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Analysis of Highway Roadbed Performance Evaluation Technology

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Abstract: With the continuous development of China, the requirements for road construction are also increasing. Among them, strengthening the performance of roadbed test can effectively improve road construction. Besides, it is also crucial to perform suitable tests in a timely manner. Therefore, highway inspection technology should be improved for the continuous development of highway construction, which will be explained in this paper, in hopes of improving the construction of highway in China.

Keywords: Highway roadbed; Performance evaluation; Testing technology

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1. Introduction

Highways will inevitably suffer some damages during long-term use. Among them, the roadbed performance is an important factor that directly affects the use of roads. Therefore, it is necessary to evaluate and roadbed performance in a timely manner for better road maintenance. Besides, timely evaluation and active search for effective solutions can minimize road damage. Through research, it was found that the elastic modulus is the key factor in highway roadbed performance.

Before researching a highway that has been open to traffic for 13 years, the basic construction of the highway should first be understood, the different structures of the highway and the selection of materials at different levels of the highway should be identified, in order to understand basic structure of the highway. The basic structure of the highway roadbed is cement-stabilized gravel soil with a thickness of 17 cm, cement-stabilized crushed stone of 38 cm, and coarse, medium, and fine-grained asphalt concrete, respectively 8 cm, 6 cm, and 4 cm. Through the investigation, it was found that the number of axes of the highway had far exceeded the designed number of axes at the initial stage, and the roadbed has also suffered relatively serious damage such as cracks, road surface subsidence, and especially traffic accidents at the bridgehead. This will affect the driving experience, and in serious cases, it will affect the performance of the vehicle, which will increase the operating cost of the vehicle and further aggravate road damage. These problems may be caused by insufficient surface strength of the roadbed. Therefore, the roadbed requires major repair. But before that, the performance of the roadbed should be evaluated to determine whether the surface of the roadbed is qualified at the current stage. If the surface is qualified, it can be directly repaired. If it is unqualified, some reinforcement treatment will be required to ensure the basic construction quality of the roadbed [1].

2. Contents related to roadbed performance evaluation

The basic performance evaluation of highway roadbed is one of the methods to understand the overall condition of the road, which makes it important. Only after fully understanding the basic performance of the roadbed can we judge the condition of the road surface, and find a suitable solution to improve it. Besides, research should be done to explore the causes of common problems such as roadbed subsidence and vehicles knocking against the bridgehead, so as to better evaluate the basic performance of the rod bed. In this paper, related content such as roadbed subsidence, traffic accidents at bridgehead, mud pumping and cracking will be discussed.

2.1. Cause analysis of roadbed subsidence

Through the investigation and research on the roadbed, it can be found that the main area of roadbed subsidence is between 0.5–150 m^2, and it mainly occurs in earthworks, cut and fill, and soft soil sections. Roadbed subsidence will also cause other problems, such as car accidents at bridgehead and cracks, which will in turn affect the overall performance of the roadbed [2].

2.2. Vehicles knocking against the bridgehead

Traffic accidents at the bridgehead will not only affect the driving experience, but in serious cases, they will even affect the lives and property of the victims. Therefore, for a better driving experience, the management of roadbeds should be strengthened to ensure that the highway roadbeds are up to standard. Besides proper management also prevents road surface subsidence and unevenness of the road surface, especially at where the bridge deck and the road surface are connected, where road accidents might occur. Therefore, the aforementioned problems should be addressed to prevent adverse events.

2.3. Mud pumping

Mud pumping mainly occurs at the junctions, especially for the cut and fill and low-fill shallow cut sections, and there will be a lot of mud pumping problems at the gap between the slow lane and the fast lane. When the mud pumping problem occurs, not only the vehicles cannot pass through the road smoothly, but the cracks of the road surface will also expand, resulting in roadbed subsidence and other adverse effects.

2.4. Research on issues related to cracking

Mud pumping will affect the smoothness of the road surface to varying degrees, causing cracks on the road surface, and the subsidence of the road surface will also cause cracks. Therefore, it is clear that cracks is caused by many factors. To prevent cracking, the roadbed should be inspected on a regular basis to evaluate whether the roadbed is qualified through continuous measurement and analysis. Through investigation, it was found that earthworks and cut and fill road sections are extremely prone to cracking problems, and the cracks are mainly longitudinal cracks, ranging from 5–50 m. Cracks will have impacts of varying degrees, therefore needing more attention [3].

It is clear that unqualified roadbed will affect the normal traffic and use of the road to varying degrees. When the roadbed is unqualified, there will be cracks, road subsidence, mud pumping, and traffic accidents. In order to better ensure the traffic conditions of the road, reduce pollution, and prevent greater hazards during the use of the road, relevant management personnel should strengthen road inspection, so as to ensure the quality of the roadbed and traffic safety.

3. Roadbed inspection content

The occurrence of roadbed-related problems will affect the service life of the road, and will also cause other adverse effects. Therefore, in order to better investigate the basic performance of the roadbed, relevant

personnel are required to mark the main survey sections, and explore the impact of different construction methods on the basic performance of the roadbed. In this project, the basic faults in different road sections from K171+000–K183+700 were identified, and the relationship between the faults and construction methods were studied, and appropriate countermeasures are proposed.

(1) For the K171+450 road section, the main problem was rutting, and cracks were found between the slow lane and the fast lane, where the transverse cracks were the main issue. This section of the road was mainly filled with asphalt roadbed [4].
(2) The problems on the K178+755 road section was quite different from the K171+450 road section, and the construction method of this road section is also different. Cracks and frost boils will damage the passing vehicles, and this road section is mainly constructed with excavation roadbed and asphalt roadbed.
(3) For the K181+210 section of the filled section and asphalt road surface, since this section is a filled road section, the concrete panel will break and cause subsidence on the road surface.

According to the investigation above, the construction methods of different road sections are quite different, so are the problems identified. Resilience modulus is a major factor affecting the basic performance of highway roadbed. Road sections with relatively small elastic modulus are more prone to road surface depression, and road sections with relatively high elastic modulus are more prone to problems such as cracks and rutting. Therefore, in the future road construction, relevant personnel should pay more attention to the influence of elastic modulus on the road surface to prevent damage to the basic performance of the roadbed caused by modulus of resilience.

In addition, the tests for the degree of compaction and water content of the roadbed should also be strengthened. It was found that the main compaction range of the above-mentioned road sections was between 83.5% and 91.3%, in which the degree of compaction was significantly lower than the required range, and the water content far exceeds the specified water content standard.

Therefore, it is clear that the factors that affect the basic performance of the roadbed are the degree of compaction of the road surface, water content, and modulus of resilience. However, the degree of compaction of the road section was found to be relatively low, and the water content was much higher than the specified standard [5].

4. Research on roadbed basic performance testing technology

Roadbed performance is the basic content of evaluating the road condition. It is of great value to the quality inspection of the road, and the roadbed is a very important crucial part of the road. Therefore, in the process of roadbed inspection, relevant personnel should ensure the structural integrity of the roadbed and avoid damage during the inspection. Therefore, in order to better protect the road surface, relevant personnel should conduct accurate inspections while ensuring the integrity of the roadbed. The detection methods mainly involve ground penetrating radar, Rayleigh wave method, and high-density resistivity method [6]. Due to the complexity of road surfaces, several methods should be used in roadbed testing to ensure validity. Testing should be done based on the characteristics of each layer of the roadbed, and fully use the algorithm to optimize the data processing to ensure the accuracy of the data.

Signal processing techniques can be used in roadbed testing, such as ground penetrating radar, fast weighted post-image projection algorithm in layered media, and Rayleigh wave method. A variety of algorithms such as the suppression method can accurately optimize the required data and aid further analyses.

The advantages of the non-destructive testing methods mentioned earlier should be fully utilized. A multi-sensor detection algorithm can be used to increase the accuracy of the readings [7]. Besides, the Rayleigh wave method and high-density resistivity method can also be used to obtain accurate data, and

the data can be processed by drawing to obtain the required information. The information can then be used to calculate the elastic modulus.

5. Application of highway roadbed performance testing technology

The K200+000-100 road section was evaluated using the methods proposed above, and the results are explained below.

(1) Roadbed-related filling characteristics

We found that when the water content of the roadbed is relatively high, the road surface will crack. Therefore, in order to better protect the roadbed and ensure the basic performance of the roadbed, its water content should be controlled at 15.2% at best, and the maximum water content should be 18.7%, whereas the maximum dry density should be 1.85 g/m^3, and the plastic limit should be 22.7% [8].

(2) Elastic modulus after the completion of the roadbed

We found that the compaction degree of this project was 96%, and the water content ratio was 18.7%. According to the formula $E = AK^MW^N_C$, the elastic modulus can be calculated as 94.2 MPa, in which the boundary points are 47.4 MPa and 76.1 MPa [9].

6. Relevant evaluation of roadbed inspection

Through the ground penetrating radar, Rayleigh wave method, and high-density resistivity method, the above-mentioned elastic modulus, water content and other relevant data can be calculated, and these data are crucial in evaluating a roadbed [10].

The elastic modulus of K200+000, +020, +040, +060, +080, and +100 road sections were calculated to be 38.6 MPa, 40.5 MPa, 48.7 MPa, 53.5 MPa, 40.8 MPa Pa and 37.6 MPa, respectively. Therefore, only K200+040 and K200+060 road sections were qualified. Since the modulus of elasticity of this section of the road was relatively low, most of the roadbed performance was unqualified. Therefore, it can be fully reflected that the structural damage of this section of the roadbed was relatively large and should be addressed in a timely manner.

7. Conclusion

The economy of our country has been developing rapidly along with the continuous development of our country, so the basic requirements for roads have also been significantly increased, and the frequency road usage is relatively high. If the basic performance of the roadbed does not meet the relevant national requirements, it will cause certain damage to the road, and cause detrimental effects on the passing vehicles. Therefore, in order to better protect our country's roads quality, relevant personnel should continuously strengthen the inspection of roadbed performance to ensure that the relevant requirements are met. Sections of roadbed that are unqualified should be repaired to ensure the normal function of the road. In the future, the roadbed performance standards should also be improved, so as to further improve the road quality in our country.

Disclosure statement

The authors declare no conflict of interest.

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