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Evaluation of Influence of Nano Kaolin on Temperature Sensitivity of Asphalt Pavement Based on Analytic Hierarchy Process

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Abstract: In order to further explore the five different dosage of nano kaolin sensitivity to the temperature of the modified asphalt concrete, combined with constant temperature heating heating experiment and stir yogurt machine constant temperature cooling experiment of these two kinds of innovative experiment of heat exchange data, based on the analytic hierarchy process (ahp) innovative obtains the temperature win min optimum dosage of nano kaolin, The influence of different nano-kaolin content on the temperature sensitivity of modified asphalt was evaluated as a whole. The experimental results show that when the content of nano-kaolin is 7%, the temperature sensitivity of asphalt mixture is the best at 10 different temperatures compared with the other four mixtures. With the increase of nano-kaolin content, the temperature sensitivity of asphalt mixture is first superior and then inferior.

Keywords: Nano-kaolin modified asphalt mixture, Thermal conductivity, Temperature sensitivity, Analytic hierarchy process.

1. Introduction

AHP is a multi-criteria decision-making method that combines qualitative and quantitative methods to deal with complex decision-making problems. The method divides the decision-making problem into four levels according to an orderly hierarchy, so as to achieve the overall goal in an orderly manner. Its main goal is to filter out the most ideal solution by calculating the weight of various solutions to achieve the overall goal. However, due to people's subjective comparison and judgment, unstable interference factors will be introduced in the analysis and research, which will cause the data results to vary from person to person. In order to overcome this problem, this study constructed an experimental framework through the constant temperature heating table heating experiment and the constant temperature cooling experiment of the fried yogurt machine. basis to make the experimental results more scientific and reliable. This provides a new possibility for the application of AHP in road engineering.

2. Data Screening

Experiments were selected nano-kaolin doping of 0%, 3%, 5%, 7%, 9%, 11% of the asphalt mixture for constant temperature heating table heating experiments and fried yoghurt machine low-temperature cooling experiments, through the experiments at 2cm and 4cm -20 ℃, -15 ℃, -10 ℃, -5 ℃, 0 ℃, 15 ℃, 20 ℃, 25 ℃, 30 ℃, 35 ℃ temperature experimental block over time intuition of the Temperature changes, thus establishing the time as the horizontal axis, heat transfer temperature as the vertical axis of the temperature curve of different doping, to doping for example, 7%, as shown in Figure 1[1-2].

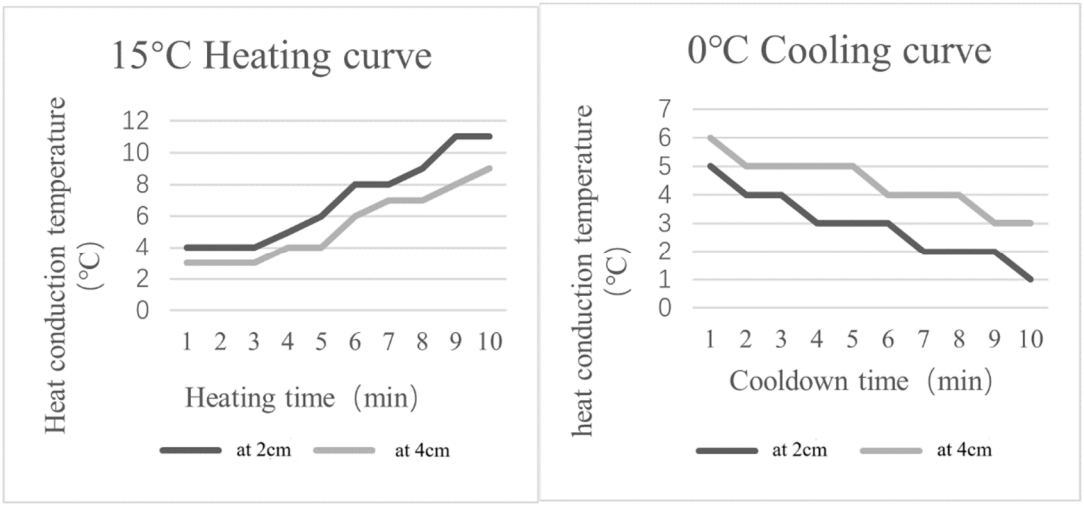

Figure 1. Temperature curve

Through the horizontal comparison of the obtained temperature curves, according to the data obtained in the experiment, it lists -20°C, -15°C, -10°C, -5°C, 0°C, 15°C, 20°C, 25°C, 30°C, 35°C, etc. At different temperatures, the temperature difference from the beginning to the end of the heat conduction experiment with different nano-kaolin content, taking -20°C, -15°C, -10°C, -5°C, 0°C, and 15°C as examples, see Table 1. The absolute value data size based on temperature difference can be used as a main reason for judging. It is concluded that at different ambient temperatures at 2cm and 4cm, the dosage of nano-kaolin with the best temperature sensitivity in my country's asphalt is changed, and the temperature is used as the horizontal axis. The comparative analysis curve of the temperature difference change between 2cm and 4cm on the vertical axis of asphalt is shown in Figure 2.

Table 1. Horizontal comparison results of temperature curve

Nano kaolin doping/%	Difference in temperature/℃											
	-20		-15		-10		-5		0		15	
	2cm	4cm	2cm	4cm	2cm	4cm	2cm	4cm	2cm	4cm	2cm	4cm
0	24	23	14	15	13	11	4	4	3	2	15	14
3	22	21	16	12	12	10	6	3	3	2	13	12
5	19	18	13	12	11	10	6	3	4	3	13	13
7	17	15	14	11	11	11	5	2	3	3	12	12
9	20	19	15	13	12	9	4	4	4	3	14	11
11	24	22	13	14	14	13	6	5	2	1	16	15

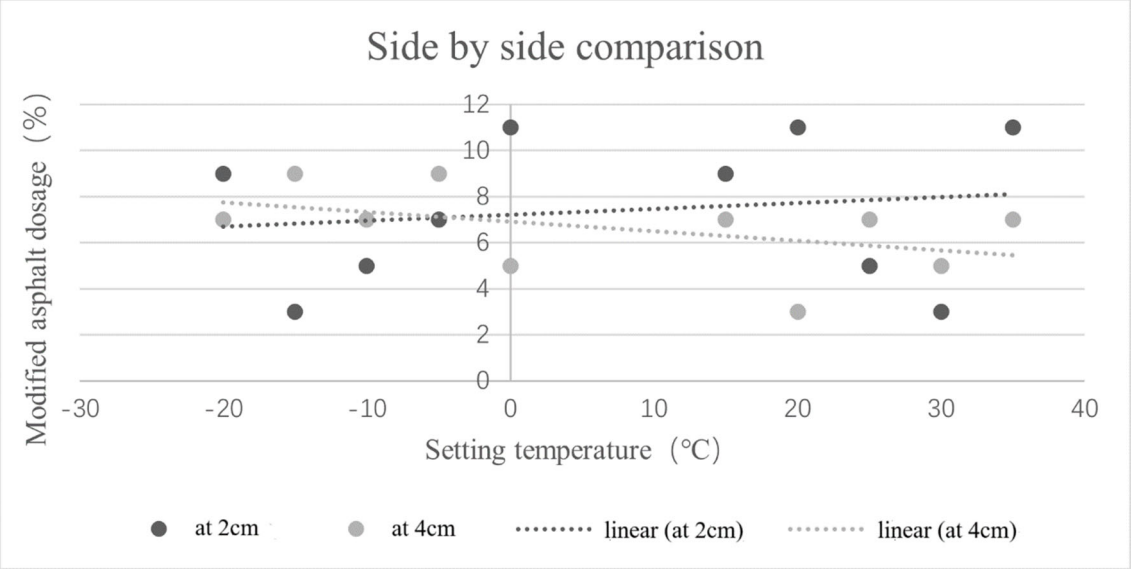

Figure 2. Temperature contrast curve

3. Data Processing

3.1. Establish a deportation hierarchy

The analytic hierarchy process required by AHP is generally composed of the following three levels:

Highest target layer: the predetermined target and target of the problem are unique. This experiment tested the temperature sensitivity of modified asphalt with different nano kaolin content. We hope to get the best content of nano kaolin used for asphalt temperature sensitive modification, that is, the decision-making goal is "to get a better content of nano kaolin with asphalt temperature sensitive modification in high cold and high altitude sections".

Intermediate criteria layer: the criteria that affect the realization of the goal. The criteria are different and miscellaneous, but there is an obvious subordinate relationship between the upper and lower levels. In this experiment, there are two kinds of elements, namely, the content of nano kaolin which is the best for the temperature sensitive modification of asphalt at 2cm and 4cm, below which there are 10 kinds of elements, such as the content of nano kaolin which is the best for the temperature sensitive modification of asphalt at -20 ℃, -15 ℃, -10 ℃, -5 ℃, 0 ℃, 15 ℃, 20 ℃, 25 ℃, 30 ℃ and 35 ℃, respectively[3].

The lowest measure layer: measures to promote the realization of the goal. In this experiment, there are five kinds of nano kaolin content, which are placed at the bottom of the hierarchy as measure layer elements.

The corresponding hierarchical structure can be worked out by clarifying the factors and their positions at each level and connecting the relationship between them with lines, as shown in Figure 3.

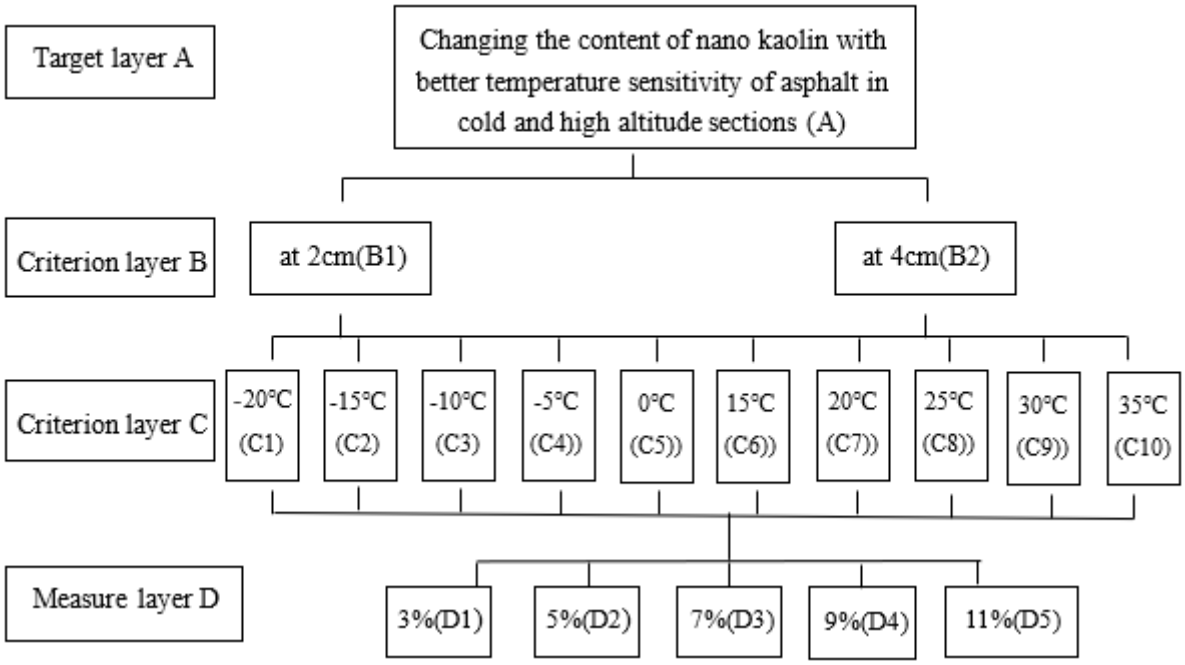

Figure 3. Hierarchical structure diagram

3.2. Construct a judgment matrix and assign values

A judgment matrix can be easily constructed by designing the structure according to the hierarchical level. When filling out the judgment matrix, the general method is: repeatedly ask people (experts) to judge and get the importance distribution. This experiment innovatively counts the difference in heat conduction temperature of each mixing amount at different temperatures through experiments. By comparing the data, it can be directly 1. Scientifically obtain the temperature sensitivity of 2cm and 4cm at different temperatures, that is, the degree of importance, and avoid the disadvantage of large subjective errors in the original hierarchical analysis method at this stage. According to the criteria of the judgment matrix, which two elements are important, which element is very important, and the degree of importance is assigned according to 1-9. Since this experiment skipped the subjective judgment of experts, more objective temperature difference data was used as the evaluation basis, so the new important scale values are shown in Table 2[4].

Table 2. Significance scale meaning table

Significance scale	Meaning
1	Indicates that compared with the temperature difference data of two kinds of dosage, it has the same value
3	Indicates that the temperature difference data for the two dosages are slightly smaller than the latter.
5	Indicates that the temperature difference data for the two dopings are significantly smaller than the latter value when compared to the former.
7	Indicates that the temperature difference data for the two dosages are strongly smaller than the latter value when compared to the former
9	Indicates that the temperature difference data for the two dopings are less extreme than the latter when compared to the former
2, 4, 6, 8	Indicates the intermediate value of the above judgement
reciprocal	If the ratio of importance of element I to element j is aij, then the ratio of importance of element j to element I is $a_{ji} = 1/a_{ij}$

3.3. Hierarchical single ranking (calculation of weight vector) and inspection

After inspection, the consistency ratio C.R. is less than 0.1, so the consistency of the judgment matrix is acceptable.

3.4. General ranking and inspection of levels

The general sequence of temperature sensitivity tests and test results are shown in Table 3 and table 4.

Table 3. Total ranking of level C (CR = 0.0000)

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
0.0978	0.0968	0.0982	0.0975	0.1071	0.1037	0.0948	0.1015	0.1071	0.0955

Table 4. Total ranking of level D(CR = 0.0000)

D1	D2	D3	D4	D5
0.1571	0.2714	0.3214	0.1634	0.0867

It can be seen that the value of C.R. of the total ranking is less than 0.1, so the overall consistency of the judgment matrix is acceptable.

3.5. Analysis of results

From the results of the total ranking of the measure layer, the weight of nano-kaolin doping of 7% (D3) is greater than the weight of the remaining 3% (D1), 5% (D2), 9% (D4), 11% (D5), and the weight value of the overall tendency of the first increase and then decrease. Therefore, the alpine high-altitude regional road sections to change the asphalt temperature sensitivity of the better nano-kaolin doping of 7%, temperature sensitivity to improve the impact of the overall effect of the first strengthened and then weakened trend[5].

4. Conclusion

(1) From the final results, the hierarchical analysis method can be applied to two innovative experiments: constant temperature heating table heating experiment and fried yogurt machine constant temperature cooling experiment.

(2) Based on the hierarchical analysis method (ahp), the temperature sensitivity of asphalt at 10 different temperatures is better than the other four when the amount of nano-kaolin is 7%.

(3) From the hierarchical total ranking, with the increase of nano-kaolin dosage, the temperature environmental sensitivity analysis of asphalt modified mixtures presents the first superior and then inferior situation, indicating that the study of nano-kaolin as a modifier to join does not completely make the asphalt material mixtures of temperature sensitivity to become better, and still need to control the study of the dosage.

(4) The addition of nano-kaolin modifier improves the road performance of asphalt in the high-cold and high-altitude road section, which provides a new direction for the research in this field.

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