalt mixtures.

#### 4- Conclusions

The main results obtained from this study are:

- In the LAS test, in asphalt binders containing RAB without rejuvenator, the fatigue life of compounds decreases

with increasing the percentage of RAB while in asphalt binders containing RAB with rejuvenator, fatigue life increases with increasing the percentage of RAB. The same was true for the four-point beam fatigue test in asphalt mixtures.

- The results of the MSCR test and dynamic creep test in asphalt binder compounds and asphalt mixtures, respectively, showed that the addition of rejuvenating agent did not have a significant negative effect on rutting resistance of binder compounds and asphalt mixtures containing RAP.

- By comparison of obtained results, it can be seen that there is a good statistical relationship between the bitumen fatigue life and the fatigue life of the asphalt mixtures.

- By comparison of obtained results, it can be concluded that there is a good statistical relationship between the rutting resistance of binder compounds and the rutting resistance of the asphalt mixtures.

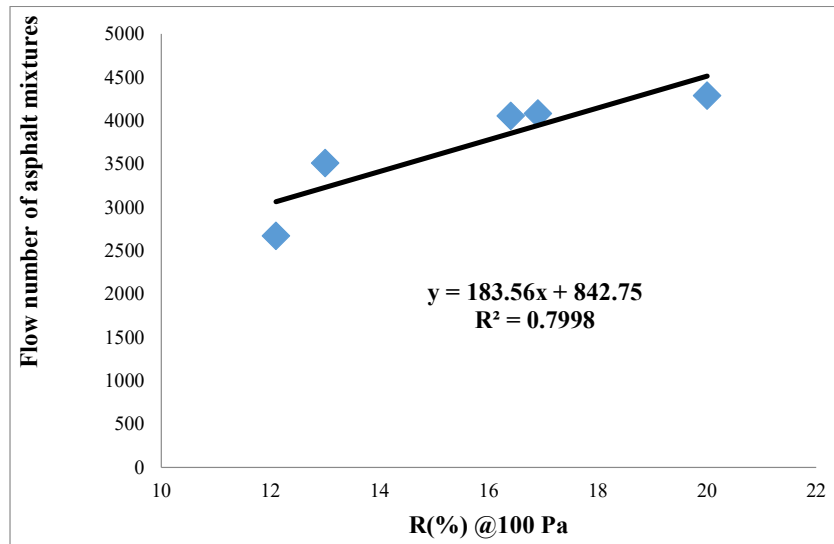


Fig. 5. Correlation between MSCR parameter (R) at 100 Pa and flow number

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