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Study on the Influence Factors of Vibration Compaction Acceleration in Asphalt Pavement Compaction Process

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Abstract: This paper analyzes the common asphalt pavement materials, and studies the influence of vibration duration, compaction degree, compaction temperature and semi-rigid base modulus, in order to provide reliable reference for the construction of foundation engineering in China.

1. Introduction

Asphalt pavement construction quality has a significant impact on the durability of highway engineering, especially the compaction quality often plays a leading role. In the compaction quality control of traditional asphalt pavement, most of them control the number of rolling times to achieve the desired goal, but the mixture has a certain heterogeneity, so it is often difficult to achieve the expected requirements by rolling times alone [1]. At the same time, the selection of rolling times mostly depends on the subjective judgment of technicians, so it is inevitable that leakage and overpressure will occur [2].

2. Test materials and methods

2.1 Test materials

The indoor test was used to carry out the analysis. Ac-20 asphalt mixture was selected as the material to be studied. Liaohe no. 70 base asphalt was used for asphalt, and the dosage was 4.4%.

In this study, cement-stabilized macadamia was used for semi-rigid base. The cement content is 3.5%, the optimum water content is 5.4%, and the maximum dry density is 2.311g/cm^3. The specimens were prepared by vibration compaction molding method, and the vibration time was set as 60s, 90s, 150s and 250s respectively. After forming, the specimens were cured in 14 days as the standard. According to the current Code for Highway Asphalt Pavement Design in China, the elastic modulus of each specimen under different vibration time is 1253MPa, 1716MPa, 2293MPa and 2645MPa respectively[3].

2.2 Test equipment

The equipment used in the indoor test includes vibration compaction equipment, vibration acceleration sensor and data acquisition equipment.

The acceleration sensor used in the test is A26D500 piezoelectric acceleration sensor, which has a range of 10g and a frequency response range of 0.2-5000Hz. A magnet is attached at the bottom of the sensor, which can be fixed to the surface of the compacting equipment. The general sensor should be arranged in the center of the vibration head, so that the vertical vibration acceleration of the equipment can be collected. The data collector adopts UT3408FRS-DY, and the acquisition and display of signals can be realized with the help of acquisition and control software. In addition, the collected signals can be processed to start subsequent time domain and frequency domain analysis.

3. Analysis of influencing factors of vibration acceleration

The compaction degree of the mixture, the compaction temperature and the modulus of the semi-rigid base have significant effects on the vibration acceleration. The influences of the above three parameters on vibration acceleration are explored by means of indoor vibration test.

3.1 Change rule of compaction degree

According to the expected requirements to carry out vibration test, the control of compaction temperature 150 ℃, in four different elastic modulus of semi-rigid base, with 1 s, 2s, 4s, 6s, 8s, 10s, 15 s, 20s, 30s vibration time get 9 groups of specimens, in order to obtain specimens compaction degree index and the relationship between the vibration time and draw the corresponding curve. In addition, the corresponding vibration time of the mixture under different compaction degree is obtained through the test, which can provide reference for the subsequent test.

When the elastic modulus of the semi-rigid base is set to different values, the compactness of the measured specimen is relatively close[4]. In other words, under the action of the same compaction work, the influence of the change of the modulus of semi-rigid base on the compaction degree of asphalt can be ignored. Therefore, the average value of the compactness measured under different elastic modes of semi-rigid base can be taken as the compactness under the corresponding vibration time, and the compactness - vibration time relationship curve can be drawn.

Vibration time was taken as the abscissa and compactness as the ordinate to draw the compactness - vibration time relationship curve at the compactness temperature of 150℃. It can be seen that in the early stage of vibration, the compaction degree of the specimen increased rapidly, and reached 93% in the 6s when the vibration began. However, from the 1s to the 6s of vibration, the compaction degree of the specimen only increased by 5%. With the passage of time, the increasing speed of the compactness decreases gradually, and when the vibration time is greater than 15s, the compactness of the specimen basically reaches a stable state.

3.2 Influence of compaction degree on vibration acceleration

The indoor vibration test was carried out with the help of vibration compaction equipment, and the relationship between vibration acceleration of test specimens and asphalt compaction degree was investigated under the condition that elastic modulus and compaction temperature of semi-rigid base were kept constant. In this study, it was assumed that the elastic modulus of semi-rigid base was 2645MPa at the compacting temperature level of 150℃, so as to measure the corresponding relationship between the compacting degree of specimens and vibration acceleration. And draw the corresponding compactment-acceleration amplitude curve. According to FIG. 3, when the compactness of the specimen increased, the vibration acceleration also showed a trend of increasing. When the compactness of the specimen increased from 88.48% to 96.01%, the vibration acceleration increased by about 2.5 times. At the same time, the relationship between compactness and acceleration amplitude can be roughly regarded as linear, and its linear regression $R^2 > 0.96$ can

be obtained through calculation.

Compactment-acceleration amplitude curve obtained from the indoor vibration test is basically consistent with the expected, and the surface vibration acceleration can play an indirect role in evaluating the compaction quality[5].

3.3 Influence of compaction temperature on vibration acceleration

For the compacting temperature less than 80℃, it is difficult to significantly improve the compacting degree of specimens even if the compacting power is increased. In addition, the current construction technical standards in China also require that the internal temperature of modified asphalt should be greater than ℃ during the rolling process, and the rolling temperature of the base asphalt mixture can be appropriately reduced. Therefore, in the laboratory test of this study, compaction temperature gradients of 80℃, 100℃, 120℃, 140℃ and 150℃ were set respectively, and vibration tests were carried out under the condition of 1253MPa semi-rigid base elastic mode, so as to measure the corresponding relationship between the compaction temperature of specimens and vibration acceleration.

The measured compactness of specimens under different compaction temperatures is not exactly the same as the actual situation, mainly because the asphalt material itself has a certain discrete type, resulting in the compactness obtained under the same vibration condition is not a fixed value, but fluctuates within a certain range. As a result, it is difficult to analyze the relationship between compaction temperature and vibration acceleration at the same degree of compaction, but the relationship curve between compaction temperature and acceleration can still be used to preliminarily analyze the change rule between them, as shown in FIG. 1.

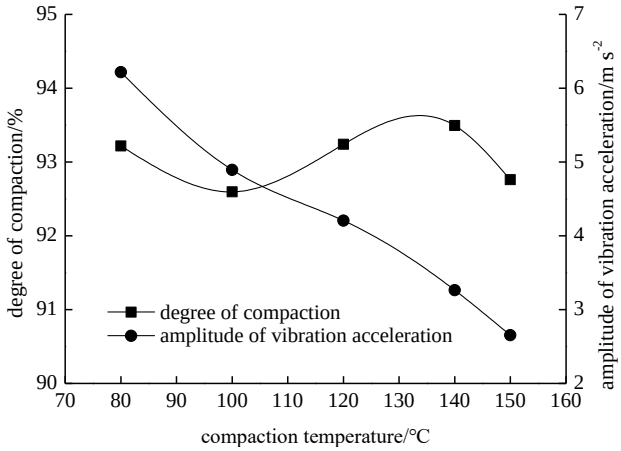

Figure 1: Compacting temperature-acceleration relationship curve

Vibration acceleration shows a rising trend with the decrease of compaction temperature, which is basically consistent with the expected judgment. In addition, in the process of increasing the compaction temperature from 140℃ to 150℃, the spacing between curves is relatively small, which is mainly caused by the material stiffness being close at higher temperature.

3.4 Influence of semi-rigid base modulus on vibration acceleration

In order to explore the influence of semi-rigid base elastic modulus on vibration acceleration, the semi-rigid base elastic modulus of 1253MPa, 1716MPa, 2293MPa and 2645MPa were respectively taken in this study. Indoor vibration tests were carried out according to the constant compacting temperature of 140℃, and the corresponding relationship between the semi-rigid base elastic .

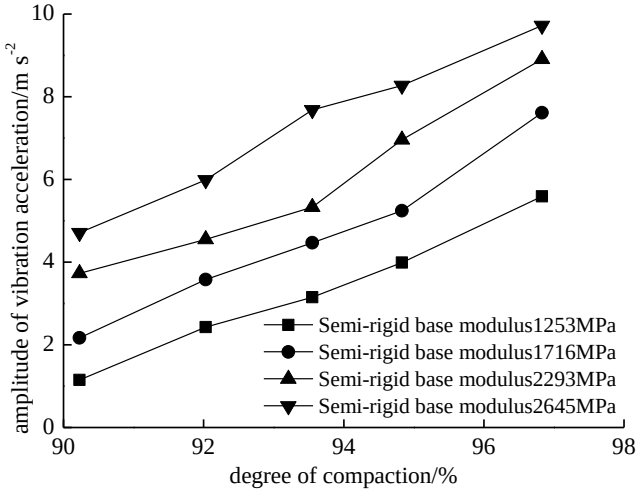

Figure 2: Elastic mode-acceleration relationship curve of semi-rigid base

According to Figure 2, with the increase of elastic modulus of semi-rigid base, the change curve of vibration acceleration keeps rising, that is, there is positive correlation between vibration acceleration and elastic modulus of semi-rigid base under the same compaction index. Taking the abscissa value of 93.55% compactness, the vibration acceleration increases 41.9% in the process of lifting the elastic modulus of semi-rigid base from 1253MPa to 1716MPa. It can be found that the elastic modulus of semi-rigid base has a significant impact on vibration acceleration, which is evaluated according to two-factor variance analysis. According to the data in the table, it can be found that the P value is lower than the significance level $\alpha=0.05$, so it can be considered that the correlation between elastic modulus and vibration acceleration of semi-rigid base is prominent.

4. Conclusion

In this paper, based on the vibration test, the effects of compaction temperature, compaction degree and elastic modulus of semi-rigid base on vibration acceleration are investigated respectively, and the corresponding relations are obtained by fitting. It is found that there is significant correlation between these three indexes and vibration acceleration.

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