Regression Analysis of Actual Measurement of Temperature Field Distribution Rules of Asphalt Pavement

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Abstract: Taking the structure of asphalt concrete pavement in actual running as the test object, a kind of actual measurement project for temperature field pavement structure was put forward. Based on the abundant measured temperature data, distribution rules of asphalt pavement temperature field were studied in detail, and the dependency relations between the air temperature and pavement temperature field were discussed with regression analysis. Considering the effect difference to asphalt pavement temperature field which was applied by temperature rise period and temperature fall period of air, the dependency relations between air temperature and different temperature changing periods were researched respectively and the prediction models on asphalt pavement temperature based on different temperature changing periods were established. The comparison between measured and predicted asphalt pavement temperatures indicates that these models have good applicability and accuracy.

Keywords: Road engineering; Asphalt pavement; Regression analysis; Temperature field; Prediction model; Temperature changing period

1. Introduction

The results show that asphalt pavement mixture is a temperature sensitive material, and its temperature changes will lead to great differences in its properties. The specific performance of this performance is: under different temperature conditions, pavement will have different forms of damage, such as low temperature cracking, high temperature rutting, and so on. Its fatigue life is also affected by temperature [1-8]. Therefore, without the temperature, the performance of asphalt mixture or asphalt pavement design will be meaningless. Relevant literature [9-15] studied the temperature field of asphalt pavement to some extent, and put forward the corresponding prediction model. These researches have certain theoretical value and practical significance, but unfortunately, these studies have not considered the influence of different temperature on the asphalt pavement temperature field. In this paper, the temperature prediction model of Asphalt Concrete Pavement Based on different temperature change stages is established.

2. Design of Temperature Field Measurement Scheme

Rich and accurate data is the key to study the distribution of asphalt pavement temperature field. Therefore, this paper selected a section of the road being operated in Henan, Zhengzhou Province as the test section. The location of the test section has good ventilation and light conditions, and there are no tall buildings and trees near the barrier. The structure of its specific test sections is shown in table 1.

Table 1. Structure of Asphalt Pavement of Test Section

Structure layer	Material type	Material name	Thickness /cm
The surface layer	AC	asphalt concrete	7
The basic level	HMAC	Hot mix asphalt	18
Subgrade	SS	Silty sand	-

2.1. Instrument selection and layout plan

2.1.1. Instrument selection

The temperature sensor uses the NZWD type resistance thermometer monitoring NARI Group Corporation dam engineering branch development, schematic diagram of the structure and the performance indicators are shown in Figure 1 and Table 2.

Figure 1. Structure of Resistance Temperature Sensor

Table 2. Performance Indexes of Resistance Temperature Sensor

Measuring range / ℃	Measuring accuracy/ ℃	Zero resistance/ ℃	Resistance factor/ ℃	insulation resistance/ ℃
-30-70	±0.3	46.60	5	≥50

The temperature data acquisition instrument is used to monitor the data acquisition instrument NARI Group Corporation dam engineering branch of research and development, the data acquisition instrument according to the user set the acquisition cycle continuously on the temperature data acquisition and storage.

2.1.2. Instrument layout

The temperature sensor is arranged to obtain a large amount of first-hand temperature data. 2 observation points are arranged on the test section, and 4 resistance temperature sensors are set at each observation point. The specific arrangement of temperature sensor of asphalt pavement is asphalt concrete pavement in top, middle and bottom layer of the layout of 1 temperature sensors and 1 temperature sensors arranged at the bottom of the base, as shown in Figure 2. In addition, 1 temperature sensors are specially designed to observe atmospheric temperature. The temperature sensor is 1.2 m away from the ground and well ventilated. A total of 9 temperature sensors are connected to the data acquisition box, which can be removed periodically for analysis and study.

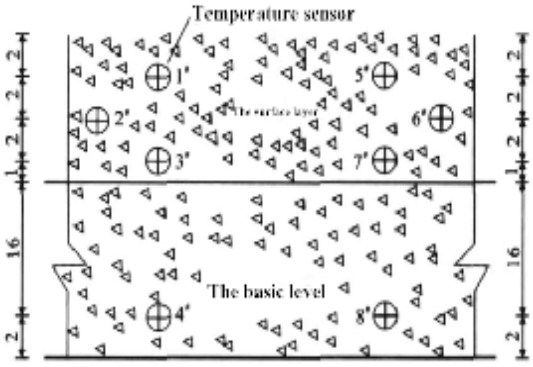

Figure 2. Location of Temperature Sensors in Asphalt Pavement Structure (Unit: cm)

2.2. Observation content and observation cycle and frequency

The temperature data that need to be observed in this paper include: Temperature at different depths of asphalt pavement; Temperature data of asphalt temperature field and synchronous temperature data. The test cycle lasted for one year, from September 2005 to September 2006. The observation frequency of the Benz experiment is 24 times a day, that is, the temperature and temperature at different depths of the asphalt road structure layer are collected 1 times per hour, and the collected data is stored.

3. Statistical Analysis

3.1. Temperature field research method

There are 2 kinds of research methods of pavement temperature field: theory method and mathematical statistics method. Each of these 2 methods has its advantages and disadvantages. The theoretical method is based on the meteorological data and the parameters of the pavement material, and applies the principle of heat transfer and the relevant assumptions to obtain the analytical expression of the pavement temperature. The disadvantage is that the analytical expression of the temperature field is too complex, which is not conducive to practical engineering applications. At the same time, the method needs a large amount of meteorological data, which limits its extension. But the theory and method are adaptable and free from geographical restrictions. The statistical method is based on the measured pavement temperature, and the formula for calculating the pavement temperature is established by regression analysis. Its characteristic is that the calculation method is simple and the calculation accuracy is high. Although the conclusion has certain regional characteristics, it is still an effective approximate method for an area. This method is also widely used in the study of pavement temperature field recently, so this method will be used to process and analyze temperature data.

3.2. Relationship between temperature and air temperature at different depths of Asphalt Pavement

In the past, the relationship between the temperature and the temperature of the asphalt pavement did not consider the influence of temperature on the asphalt temperature, but simply considered it to be an equivalent process. It can be seen from the above research that the amplitude and temperature change rate are obviously different. Therefore, the influence of the same temperature on the temperature of asphalt pavement during heating and cooling stage is different. In this paper, according to the law of temperature change, the process of temperature change is divided into heating stage and cooling stage, and the relationship between the temperature and the temperature of asphalt is analyzed, as shown in Figure 3 and Figure 4.

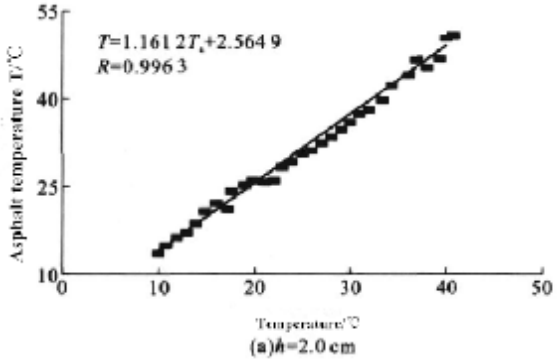

Figure 3. Relations Between Asphalt Temperature and Air Temperature in Temperature Fall Period

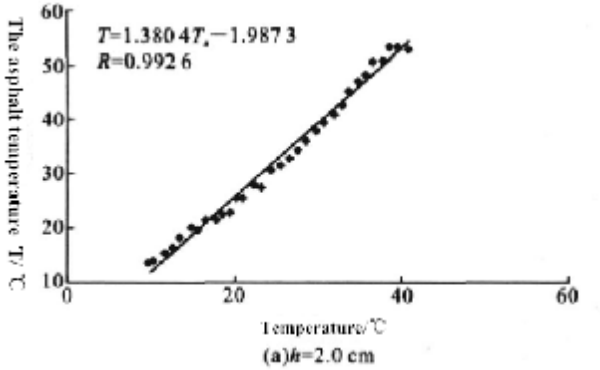

Figure 4. Relations Between Asphalt Temperature and Air Temperature in Temperature Rise Period

The same can be seen from Figure 7: heating stage and temperature except at the bottom of the base (Ch=25.0 cm) and a logarithmic relationship between good asphalt temperature (h=0.971 2), and asphalt in 2.0,3.5,7.0 at cm depth temperature showed a good linear relationship, and the correlation coefficients are all 0.99.Similarly, it can be concluded that the prediction accuracy of asphalt pavement temperature in cooling stage is the highest. With these conclusions, we can adopt the no prediction formula according to different requirements in practical engineering.

4 . Conclusions

Relation between variation of the air temperature and the air temperature and the temperature of asphalt pavement are studied in detail, and on this basis, through regression analysis the relationship between temperature and temperature at different depths of asphalt. Taking into account the influence of temperature, temperature rise stage and cooling stage on asphalt pavement temperature, the relationship between temperature and asphalt temperature based on temperature rise stage and cooling stage is given respectively. In this study, the multiple regression of asphalt temperature, air temperature and pavement structure depth was carried out by using the least square method, and the prediction formula of temperature at any depth of pavement was obtained. Finally, the predicted values of these formulas are compared with the observed ones, and these formulas are proved to be of high accuracy and practical value.

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