The Mechanical Analysis of Cement Concrete Surface Layer With Load-transfer Bar for Joints Based on Computer

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Abstract. To establish a joint dowel bar and dowel bar set of cement concrete pavement structure in three dimensional finite element model, using the method of numerical analysis, analysis of the joint of cement concrete road surface of the load stress, deflection and deflection difference, to study the foundation modulus, dowel bar diameter on the load stress and the influence law of deflection is poor, and the condition of the same calculation results are analyzed in comparison. The results show that the principal stress, shear stress, deflection value and deflection difference decrease with the increase of the diameter of the rod. When the diameter of the transmission rod is greater than 35mm, the effect of increasing the diameter of the transmission rod on reducing the stress value at the calculated point in the cement concrete surface layer is not obvious. The calculated point load stress and deflection difference of cement concrete surface layer are obviously less than the calculated results when no load rod is installed in joints. When the foundation modulus is not greater than 800MPa, it is suggested to estimate the joint load transfer efficiency based on shear stress: when the foundation modulus is greater than 800MPa, it is suggested to estimate the joint load transfer efficiency based on the bending and sinking value or the principal stress[1-2].

Keywords: Road Engineering, Cement Concrete Surface, Dowel Bar, Seams, Shear Stress, Load Transfer Efficiency, Three-dimensional Finite Element, Numerical Analysis

1. Introduction

It has been proved in practice that joints are the weak parts of cement concrete surfaces and their load transfer capacity is the key factor affecting the service life of cement concrete pavement and the smoothness and comfort of driving. There are scholars using Timoshenko on elastic foundations. The upper bar bending formula analyzes the required diameter, length and spacing of the rod. The deflection ratio was first proposed by Huang Yangxian as an indicator for evaluating the load carrying capacity of joints Friberg, using Timoshenko's formula for further analysis, proposed to reduce the length, increase the diameter and reduce the spacing of the load carrying rods[3-6]. Dedicated to the dowel bar and joint design theory research, but at present China's highway design specification dowel bar and seams is mainly based on experience design, the size of dowel bar used depends on the
thickness, the analysis of the dowel bar set joint load transfer efficiency, though the most widely used is based on the criterion deflection and bending tensile stress load transfer efficiency. So whether the design of the dowel bar size should be increased with increase of thickness of surface layer, the design of the dowel bar size has great limit. When conditions change based on the measured deflection and bending tensile stress load transfer efficiency is objective and effective[7-10]. Therefore, this article uses more accord with the actual situation of 3 d model, dowel bar for the seam in the cement concrete pavement structure under load deflection difference, stress state and the joint load transfer efficiency is analyzed, in order to further improve the cement concrete pavement design method provides the theory basis.

Figure 1. Calculation model of joint strut - free cement concrete pavement structure.

2. Finite element model and calculation parameters

2.1. Finite element model
In this study, the pavement structure is regarded as a single slab in elastic foundation. The research object is composed of cement concrete surface layer with joints, joint force transmission rod and foundation, and a three-dimensional model is established. The cement concrete surface layer, the transmission rod and the foundation structure layer adopt the 8 node solid element, carries on the stress, the displacement analysis. In order to reflect the characteristics of the half-space foundation, the expanded size is adopted to simulate the joint model without force transmission rod, shows the model of torque rod for joints; The following assumptions are made for each structural layer: Each structural layer is a homogeneous, continuous and isotropic continuous elastomer; The vertical and horizontal displacements of each layer are continuous, and the vertical displacement of the top surface of the foundation is equal to the vertical displacement of the middle surface of the plate; The displacement of the foundation bottom is 0 in each direction, the lateral displacement of the foundation is 0 in the horizontal direction, and the four sides of the cement concrete panel are free; not the pavement structure of the weight; The transmission rod is a cantilever beam embedded in uniform elastic medium; 6. The width of the joint is 1 cm, and there is no load carrying capacity at the joint when there is no force carrying rod, and there is load carrying cacity at the joint when ce carrying rod is set.

2.2. Calculation of basic parameters
The basic calculation parameters are as follows: the length and width of the cement concrete panel are 5 m and 4.5 m respectively. After calculation error analysis of different dimensions of foundation, the dimensions of length, width and thickness of foundation are proposed to be 12.01mx6.5mx8m.

Without special instructions, the driving load is bZZ-100 with standard axle load, the tire pressure is 0.7mpa, the action range of single wheel pressure is 18.9cmx18.9cm, the contact area is 357.21cm2, the space between two wheels is 32cm, and the space between two wheels is 182cm. After calculation, analysis and comparison of different load positions, the partial load of wheel load on the joint side is the most unfavorable to the surface layer. The loading mode is shown in FIG. 4 and FIG. 5. Through comparative analysis of single and bilateral wheel loads at the joints, it is found that the unilateral
wheel loads on the symmetry axis have a greater adverse impact on the surface layer than the bilateral loads. The reason is that the anti-warped action of the other side of the bilateral loads cancels the partial stress values on the symmetry axis, so only the symmetry axis is considered in the calculation. Single side loading on. The symmetry of the loading position is used to take half of the model for calculation. In order to meet the requirements of calculation accuracy, mesh refinement is carried out for key parts, such as joints, force carriers and their adjacent surface layer structures, and appropriate mesh gradient is adopted from joints to distant boundary. Without special instructions are the calculation points of the stress value and bending value of the cement concrete surface layer, and point 3 is the calculation point of the stress value of the transmission rod. The main calculation parameters of each structure layer are shown in Table 1.

Table 1. The main calculation parameters.

| Items                  | Thickness or rod diameter | Modulus of elasticity | Poisson’s ratio |
|------------------------|---------------------------|-----------------------|-----------------|
| Cement concrete surface| 22-30                     | 30000                 | 0.15            |
| rod                    | 2.8-3.8                   | 200000                | 0.25            |
| foundation             | 50-1500                   | 50-1500               | 0.35            |

3. Stress analysis of cement concrete surface at joints

3.1. Load stress analysis of cement concrete surface layer when joints have no transmission rod

It can be seen from the calculation results in Table 2 and Table 3 that when the thickness of cement concrete surface layer is fixed, the principal stress, shear stress, bending and sinking value and bending and sinking difference of the calculation point decrease with the increase of foundation mold. When the foundation modulus is fixed, the principal stress, shear stress, deflection value and deflection difference of the calculation point decrease with the increase of the cement concrete surface thickness. The stress and flexural value at the calculation point 2 are obviously larger than that at the calculation point 1, indicating that the stress and flexural value at the joint near the loading side are larger, and the plate at the joint is obviously misaligned.

3.2. Load stress analysis of cement concrete surface layer when connecting rod is set

In the cement concrete surface layer where the joint is provided with the transmission rod, the factors affecting the load stress and deflection mainly include the thickness and modulus of the surface layer, foundation modulus, diameter, spacing and length of the transmission rod, etc. The influences of foundation modulus and rod diameter on load stress and flexural value are analyzed in detail below.

3.3. Influence of foundation modulus on load stress and deflection value

When the thickness of cement concrete surface layer is 24 cm and the diameter of the transmission rod is 28 mm and 32 mm, the 1 and g at the calculation point 2 in cement concrete surface layer change with the foundation modulus between 50 and 1500 MPa. See Figure 7 and figure 8 for the change. Calculation point of force rod in cement concrete surface layer: 1 and. With the change of foundation mold between 50 and 1500 MPa, see FIG. 9 and FIG. 10. The deflection difference of cement concrete surface varies with the modulus of foundation between 50 and 1500 MPa.it can be seen that and s at the calculation point 2 and the calculation point 3 of the transmission rod in the cement concrete surface layer decrease with the increase of the modulus of foundation. With the increase of > modulus of foundation. The decrease amplitude of principal stress is larger than that of shear stress, which indicates that the increase of foundation modulus has obvious effect on reducing principal C stress at the calculated point in cement concrete surface layer. In FIG. 11, the deflection difference of calculated points within the cement concrete surface decreases with the increase of foundation modulus.
4. Conclusion
The load stress analysis of the cement concrete surface layer when the joint is set with the transmission rod shows that when the thickness of the cement concrete surface layer and the modulus of foundation are certain, the principal stress, shear stress, bending and sinking value and bending and sinking difference of the calculation point decrease with the increase of the diameter of the transmission rod; When the thickness of the cement concrete surface layer and the diameter of the transmission rod are 1 -, the principal stress, shear stress, deflection value and deflection difference at the calculation point decrease with the increase of the foundation modulus. Set dowel bar in the joint of cement concrete pavement, subgrade modulus on analysis shows that the influence of load stress and deflection with the increase of subgrade modulus, the lower margin of principal stress is greater than the shear stress reduction, indicates that the increase of subgrade modulus to reduce calculation point in the cement concrete pavement of the principal stress effect is obvious. The analysis of the influence of the diameter of the transmission rod on the load stress and flexural subsidence shows that with the increase of the diameter of the transmission rod, the reduction amplitude of shear stress is greater than that of the main stress.

The results show that the load transfer rod at the joints bears great shear stress and effectively transfers the load to the adjacent plates, thus reducing the shear stress at the calculated point in the cement concrete surface layer. When the diameter of the transmission rod is no more than 35mm, with the increase of the diameter of the transmission rod, the reduction amplitude of shear stress is greater than that of the main stress, indicating that the increase of the diameter of the transmission rod has an obvious effect on reducing the shear stress at the calculated point in the cement concrete surface layer. However, when the diameter of the rod is greater than 35mm, the values of principal stress and shear stress increase with the increase of the diameter of the rod, indicating that the effect of load transfer is no longer obvious.

Joint and dowel bar set cement concrete pavement load stress and deflection difference comparative analysis show that the seam when setting dowel bar cement concrete pavement calculated point load stress and deflection difference significantly less than the seam no dowel bar when the corresponding calculation results, dowel bar indicates that the joint can make the load transfer to the adjacent plate, joint board fault effect significantly reduced.

A load transfer efficiency (K3) based on shear stress, namely the ratio of the value of shear stress of the unloaded plate to the value of shear stress of the loaded plate, is proposed to analyze the load transfer efficiency of joints. The analysis shows that when the modulus of foundation is no more than 800MPa, the displacement based analysis results overestimate the load transfer efficiency, while the flexural stress based analysis results underestimate the load transfer efficiency. Therefore, it is recommended to use shear stress-based load transfer efficiency (K3) to estimate load transfer efficiency. When the foundation modulus is close to and greater than 800 MPa, when two curves representing K2 and K3 intersect, KZ tends to increase and approach K1, while K3 tends to decrease. When the foundation modulus reaches.

When it comes to 1,500 MPa, the order of the three is K3 zk1, and K2 and K. The results are relatively close. Under such conditions, it is recommended to use K1 or K2 to estimate the joint load transfer efficiency.

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