Load Stress Analysis of White-to-Black Pavement

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Abstract: Old cement concrete pavement modified with asphalt surface, with its cost-effectiveness, is widely used in road upgrading project. This paper selects the typical "white to black" road reconstruction project, and uses a conventional pavement design software Southeastern University asphalt concrete pavement design system HPDS, to analysis and calculate the impact on the load stress of the thickness of asphalt overlay, the old concrete elastic modulus, equivalent modulus of elasticity of the original road base and the stress reduction factor of the joint of the old concrete face. At last, Concluding variation provide a theoretical basis for the "white to black" pavement design and construction.

Keywords: Concrete pavement; Paving asphalt surface; Largest integrated load stress; Elastic modulus

1. Introduction

White cement concrete pavement with its load bearing ability, good durability, low technical requirements, and occupy a dominant position in the early in road construction. But over time, the disadvantages of cement concrete pavement ,including poor driving comfort, Loud noise, long maintenance and repair time, it can't meet the need of the times[1]. At present, the total mileage of cement concrete pavement in China has exceeded 10 million kilometers (data do not yet contain a large number of low grade road), and most of them have entered into the maintenance phase of reconstruction. White cement concrete pavement in urgent need by rebuilding, replacement for superior black asphalt pavement. And most cost effective way is based on the treatment of old cement concrete pavement and asphalt pavement.

The actual operation method : according to the use requirements and the comprehensive evaluation results of the old concrete pavement (mainly based on "highway cement concrete pavement maintenance code"), select the program of overlay. When the overlay, after targeted treatment of old cement concrete pavement, pavement is not less than 80mm (expressways and arterial roads is not less than 100mm) of asphalt concrete surface layer[2].

According to the characteristics of the surface layer of asphalt concrete pavement on old cement concrete overlay, in the computational analysis, we think asphalt concrete surface layer is regarded as the new pavement, and the old cement concrete pavement and the following structure layer regarded as roadbed. We use a conventional pavement design software Southeastern University asphalt concrete pavement design system HPDS, to analysis and calculate the impact on the load stress of t-he thickness of asphalt overlay, the old concrete elastic modulus, equivalent modulus of elasticity of the original

road base and the stress reduction factor of the joint of the old concrete face. At last, Concluding variation provide a theoretical basis for the "white to black" pavement design and construction.

2. Calculation Conditions and Related Data of the Old Concrete Overlay

As a true reflection of the old concrete paving asphalt concrete renovation engineering characteristics, this paper selects the typical model: Road Reconstruction, in secondary road, is located in the natural division of highway China IV, and the surface layer temperature gradient is chosen as 89 DEG /m. The original design of concrete pavement design reference period of 20 years, has been used for 10 years, the design lane design axle load cumulative effect is 100000 times the number of the remaining design reference period. The design axle load Chinese specification 100kN, under overloading, the heavy axle load is 200kN. The material properties, as the Table 1 below:

Table 1. Material property parameter

Physical property name	parameter	Physical property name	parameter
Linear expansion coefficient of concrete	1.0×10^{-5}/℃	Thickness of old concrete surface layer	260mm
Linear expansion coefficient of concrete	5m	Flexural tensile strength of old concrete	4.5MPa
Linear expansion coefficient of concrete	29000MPa	Fatigue index of old concrete materials	0.057
Linear expansion coefficient of concrete	0.87		

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International Journal of Intelligent Information and Management Science
ISSN: 2307-0692, Volume 5, Issue 4, August 2016

When old concrete paving asphalt concrete, critical load in concrete slabs in the edge of middle, in the design of axial load and the heavy axle load, we need to check the comprehensive load whether stress sigma synthesis is less than or equal to old concrete flexural tensile strength[3].

3. Effect of Different Variables on the Comprehensive Stress of Old Concrete Layer

On the basis of the above parameters, according to the arithmetic incremental changing Corresponding variables, we calculate the corresponding load stress value, which includes the design load and the heavy load of two groups corresponding to the old concrete maximum comprehensive load stress value, and by the group of data interpolation spline curve and summarize the regularity.

3.1. The thickness of asphalt overlay on old concrete layer effects of combined stress

Code for design of cement concrete pavement in China, limits the minimum thickness of asphalt overlay on the highway, and provides details of the calculation. When calculating the old concrete surface layer of stress with the asphalt concrete overlay, based on the old concrete surface layer of stress to meet code requirements, to determine the thickness of asphalt concrete overlay on design. Rational design of the thickness of the overlay related to engineering quality of and rebuilt the level of cost.

By the data of spline curve in Figure 1, we can know: with paving layer thickness increase, old cement concrete slasb of the maximum stress decreased significantly. Asphalt overlay is thicker, the initial cost will lead to a significant increase. However, due to the lower plate stress is less, after the transformation of the road maintenance fees and user fees will decrease accordingly. So we need to trade-off considerations to meet the specification of paving thickness.
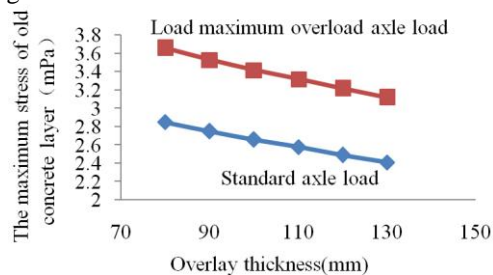

Figure 1. Overlay thickness&the maximum stress of old concrete layer

3.2. Effect of each layer modulus of the original road of old concrete layer stress

The original road each layer rebound modulus can comprehensively reflect the foundation, it is an important design parameter of the code for design of cement concrete pavement in asphalt overlay layer design provisions. According to the value of the modulus of resilience, we can determine the extent of the damage and to determine the original pavement treatment scheme[4].

1) Effect of elastic modulus of old concrete on the composite stress of old concrete layer

The elastic modulus of the old concrete slab is influenced by many factors, including the size of the original concrete elastic modulus, the degree of carbonation of concrete, the degree of freeze-thaw damage, the temperature stress, and the damage degree of the original load and so on. Old concrete slab of elastic modulus can be used for characterization of concrete residual performance after a period of time in use. Paving asphalt surface layer, concrete slab become base of asphalt layer, and directly affected by vehicle load surface layer to transfer of load from the grassroots, stress distribution corresponding changes[5] . The elastic modulus of old concrete & the maximum comprehensive stress of old concrete layer is shown as Figure 2.
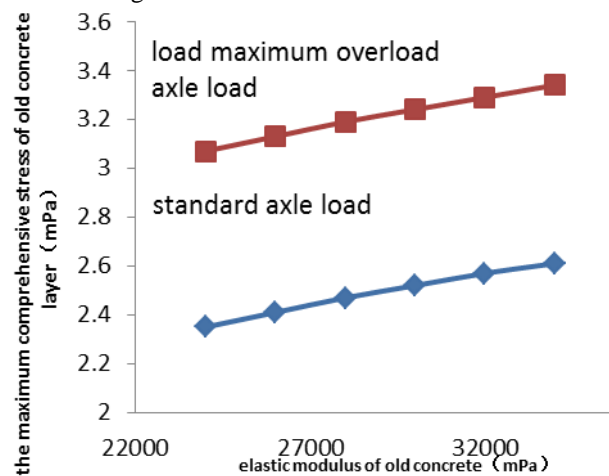

Figure 2. The elastic modulus of old concrete & the maximum comprehensive stress of old concrete layer

The old concrete elastic modulus grows in grade, but the elastic modulus of asphalt do not change. the number of E (concrete) /E (asphalt) increases, and the maximum stress of concrete slab increases. when The strength of concrete is large, it can be allocated more stress. In the design, the ratio of elastic modulus of cement concrete and asphalt concrete should not be too large.

2) The effect of equivalent modulus of elasticity of the original road base on the comprehensive stress of the old concrete layer

The original road base top surface equivalent modulus can synthetically reflect the state of original subgrade base, cushion, including the ability to resistance to vertical deformation, internal moisture content and internal

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International Journal of Intelligent Information and Management Science
ISSN: 2307-0692, Volume 5, Issue 4, August 2016

packing whether voids. Therefore, it is important parameters of the reconstruction engineering of. If the elastic modulus is too small, it is necessary to fill in the inner base layer and the cushion layer[6].

From Figure 3, we know :after the original road base top surface equivalent modulus grown, concrete slab of the maximum stress decreases. When the subbase state is good, the old concrete slab is subjected to the maximum stress reduced accordingly, and it is good for the durability of the concrete slab. But by the data in Figure 3, when the subgrade resilient modulus increases 60MPa but old concrete slab maximum comprehensive stress corresponding declines only about 0.25MPa. And for foundation treatment, on the top of the basic equivalent rebound modulus increase 60MPa is extremely difficult, costing too high, it is not desirable.
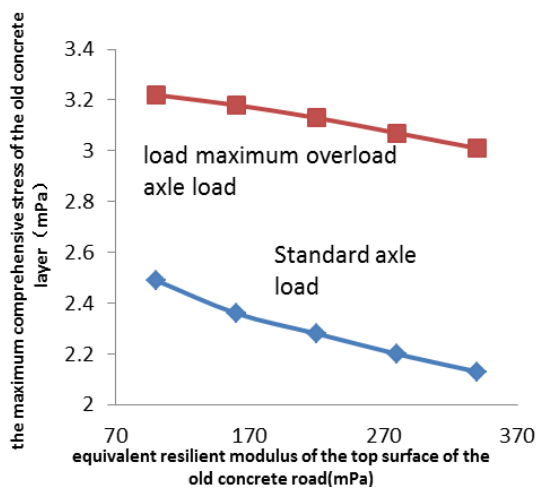

Figure 3. Equivalent resilient modulus of the top surface of the old concrete road & the maximum comprehensive stress of the old concrete layer

3.3. The influence of the joint state of the existing concrete pavement on the comprehensive stress of the old concrete layer

The concrete surface layer of the actual concrete reconstruction project is often damaged in different degrees, and the problems such as cracks, broken plates, aggregate shedding, and the failure of the joints between the concrete and concrete surface layer [7]. In this regard, "cement concrete pavement design code" orders that we must solve such problems, before paving the asphalt concrete surface layer,. In this paper, using the old concrete face layer joint stress reduction factor, in the HPDS software, represent such a phenomenon.

1) Effect of stress reduction coefficient on the composite stress of old concrete layer

In "code for design of cement concrete pavement", we need to consider the stress reduction factor of joints when calculating the load fatigue stress at the critical load of the plate. Under normal circumstances, when the longi-

tudinal seam design rod sewing or Concrete shoulder, strength reduction coefficient selects 0.87-0.92; when the longitudinal seam is not pull rod sewing or flexible shoulder, strength reduction coefficient selects 1. Using the longitudinal seam from rod to not pull rod , its capacity of transfer load to the surrounding decreases. For the sake of knowing the relationship trend between reduction coefficient of joint shall strength and the composite stress of concrete layer, we think strength reduction coefficient selects between 0.87 and 1. The stress reduction factor of the joint of the old concrete face layer & the maximum comprehensive stress of the old concrete layer is shown as Figure 4.
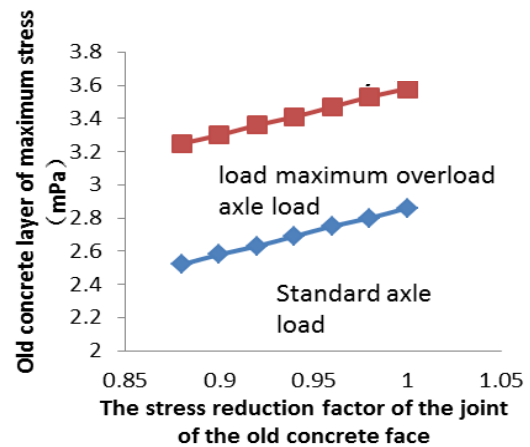

Figure 4. The stress reduction factor of the joint of the old concrete face layer & the maximum comprehensive stress of the old concrete layer

Old concrete layer of maximum stress and facing joint stress is proportional to the reduction coefficient. Joints in concrete's ability to transfer loads to reduce joint stress reduction coefficient of surface, resulting in the maximum combined stress on the old concrete slab. As engineering introduced, this road has been using 10 years, in actual situation , concrete has appeared broken board, its State has not meet specification conditions, on forced parts, it's difficult to pass load contains, and stress concentrated phenomenon more serious [8], integrated stress in concrete Board also is more than maximum integrated stress in Figure 4.

4. Epilogue

In "white to black" engineering design, selection should focus primarily on the thickness of the surface layer of asphalt overlay. The overlay thickness increasing with significantly reduced the old concrete slabs largest integrated stress can greatly extend the life of the concrete slab, reducing ongoing maintenance cost.

Under the same other conditions, the asphalt material is fixed, the old concrete slabs largest integrated stress is proportional to the modulus of elasticity of the old con-

crete, road base and the top surface of the original is inversely proportional to the equivalent resilient modulus, but it does not have significant influence, if you want to by changing the resilient modulus, concrete slab to reduce the stress load, often uneconomical.

Under other conditions the same, the old concrete layer maximum combined stresses significantly increases with the old concrete pavement joint stress reduction factor, reconstruction, we should focus on breaking the old concrete slab joints, cracks and other treatment.

The above figure 4 two spline curves, design load and two heaviest loads corresponding to the maximum combined loading stress the old concrete, apparent under overload conditions, the old concrete slabs comprehensive stress is much larger than the normal maximum axle load integrated under stress, under conditions unfavorable combination of circumstances, which are close to the value of bending tensile stress concrete ultimate flexural tensile stress, easily destroying the road at once.

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