The Effects of SCB test support configurations on different fracture mechanic parameters in asphalt mixtures

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ABSTRACT

Today, the semi-circular bending (SCB) test has become a common method and used in studying the mechanical behavior of asphalt mixtures. According to the regulations, this test has specified laboratory conditions such as sample geometry, test temperature and a certain loading rate. However, in addition to providing these conditions for SCB testing, the shape and type of supports used in the experiment are less considered and they do not have an integrated type and shape, which may cause differences in laboratory results. Therefore, in this study, the effects of 5 different support configurations on important parameters of fracture mechanics at intermediate temperatures was investigated by considering the coefficient of variation (CV). The used loading rate was selected 5 mm/min in which the asphalt samples were subjected to uniform static loading under mode I. The experimental results showed that the selection of support type has a direct influence on the fracture mechanic parameters, while the selection of the wrong support type may cause significant error in the test results. Nevertheless, the friction between the sample and the support causes more dispersion in the test results and could reduce its repeatability. For this purpose, it could be recommended not to use rigid supports that have considerable friction with the sample. Finally, considering specific laboratory conditions for the SCB test (i.e., sample geometry, test temperature and specific loading rate), support No. 1 was selected as the most suitable support with high repeatability of the results.

KEYWORDS

Semi-Circular Bending (SCB) test, Support Configurations, Fracture Mechanics, Asphalt Mixture, Coefficient of Variation (CV).

Introduction

Pavement cracking in cold and high-traffic areas is one of the most common failures in these regions, which requires further study by understanding the mechanism of crack growth and pavement failure on how this type of failure has appeared. By conducting and evaluating the index of fracture tests such as SCB testing parameters, many researchers evaluated the cracking performance of asphalt mixture. Previous research shows that various supports have been used in conducting the SCB test [1-4]. Due to the use of different types of supports in previous studies, the effect of the kind of support on the failure of asphalt mixture has not been widely studied, so it is necessary to examine the impact of the type of

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support on the SCB testing parameters and repeatability of test results. This research investigates the effect of 5 types of supports on different SCB testing parameters at intermediate temperature was studied based on the coefficient of variation and dispersion of the data.

Methodology

In this study, to evaluate the effect of support type on the fracture parameters, the SCB fracture test with five different support types was conducted. According to previous research, Yousefi et al., the suitable loading rate for conducting the SCB test at loading mode I, 5 mm/min considered [5]. Figure 1 shows the support type used to perform the test. In each type of support, different parameters were obtained from SCB test, including the maximum load (P_{cr}), fracture energy (FE), flexibility index (FI), and cracking resistance index (CRI).

Figure 1. Support types used for SCB test in this research

a) Maximum Load (P_{cr})

This parameter is the maximum load available in the load-displacement curve.

b) Fracture Energy (G_f)

This parameter is calculated by dividing the area under the load-displacement curve by the cracked cross section [6].

c) Flexibility Index (FI)

This parameter is calculated using the following formula [7].

$$FI = A * \frac{G_f}{|m|}$$

where, |m| is the slope of the post-peak curve at the inflection point.

d) Cracking resistance Index (CRI)

This parameter is defined as follows [8]:

$$CRI = \frac{G_f}{P_{max}}$$

Results and discussion

The results of the SCB testing parameters are shown in Figures 2-5. According to Figure 2, the maximum load of supports except support case-4 are approximately equal. In case 2 and 5, due to the rigidity (Fixed support), the asphalt sample is experienced the most before breaking.

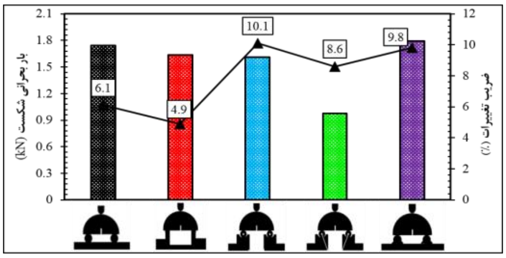


Figure 2. Maximum load for various support types

According to Figure 3, it can be seen that except support 1, the effect of the type of support on the FE of asphalt mixture at intermediate temperature has a similar trend to the results of Pcr; So that the maximum and minimum value of FE of the specimens occur in case 5 and 4, respectively.

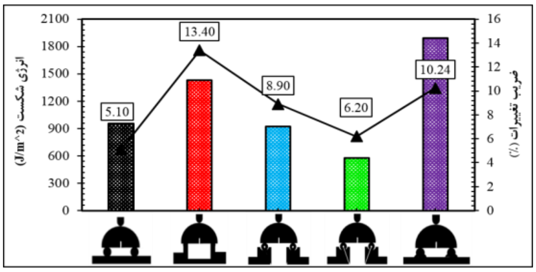


Figure 3. Fracture energy for various support types

As the results of FE, the two fixed supports case-2 and 5 have the highest FI of asphalt mixture, which may be directly related to the high level of FE of asphalt mixture in two supports.

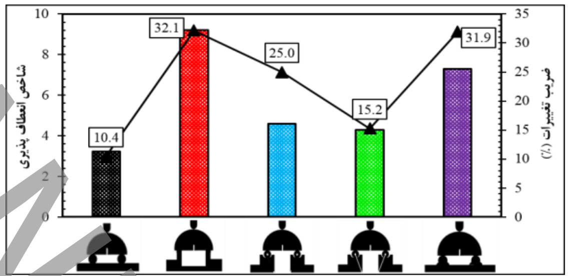


Figure 4. Flexibility index for various support types

According to Figure 5, it can be seen that the value of CRI, increases with increasing the freedom of the support (fixing the cylindrical roller on the support and adding a spring to support's roller).

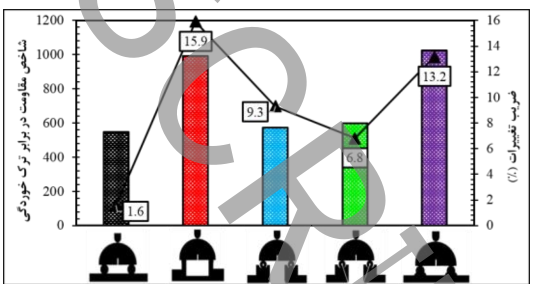
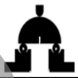


Figure 4. Cracking resistance index for various support types

Coefficient of variation of SCB testing parameters

The coefficient of variation related to all fractures mechanics parameters studied in this research is summarized in Table 1. In order to draw a general conclusion about how the effect of the type of support works, considering the average coefficient of variation of all the discussed parameters, it can be seen that the repeatability of the results of all parameters discussed in support 1 is more appropriate than other supports and has the lowest coefficient of change. Number 5 has the highest data scatter.

Table 1. The value of the coefficient of variation related to fracture mechanics parameters

Parameters	Coefficient of variation				
					
Pcr	6.09	4.87	10.12	8.62	9.76
FE	5.12	13.45	8.90	6.2	10.24
FI	10.41	32.15	24.98	15.24	31.92
CRI	1.61	15.95	9.34	6.85	13.16
Average	**5.81**	**16.6**	**13.34**	**9.22**	**16.27**

Conclusion

The main results obtained include the following:

- The geometric shape of the contact surface between the sample and the support has a minor effect on the fracture mechanics parameters of asphalt mixtures.
- The choice of the type of support has a direct and effective effect on the mechanical parameters of the failure, and the choice of the wrong support may lead to a significant error in the test results.
- The presence of friction in the supports has a significant effect on the results of the failure parameter mechanics and causes errors and scattering of the results.
- In rigid supports (fixed supports 2 and 5) due to the maximum frictional force between the specimen and the support, the asphalt specimens experience more displacement before failure and a larger surface diagram is formed.
- The amount of constant spring stiffness in a roller support (support 4) is a determining factor in the type of support reaction, so that with increasing spring stiffness, the friction between the support and specimen increases and the support behavior towards the fixed support and acts as a rigid support. (support 4 becomes support 5) and with decreasing spring stiffness, the amount of friction between the support and the specimen decreases and the behavior of the support will be towards the free roller support with curved surface (support 4 becomes support 3).
- Considering the average coefficient of variation of all parameters studied in this study, the free roller support (number 1) has the least scatter of results and provides relatively more accurate results

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