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Mechanical Response of Asphalt Pavement Subgrade in Wet and Dry Condition

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Abstract: The mechanical response of asphalt pavement under different condition of dry-wet subgrade was studied byBISAR3 software from the perspective of pavement mechanics. The change of the displacement, normal stress and shearstress of every layers were analyzed by roadbed resilient modulus and connection status between the layers. The results shows that subgrade dry-wet state has great influence on asphalt pavement structure, especially the displacement and the bottom normal stress and shear stress

Keywords: component; formatting; style; styling; insert (key words)

1. Introduction

The dry and wet condition of the roadbed is of great significance in the design of asphalt pavement. The dry and wet types of subgrade are divided into 4 kinds, such as dry, wet, wet and over wet. The response of the subgrade to pavement mechanics is very different in different state. In the design of asphalt pavement, subgrade resilient modulus is a very important parameters, the modulus of Subgrade under different dry and wet condition changes greatly. In the same area, under the same natural condition, the strength of subgrade is largely related to its relative water content. In the dry condition, the strength of the subgrade is higher, and vice versa. The dry and wet type of subgrade is mainly reflected by the consistency and water content. Fine grained soil, sand soil and gravel soil by atmospheric precipitation, surface water, groundwater, the influence of capillary water and other external factors, the dry and wet state happening great changes, including content varies with the seasons the periodic change and the stress state of pavement also presents periodic variation. At the same time, with the increase of water content, the increase of the subgrade humidity affect the connection status of the subgrade and the bottom base.

2. Dry and Wet Condition and Moisture content, Consistency

The wet and dry conditions of the subgrade are divided into 4 types according to the consistency: dry, medium wet, wet and over wet; The consistency of the soil is more accurate to represent the relationship between the various forms and the humidity of the soil. The consistency index combined the plastic properties of the soil, including the liquid limit and plastic limit, which fully reflects the hard and soft degree of the soil, and the physical concept is clear. Therefore, it is reasonable to use the consistency as an index to divide the dry and wet type of soil subgrade. In order to achieve the purpose of the study, the author chooses the different consistency of the roadbed to respond to different roadbed state. According to the highway (highway is located in the northwest soil loess, liquid limit and plastic limit was 32.4%, 15.6%) to see the area of natural zoning for dry wet type boundary consistency is 1.2 (dry state common lower bounds consistency). 1.12,0.96,0.81. The author chooses 5 representative consistency in the range of wet and dry type divided by 3 boundary

consistency to analyze, respectively, 1.4,1.2,1.0,0.9,0.75. Considering the consistency of the consistency and the recommended value of each natural division and wet type division, the control analysis was carried out at 5 levels: 8%, 11%, 14%, 17%, 20%.

3. Relationship between Subgrade Resilient Modulus and Water Content

According to the literature, the modulus of resilience of the subgrade and the moisture content of the subgrade are measured by the seasonal data, the modulus of elasticity of the subgrade is obtained, and the relationship between the water content and the time is as shown in Figure 1.

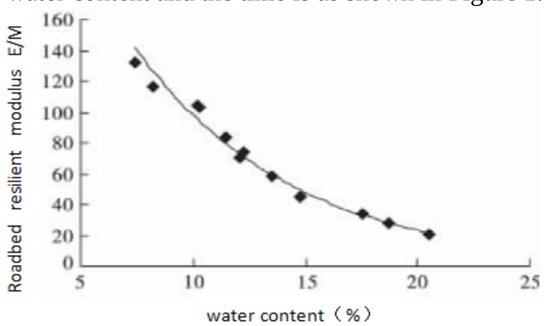

Figure 1. Relationship between moisture and resilient modulus of soil

From Figure 1 it can be found that with the water content increase of subgrade resilient modulus decreases, and reduction of the amplitude of very large, containing water from 10% to 25%, subgrade resilient modulus decreases nearly 9 / 10, it can be seen that with the effect of moisture content on the subgrade resilient modulus is very significant. It is proved that the design and construction of drainage system must be done in order to meet the use function of the project in the design and construction of subgrade and pavement.

4. The Establishment of the Model and the Selection of Parameters

The highway pavement structure is a typical semi-rigid base asphalt pavement in our country, and the related parameters of each layer are shown in Table 1. Using multilayer elastic system theory, the asphalt surface layer is divided into 3 layers, the upper, middle and lower 3 layers are selected as fine, medium and coarse grained asphalt concrete, cement stabilized crushed stone as the base, lime soil as the base.

Table 1. Parameters of pavement structure

Layer	Thickness h /cm	Modulus of resilience E/MPa	Poisson ratio
Fine grained asphalt concrete	4	1400	0.25
Medium grained asphalt concrete	6	1200	0.25
Coarse grained asphalt concrete	8	1000	0.25
Cement stabilized crushed stone base	20	1600	0.25
Lime soil base	30	600	0.35

5. Calculation Results and Analysis

The elastic physical theory is used to calculate the elastic modulus and the elastic modulus of the subgrade and the connection state between the layers. In addition to the roadbed and the bottom of the connection surface a as a variable, the rest of the layers in a completely continuous state that is a=0. According to the established model and selected parameters, a set of resilient modulus of different dry and wet conditions were selected, and the BISAR3 software was used to calculate.

5.1. The influence of the dry and wet condition on the pavement deflection

Pavement deflection is the vertical displacement of pavement structure under the action of load, and it is a comprehensive, comprehensive and apparent index. Deflection is the control index of asphalt pavement design, and the relationship between them is shown in Figure 2, Figure 3.

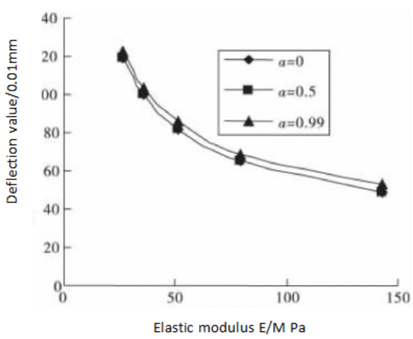

Figure 2. Relationship between pavement deflection and resilient modulus

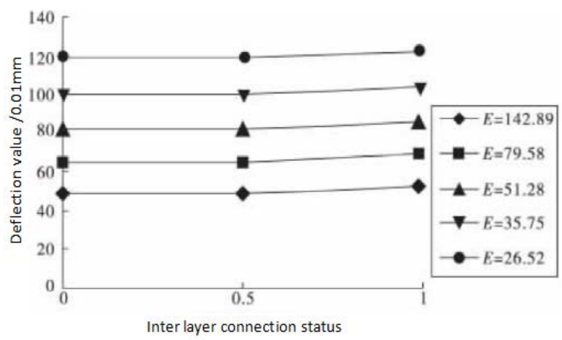

Figure 3. Relationship between pavement deflection and'a'

As can be seen from Figure 3, the overall trend of the 2 curves is that the road surface deflection decreases with the increase of the modulus of subgrade resilience, that is, the same trend of the different base level and the interlayer contact state. The elastic modulus is less than 50 MPa, the modulus of resilience of deflection effect is very obvious, in this section a 50%. When the resilient modulus of subgrade is greater than 50 MPa, the rebound deflection of pavement decreases, but it is more and more slow. That is to say, with the increase of the modulus of resilience, to a certain extent, the change of the modulus of subgrade resilience has no effect on the deflection of the road surface. According to figure 3 shows, trend curve tends to be gentle, except for a slight change in the sliding state completely and other basic invariant that in same subgrade resilient modulus under different interlayer contact state road surface deflection effect can be neglected.

5.2. The influence of the dry and wet condition on the radial stress

Radial stress is one of the important aspects in pavement mechanics. It is beneficial to understand the stress of pavement, and it is also the test condition of pavement design. According to the data, the positive stress varies with depth and the stress response of each layer is shown in Figure 4, Figure 5.

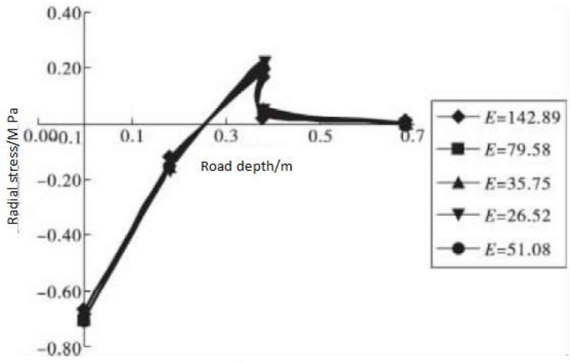

Figure 4. Relationship between normal stress and depth

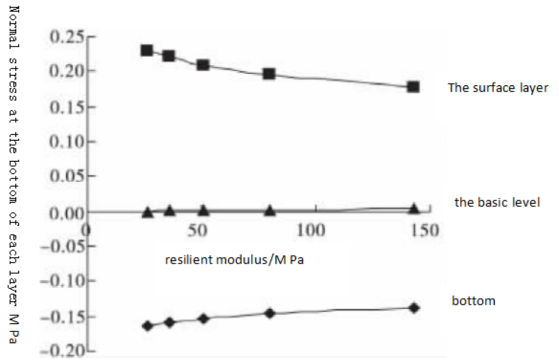

Figure 5. Relationship between normal stress and resilient modulus

From Figure 4, we can find that with the change of the depth, the positive stress also changes, 5 curves show the same trend, that is, the different subgrade resilient modulus, the positive stress change trend with the increase in depth is the same. Surface layer medium pressure stress and tensile stress are all exist, and become a certain change trend, from the surface to show the compressive stress gradually become tensile stress, the maximum tensile stress at the basic level, then pull stress decreases, until it tends to zero. It is proved that the bending tensile stress on the bottom of the pavement is the reliability of the design index in the pavement design. According to Figure 5, the bottom surface of the face layer is in a state of compression, the bottom of the base is in a state of tension, and the bottom of the base is also subjected to tensile stress.

In different subgrade resilient modulus, stress in each structure layer reflects different characteristics. Figure 5 shows that with the decrease of the modulus of subgrade resilience, the radial stress at the bottom of each layer increases, and the change is obvious after less than 35 MPa. In particular, the tensile stress at the bottom of the base, which increases with the decrease of the modulus of elasticity, is extremely detrimental to pavement design. Due to a certain depth, so the bottom of the bottom surface of the radial stress is very small, can be considered to have no effect.

6. Conclusions

The results of the comprehensive calculation and analysis are concluded:

(1) Different subgrade resilient modulus of the subgrade strength of different dry and wet conditions, the increase of water content makes the modulus of resilience decrease sharply, resulting in the sharp increase of the road surface deflection, which is not conducive to the long-term use of the road. So in the roadbed design and construction of the time, we must do a good job of drainage system.

(2) The connection between the bottom layer and the bottom layer of the subgrade has a significant impact on the positive strain, normal stress and shear stress of the present layer, but it has little effect on the other layers and other layers, which can be ignored.

(3) Subbase surface tensile stress with the reduction of subgrade resilient modulus increased and thus more likely to be ripping, does not change in the surface layer thickness, in the design should be appropriate to increase the subgrade stiffness, in order to ensure the service life of the pavement.

(4) Shear stress is usually the largest in the middle of the surface layer, but with the relative modulus of pavement and subgrade resilient modulus ratio increases, the maximum shear stress position to move down, and even to the basic level. The shear stress in the surface layer and the connection of the basic level has the phenomenon of sudden change, it is because the resilient modulus of the base is greater than the modulus of elasticity of the surface layer, and the modulus ratio is larger, and its mutation is obvious.

(5) Road surface deflection and bending tensile stress at the bottom of the base are very obvious with the change of subgrade resilient modulus. It is proved that these two indexes are scientific of pavement design index and other indicators such as shear stress.

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