SUBGRADE STRESS COMPONENT CALCULATION UNDER FULL-LOAD

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Abstract: Highway subgrade often damage when put into operation for a period of time, part of the reason from overloading. This paper employ semi inverse method to calculate subgrade stress component under full-load, taking a road as an example, subgrade stress component obtain, verifying the correctness of the formula.

Keywords: Road Subgrade; Stress Component; Semi Inverse Method; Full-load

1. Introduction

Expressway construction in china, nearly 30 years of development history, originated in the 80's of the last century which has a total mileage of highway number up to 100,000 kilometers[1], and the results are remarkable. Nevertheless , every year , the cost for the highway maintenance not at minority but also with a frequent maintenance. The reason for this is of course in many aspects because of the construction area also has the reason of the external environment. The external environment can be a highway operation environment and loading environment. There are many research achievements , at home and abroad , put it in different environmental conditions of pavement bearing performance research published, for instance , Lv Huiqing introduced in the system of elastic foundation plate, cement concrete pavement structure layered elastic system and other mechanical model, summarizes the mechanical properties of cement concrete pavement, and points out that future development trend in this research field [2]; Xie Jun, Guo Zhongyin, using the finite element method to 6 different grades of non-uniform distribution of 8 kinds of pavement structure under the loads do mechanics analysis, the results show that the surface layer is a layer of pavement structure layer system in force of the most disadvantaged, related conclusions can provide theoretical basis for as a design index of asphalt pavement under heavy load and carry out[3];The mechanical properties of the typical structure of Zhang Huiyu selected 2 kinds of pavement on semi-rigid asphalt pavement and flexible base pavement under overload action, think of flexible pavement need special consideration of in case of overload[4]; Hu Xiaodi thought to produce a running vehicle on road load is non uniformly distributed, and on different models load and different load distribution of pavement mechanical response analyzed by using three dimensional finite element method[5]; Zhang Hao studied under the dynamic load of the structure of Asphalt Pavement Stress and deflection value change rule, points out that the dynamic load and static load on the mechanics performance of asphalt pavement has different effect [6].

In spite of this situation, there are few achievements about the road subgrade full load stress component research both in the domestic and foreign. This paper uses the method of elasticity mechanics calculating subgrade load under the internal stress of each component, and provide a reference for scientific evaluation of subgrade life.

2. Full-load of Roadbed Modeling Situation

"Full-load", as the name implies, roadbed throughout a wide range load, this paper for the formula is convenient, load is assumed to be uniform analysis model of form, as shown in Figure 1.

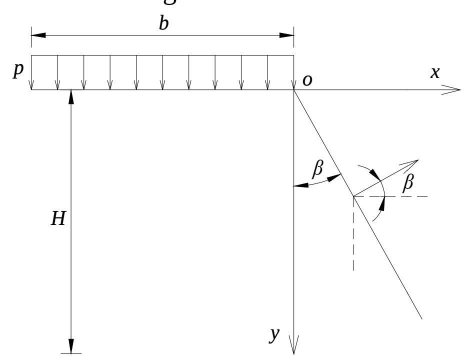

Figure 1. Subgrade model under full-load

In the figure, P are the load acting on the subgrade (kPa); B are the width of roadbed (m); H are the subgrade height (m); β is on both sides of the subgrade slope angle ( ).

3. The Solution for the Inside of Subgrade Stress Component

ISSN: 2307-0692 Volume 4, Issue 2, April 2015

As the Figure 1 put it, the subgrade model, by using the elasticity of the semi inverse method, the assumed stress component has the formula (1) form[7].

$$s_y = \frac{\partial^2 \Phi}{\partial x^2} = xf(y) \quad (1)$$

integral to both ends :

$$\Phi = \frac{1}{6}x^3 f(y) + xf_1(y) + f_2(y) \quad (2)$$

The stress function for solving the problems of elastic mechanics should satisfy the compatibility equation, thus there will be an equation (3)

$$\frac{1}{6}\frac{d^4 f(y)}{dy^4}x^3 + [2\frac{d^2 f(y)}{dy^2} + \frac{d^4 f_1(y)}{dy^4}]x + \frac{d^4 f_2(y)}{dy^4} = 0 \quad (3)$$

This is a x on the three time equation, requirements for all x values are set up, it's visibly that the coefficient of equation must be equal to zero and both to the free item, so that equation (4), (5) and (6) are established.

$$f(y) = Ay^3 + By^2 + Cy + D \quad (4)$$

$$f_2(y) = Ey^3 + Fy^2 \quad (5)$$

$$2\frac{d^2 f(y)}{dy^2} + \frac{d^4 f_1(y)}{dy^4} = 0 \quad (6)$$

Take the formula (4) into equation (6) and points:

$$f_1(y) = -\frac{1}{10}Ay^5 - \frac{1}{6}By^4 + \frac{1}{6}Gy^3 + \frac{1}{2}Hy^2 + Iy \quad (7)$$

Take the formula (4),(5)and (7) into formula (2) deriving a stress function:

$$\Phi = \frac{1}{6}x^3(Ay^3 + By^2 + Cy + D) + x(-\frac{1}{10}Ay^5 - \frac{1}{6}By^4 + \frac{1}{6}Gy^3 + \frac{1}{2}Hy^2 + Iy) + Ey^3 + Fy^2 \quad (8)$$

Solving the stress components:

$$s_x = \frac{\partial^2 \Phi}{\partial y^2} - f_x x = \frac{1}{6}x^3(6Ay + 2B) + x(-2Ay^3 - 2By^2 + Gy + H) + 6Ey + 2F \quad (9)$$

$$s_y = \frac{\partial^2 \Phi}{\partial x^2} - f_y y = x(Ay^3 + By^2 + Cy + D) - gy \quad (10)$$

$$t_{xy} = -\frac{\partial^2 \Phi}{\partial x \partial y} = -\frac{1}{2}x^2(3Ay^2 + 2By + C) + \frac{1}{2}Ay^4 + \frac{2}{3}By^3 - \frac{1}{2}Gy^2 - Hy - I \quad (11)$$

Given the form of the stress component needs to satisfy the stress boundary condition, and according to the stress boundary condition equation of column type (9) ~ (11) to calculating the unknown quantity.

$$\left.\begin{aligned} &A = 0,\ B = 0,\ C = 0,\ D = \frac{2P}{b} \\ &E = \frac{1}{3}\tan^2 b(\frac{2P}{b}\tan b - g),\ F = 0,\ G = 0 \\ &H = -\frac{2P}{b}\tan^2 b + g\tan b,\ I = 0 \end{aligned}\right\} \quad (12)$$

Take all above of these coefficients to the stress component expressions of (9) ~ (11), then:

$$s_x = x(g - \frac{2P}{b}\tan b)\tan b + 2\tan^2 b(\frac{2P}{b}\tan b - g)y \quad (13)$$

$$s_y = \frac{2P}{b}x - gy \quad (14)$$

$$t_{xy} = (\frac{2P}{b}\tan^2 b - g\tan b)y \quad (15)$$

At this point ,the internal road subgrade under full load stress component is solved, the above analysis of all kinds of set the same level of X subgrade section normal stress changes linearly, y normal stress increases linearly, the transverse shear stress are the same.

4. Example Analysis

The highway roadbed from Guizhou Daozheng to Xinzhai has height H=6m,width b=10m, both sides of the subgrade slope rate are 1:1.5, the Subgrade cohesive force c=32KPa,the Angle of internal friction φ=25, The bulk density of roadbed γ=21kN/m3, A fully loaded Subgrade P=1MPa.

Take the above data into the type of (13)~(15) :

$$s_x = -418.5x + 1255.5y$$

$$s_y = 200x - 21y$$

$$t_{xy} = 418.5y$$

5. Conclusion

The subgrade failure of highway often due to upper loaded, in this paper, by using the the method of semi inverse in elasticity solve the Subgrade under internal load analytical expressions of stress components, and taking Guizhou Daozheng to Xinzhai expressway as an example to calculating the interior of the highway roadbed full load stress component, finally verified the formula from this paper.

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