



Research article

Investigating the effect of the properties of natural stone materials on asphalt performance using the response surface method

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Keywords

Asphalt
Natural aggregate
Compressive strength
Rutting
Slip resistance

English Extended Abstract

Summary

In the road construction industry, natural aggregates have achieved a special position from an economic and technical point of view; in such a way that aggregates form a large amount of materials used in road construction projects. On the other hand, one of the effective factors

in asphalt quality is the quality and properties of asphalt stone materials. So, it is very crucial to check the quality of aggregates used in engineering road paving. Therefore, this research was conducted to investigate the effect of natural stone materials on the performance of asphalt pavement, including compressive strength, rutting resistance, and slip resistance using the response surface method. For this purpose, asphalt samples were made with 8 different types of natural stone samples and subjected to Marshall and slip resistance tests and the results of the tests were checked with Design Expert software. The results of this research showed that the Marshall ratio of asphalt samples increases by increasing the resistance parameters of stone materials and the tensile strength has the greatest effect on this variable. In addition, except for the adhesion, the sliding resistance also increases with the increase of the resistance parameters of the stone and the uniaxial resistance of stone materials has the greatest effect on this parameter. Also, according to the relationships presented in this research, it is possible to calculate Marshall's compressive strength, Marshall's ratio, and asphalt slip resistance by having the results of uniaxial resistance, triaxial resistance, shear wave speed, and indirect tensile strength of stone.

Introduction

The increasing traffic growth in recent years and the increase in axle weight of vehicles causes more forces to be applied to the pavement system and asphalt procedures and reduces the useful life of the pavement. The high costs of construction and maintenance of asphalt pavements make researchers search for solutions to increase the durability and stability of asphalt pavements [1, 2]. The use of quality materials, modification of bitumen, modification of granulation, use of suitable filler, and use of various additives have been desired by various researchers during the past years [3-7]. Since more than 90% of the volume of asphalt consists of stone materials, it can be said that aggregate plays an important role in the performance of paving materials. The effect of the type of stone materials and its characteristics on the properties of asphalt has been of great interest to researchers [8] and many researches have been done in this field. As an example, Fatahi and his colleagues (1400) investigated and compared the use of hard aggregates, granulation and different mixing plans in concrete and found that the type of minerals and elements that make up stone materials have a direct effect on the wear resistance of rolled concrete. Also, Salehi and Benadaki (1401) in research investigated the effect of the angular coefficient of fine-grained stone materials on moisture sensitivity and fracture resistance

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of hot asphalt mixture and found that the angular coefficient of stone materials has a significant effect on the performance of asphalt. In another research, Ren and Yin investigated the mechanical properties of aggregate structure for pavement materials and found that the type of material and its granularity have a significant effect on pavement performance. As mentioned, many researches have been carried out in the field of the effect of the properties of stone materials on the properties of pavements; but none of them have responded to a comprehensive investigation regarding the effect of stone material properties on Marshall resistance, rutting resistance and slip resistance with the surface method. Therefore, this research was conducted to investigate the effect of stone material properties on the resistance performance, rutting, and slip of asphalt pavement by using the response surface method.

Methodology and Approaches

As mentioned, this research aims to investigate the effect of the properties of natural aggregates on the performance of asphalt pavement, including compressive strength, rutting resistance, and slip resistance using the response surface method. Therefore, 8 types of natural stone materials were prepared. Then, to investigate the effect of the properties of natural stone materials on asphalt performance using different aggregates, asphalt samples were prepared and subjected to English pendulum and Marshall resistance tests. After determining the characteristics of asphalt mixture, Design Expert software was used in order to investigate the effect of stone material properties on asphalt performance by response surface method.

Results and Conclusions

The results of the experiments are presented in Figures 1 and 2. The results of multivariate statistical analysis show that the Marshall resistance of asphalt samples is a constant value considering all independent variables. Also, the results show that the Marshall ratio of asphalt samples increases by increasing the resistance parameters of stone materials and the tensile strength has the greatest effect on this variable. In addition, the results show that with the increase of stone resistance parameters, except for adhesion, the sliding resistance also increases and the uniaxial resistance of stone materials has the greatest effect on this parameter. According to the relationships presented in this research, it is possible to calculate Marshall's compressive strength, Marshall's ratio, and slip resistance of asphalt by having the results of tests of uniaxial strength, triaxial strength, shear wave speed, and indirect tensile strength of stone. In general, the results of this research show that the properties of stone materials have a great effect on the performance of asphalt; therefore, according to the purpose of the project, suitable stone materials should be selected for the construction of asphalt pavement.

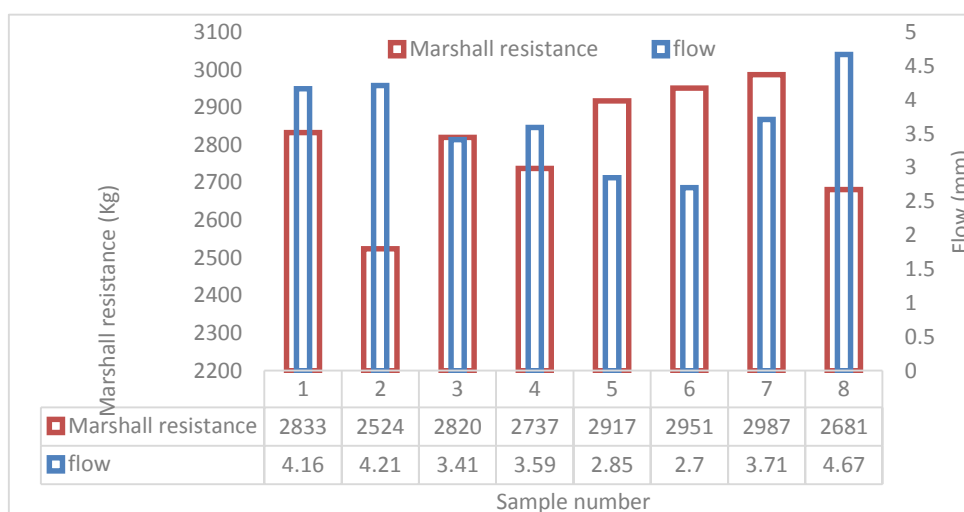


Fig. 1. Marshall resistance test results

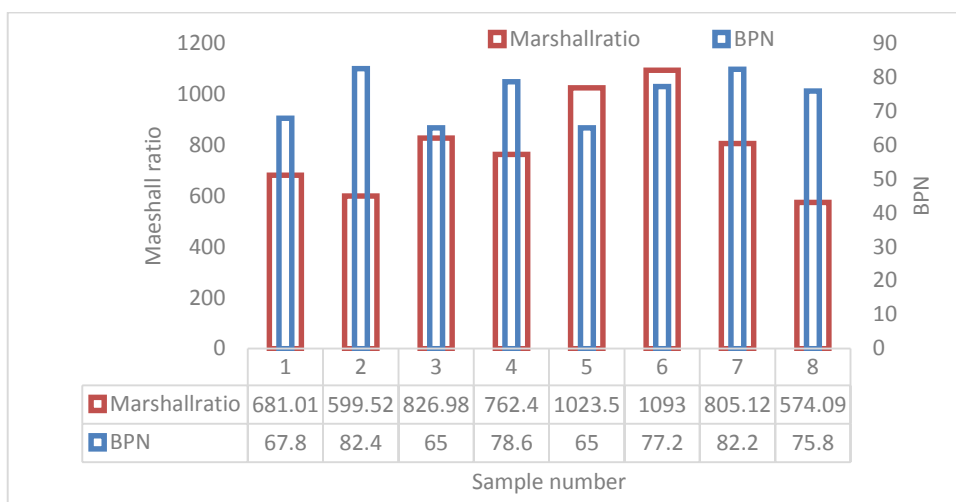


Fig. 2. Slip resistance test results and Marshall ratio values

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