A Generalized Mathematical Model for the Fracture Problem of the Suspended Highway

Ying Zhao and Ming Lu

Hebei University of Engineering, Handan, China

First author: Zhao Ying E-mail: 364408161@qq.com

Second author: Lu Ming E-mail: 469331499@qq.com

Abstract. In order to answer dangling fracture problems of highway, the suspended pavement equivalent for non - suspended pavement, through the special boundary conditions has been suspended highway stress field of expression, in accordance with the 3D fracture model of crack formation, and establish a vacant, a general mathematics model for fracture problems of highway and analysis in highway suspended segment weight and vehicle load limit of highway capacity of Pu For overturning road inPu is less than the force of carrying more than compared to the work and fruit Bridge Hydropower Station Road engineering examples to verify suspended highway should force field expressions for the correctness and applicability. The results show that: when the hanging ratio R 0.243177 limits of Pu design axle load 100kN. When the vertical crack in the vacant in the direction of length greater than 0.1, the ultimate bearing capacity is less than the design axle load 100kN; when the hanging ratio R is less than 0.5, the road to local fracture, the ultimate bearing capacity of suspended stress field expressions in solution; when the hanging ratio is greater than or equal to 0.5, the road does not reach the limit bearing capacity of the whole body; torque shear surface of the effect is far less than the bending moments on shear planes.

Keywords. Road engineering, fracture mechanics, generalized integral model, stress field expression.

1 Introduction

The problem of fracture and damage of suspended highway is related to the safety of driving and the progress of construction. It is a common concern of hydraulic engineering, road engineering and civil engineering field [1, 2]. Due to the coupling effect of the complex stress factor and the development effect of the crack port, it has brought many difficulties [3] to the research work.

In view of this, the domestic and foreign scholars have conducted a lot of research on the problem of the fracture and failure of the suspended highway. J L [4] based on the finite element theory to generalized the finite size of the plate with a crack and to obtain the numerical solution of the weight function, finally chalk up the stress intensity factor. Ozer H [5] based of experiment exploring the concrete pavement fracture mechanism under the action of stress in low, found that the transition layer between the surface layer and the base is the root cause of fracture, but Ozer H found that the transition layer and the classic smooth contact hypothesis conflict. X Chen [6] using the Fourier transform to convert the load on the suspended part of the highway pavement into the positive half wave load and then obtained the analytical expression of the deflection and the analytical expression of the stress. Li Chuang [7] Using the idea of semi analytical and

generalized mathematical integral to solve water conservancy engineering problems, B Hill [8] and others based on Li Chuang's idea obtained the fatigue crack growth rate model . J Hebel [9] and others based on the finite element simulation method to explore the role of brittle materials under the load of the role of their own fracture damage and the degree of damage to the mathematical relationship with the load.

However, the literature is the use of westergarrd formula of boundary conditions, Seidl S [10] found that the popular westergarrd formula of boundary conditions is not suitable for the suspended highway fracture problem we should explore the new boundary conditions to answer problems of suspended highway. T P [11] Corrales and others found that the analytical method is more accurate than the numerical method, which can reflect the mathematical relationship between the crack and the fracture damage more directly and effectively. In view of this, this article from the Huaneng Lancang River Commission Ministry Gongguo bridge project, aiming at Gongguoqiao highway fracture cases used the classical Winkler foundation hypothesis, special boundary conditions, semi analytical solution and generalized integral mathematical model, studying on stress field distribution of suspended highway concrete, fracturing condition for suspended concrete ultimate load and the corresponding state , in order to provide reference for engineering project.

2 Derivation of stress field

Fig.1. Top view (left) and left view (right) of the model of highway suspension.

Figure 1 shows the suspended highway model, P1 to P8 for the eight vertices of the suspended part. And the prescribed parameters b and R

$$b=b_1+b_2 \tag{1}$$

Among them, b is the overall width of the highway pavement, b1 is the width of the non suspended part of the concrete road pavement, b2 is the width of the suspended part of the concrete road pavement.

$$R=\frac{A_{sus}}{A} \tag{2}$$

Among them, R is the suspension ratio, A is the total volume of the concrete highway pavement, Asus is the volume of the suspended part of the concrete road pavement. Figure1, in the mechanics studies literature was said elastic foundation, and highway engineering prefer subgrade pavement, in order to facilitate the presentation, do not distinguish between subgrade and roadbed, pavement and patch panels nor area in this paper.

Fig.2. Pavement Stress Condition.

Figure 2 shows the stress situation of the suspended highway model, W_1 is the dead weight of the suspended road surface, M_{W1} is the moment of the dead weight of the suspended road ,generated in the $P_8 P_5 P_6 P_7$ section (shear surface), q for the gravity equivalent uniform load. So

$$W_1 = lb_2 h \gamma \tag{3}$$

$$q = \frac{W_1}{l} = b_2 h \gamma \tag{4}$$

$$M_{W1} = \frac{W_1 b_2}{2} = \frac{1}{2} l b_2^2 h \gamma \tag{5}$$

Among them, the γ is the gradation of concrete.

Fig.3. Traffic load condition.

In the same way, assuming that the vehicle load is Q , b_3 is the distance from the $P_8 P_5 P_6 P_7$ section (the shear surface), and the M_Q is the moment of the driving load, and T_Q is the torque generated by the driving load.

$$M_Q = Q b_3 \tag{6}$$

$$T_Q = \frac{1}{2} Q l \tag{7}$$

In the $\overrightarrow{P_8 P_9}$ direction is the positive direction of axis Y, in the $\overrightarrow{P_7 P_8}$ direction is the positive direction of axis X, in the $\overrightarrow{P_5 P_8}$ direction is the positive direction of axis X. Section $P_8 P_5 P_6 P_7$ to coordinate origin coordinate system.

Because the Winkler elastic curved surface deflection equation can be expressed as:

$$D_g \nabla^4 \omega(x, y) + k \omega(x, y) = q(x, y) \tag{8}$$

Among them, $\omega(x, y)$ for the pavement deflection; $q(x, y)$ for the uniform load; k for the foundation reaction modulus; D_g for the pavement bending stiffness, the expression for the:

$$D_g = \frac{E h^3}{12(1 - \mu^2)} \tag{9}$$

Among them, E is young's modulus; μ is Poisson's ratio. Type (8) is equivalent to the general solution of homogeneous equation:

$$\nabla^4 \omega(x, y) + \frac{k}{D_g} \omega(x, y) = 0 \tag{10}$$

On type decomposition:

$$\omega = \omega_1 + \omega_2 \quad (11)$$

Where ω_1 is deflections of the unit plate parallel to the Y direction, but has nothing to do with X; ω_2 is the actual deformation of the plate which is related to X and Y, the type can be substituted into the equation 8. Available

$$\begin{aligned} \omega_1 = & e^{\frac{-y}{\sqrt{2}l}} \left(A \cos \frac{y}{\sqrt{2}l} + B \sin \frac{y}{\sqrt{2}l} \right) \\ & + e^{\frac{-y}{\sqrt{2}l}} \left(C \cos \frac{y}{\sqrt{2}l} + D \sin \frac{y}{\sqrt{2}l} \right) \end{aligned} \quad (12)$$

Among them, A, B, C, D is the undetermined coefficients, according to the boundary conditions:

$$\omega_1|_{y=b_1} = 0 \quad (13)$$

$$M_y = -D_g \left(\frac{\partial^2 \omega}{\partial y^2} + \frac{\partial^2 \omega}{\partial x^2} \right) \quad (14)$$

$$F_{sy} = -D_g \frac{\partial}{\partial y} \nabla^2 \omega \quad (15)$$

Among them, M_y is bending moment perpendicular to the Y axis, F_{sy} is shear force perpendicular to the Y axis, simultaneous formula (12), type (13), type (14), type (15) can get undetermined coefficient A, B, C, D

$$\begin{aligned} A = & -\eta_1 + \eta_2 - \frac{\eta_2 \lambda_1}{-\lambda_2 + 2\lambda_3 + \lambda_4} \\ & + \left(1 + \eta_2 \lambda + \frac{\lambda_1 + 2\lambda_2 + \lambda_3 + 2\lambda_4}{-\lambda_2 + 2\lambda_3 + \lambda_4} \right) \end{aligned} \quad (16)$$

$$Q_1 = \frac{\eta_2 \lambda_1 (2\lambda_1 - \lambda_2 + \lambda_3)}{(-2\lambda_1 + \lambda_2 + \lambda_4)(-\lambda_2 + 2\lambda_3 + \lambda_4) - (\lambda_1 + 2\lambda_2 + \lambda_3 + 2\lambda_4)(2\lambda_1 - \lambda_2 + \lambda_3)} \quad (17)$$

$$B = \eta_1 - \frac{\eta_2 \lambda_1 (2\lambda_1 - \lambda_2 + \lambda_3)}{(-2\lambda_1 + \lambda_2 + \lambda_4)(-\lambda_2 + 2\lambda_3 + \lambda_4) - (\lambda_1 + 2\lambda_2 + \lambda_3 + 2\lambda_4)(2\lambda_1 - \lambda_2 + \lambda_3)} \quad (18)$$

$$C = -\frac{\eta_2 \lambda_1}{-\lambda_2 + 2\lambda_3 + \lambda_4} + \frac{\eta_2 \lambda_1 (2\lambda_1 - \lambda_2 + \lambda_3)(\lambda_1 + 2\lambda_2 + \lambda_3 + 2\lambda_4)}{(-2\lambda_1 + \lambda_2 + \lambda_4)(-\lambda_2 + 2\lambda_3 + \lambda_4) - (\lambda_1 + 2\lambda_2 + \lambda_3 + 2\lambda_4)(2\lambda_1 - \lambda_2 + \lambda_3)} \quad (19)$$

$$D = \frac{-\eta_2 \lambda_1 (2\lambda_1 - \lambda_2 + \lambda_3)}{(-2\lambda_1 + \lambda_2 + \lambda_4)(-\lambda_2 + 2\lambda_3 + \lambda_4) - (\lambda_1 + 2\lambda_2 + \lambda_3 + 2\lambda_4)(2\lambda_1 - \lambda_2 + \lambda_3)} \quad (20)$$

$$\lambda_1 = e^{\frac{-y}{\sqrt{2}l}} \cos \frac{y}{\sqrt{2}l} \quad (21)$$

$$\lambda_2 = e^{\frac{-y}{\sqrt{2}l}} \sin \frac{y}{\sqrt{2}l} \quad (22)$$

$$\lambda_3 = e^{\frac{-y}{\sqrt{2}l}} \cos \frac{y}{\sqrt{2}l} \quad (23)$$

$$\lambda_4 = e^{\frac{-y}{\sqrt{2l}}} \sin \frac{y}{\sqrt{2l}} \quad (24)$$

$$\eta_1 = \frac{(M_{w_1} + M_Q)l^2}{D_g} \quad (25)$$

$$\eta_1 = \frac{(Q + W_1)l^2}{D_g} \quad (26)$$

By substitution type 12 from type 16 to type 26, get ω_1 . Suppose:

$$\omega_2 = \sum_{m=2}^{+\infty} Y_m \cos \frac{m\pi}{\alpha} x \quad (27)$$

Among them, Y_m is strange function, and α is the spacing of Q. The type (27) substitution into the equation (12), available:

$$Y_m^{(4)} - 2Y_m'' \left(\frac{m\pi}{\alpha} \right)^2 + Y_m \left[\left(\frac{m\pi}{\alpha} \right)^4 + \frac{k}{D_g} \right] = 0 \quad (28)$$

Because

$$M_{yx} = M_{xy} = -D_g (1 - \mu) \frac{\partial^2 \omega}{\partial x \partial y} \quad (29)$$

$$M_{yx} \Big|_{y=0} = Q \quad (30)$$

M_{xy} and M_{yx} is torque. The type (27), (28), (29), (30) substitution into the type (12), combined with Y_m is an odd function of this information, took the first item of the infinite series, available:

$$\begin{aligned} \omega = & e^{\frac{-y}{\sqrt{2l}}} \left(A \cos \frac{y}{\sqrt{2l}} + B \sin \frac{y}{\sqrt{2l}} \right) + e^{\frac{-y}{\sqrt{2l}}} \left(C \cos \frac{y}{\sqrt{2l}} + D \sin \frac{y}{\sqrt{2l}} \right) \\ & + \frac{\alpha T_Q \cos \frac{m\pi}{\alpha} x \sin \gamma_m y (e^{\beta_m y} + e^{-\beta_m y})}{4\pi D_g (1 - \mu) \gamma_m \sin \frac{m\pi}{\alpha}} \end{aligned} \quad (31)$$

Among

$$m = 2 \quad (32)$$

$$\gamma_m = \sqrt{\frac{\left(\frac{m\pi}{\alpha} \right)^4 - \left(\frac{k}{D_g} \right) - \left(\frac{m\pi}{\alpha} \right)^2}{2}} \quad (33)$$

$$\beta_m = \sqrt{\frac{\left(\frac{m\pi}{\alpha} \right)^4 - \left(\frac{k}{D_g} \right) + \left(\frac{m\pi}{\alpha} \right)^2}{2}} \quad (34)$$

The analytical expression of the whole stress field can be got at this point:

$$M_x = -D_g \left(\frac{\partial^2 \omega}{\partial x^2} + \mu \frac{\partial^2 \omega}{\partial y^2} \right) \quad (35)$$

$$M_y = -D_g \left(\frac{\partial^2 \omega}{\partial y^2} + \mu \frac{\partial^2 \omega}{\partial x^2} \right) \quad (36)$$

$$M_{y,x} = M_{x,y} - D_g (1 - \mu) \frac{\partial^2 \omega}{\partial x \partial y} \quad (37)$$

3 Generalized mathematical model of crack

Fig.4. Pavement crack.

According to figure 4, elliptic P_{13} represents crack; P_{12} and P_{14} for the quadrant point of the ellipse; P_{15} is the midpoint of line $P_5 P_6$; P_{16} is the midpoint of the line segment $P_8 P_5$; P_{11} is the midpoint of section $P_8 P_5 P_6 P_7$ (shear plane), which is the length of the line $P_{14} P_{15}$

$$|P_{14} P_{15}| = h_1 \quad (38)$$

$$|P_{13} P_{12}| = a' \quad (39)$$

$$|P_{11} P_{13}| = e \quad (40)$$

$$|P_{13} P_{14}| = b' \quad (41)$$

iteration, stress intensity factor

$$\begin{cases} K_1 = M \sigma_y \frac{\sqrt{\pi b'}}{E(i)} \left[\left(\frac{b'}{a'} \right) \sin^2 \theta + \cos^2 \theta \right]^{\frac{1}{4}} \\ i^2 = 1 - \left(\frac{b'}{a'} \right)^2 \end{cases} \quad (42)$$

Among them, K_1 is the stress intensity factor; $E(i)$ for the second kind of complete elliptic integral; θ is the circumferential angle of elliptic crack

$$\sigma_y = - \frac{Ez}{(1-\mu)^2} \left(\frac{\partial^2 \omega}{\partial y^2} + \mu \frac{\partial^2 \omega}{\partial x^2} \right) \quad (43)$$

The type (31) substitution into the equation (43), available

$$\sigma_y = - \frac{Ez}{(1-\mu)^2} \left\{ \frac{A}{l^2} \sin \frac{y}{\sqrt{2l}} e^{\frac{y}{\sqrt{2l}}} + \frac{1}{l^2} \left[D \left(\cos \frac{y}{\sqrt{2l}} + \sin \frac{y}{\sqrt{2l}} \right) - C \sin \frac{y}{\sqrt{2l}} \right] + Q_2 + Q_3 \right\} \quad (44)$$

$$Q_2 = \frac{\alpha T_0 \cos \frac{2\pi}{\alpha} x (\beta_2^2 - \gamma_2^2) \cos \gamma_2 y (e^{\beta_2 y} + e^{-\beta_2 y}) + 2\gamma_2 \beta_2 \cos \gamma_2 y (e^{\beta_2 y} - e^{-\beta_2 y})}{4\pi D_g (1-\mu) \gamma_2 \sin \frac{2\pi}{\alpha} x} \quad (45)$$

$$Q_3 = \frac{-\pi \mu T_0 \sin \gamma_2 y (e^{\beta_2 y} + e^{-\beta_2 y})}{2\alpha D_g (1-\mu) \gamma_2} \cdot \frac{4 \sin^2 \frac{2\pi}{\alpha} x \sin^2 \frac{2\pi}{\alpha} x + \sin \frac{8\pi}{\alpha} x \cos \frac{2\pi}{\alpha} x}{\sin^4 \frac{2\pi}{\alpha} x} \quad (46)$$

Assumed fracture toughness $K_{IC}=K_I$, according to the boundary conditions of $y=0$, simultaneous formula (7)、 formula (16) ~ (26)、 formula (44) ~ formula (46), the solution is obtained.

$$Q_{up} = \frac{W_1 l^2 \lambda_1 (2\lambda_1 - \lambda_2 + \lambda_3)}{(-2\lambda_1 + \lambda_2 + \lambda_4)(-\lambda_2 + 2\lambda_3 + \lambda_4) - (\lambda_1 + 2\lambda_2 + \lambda_3 + 2\lambda_4)(2\lambda_1 - \lambda_2 + \lambda_3)} \cdot \frac{1}{1 - \mu^2 D_g E(i) K_{IG}} \cdot \frac{1}{MEz \sqrt{\pi b'} \left[\left(\frac{b'}{a'} \right)^2 \sin^2 \theta + \cos^2 \theta \right]^{\frac{1}{4}}} \quad (47)$$

$$Q_{down} = \frac{-\lambda_1 (2\lambda_1 - \lambda_2 + \lambda_3)}{(-2\lambda_1 + \lambda_2 + \lambda_4)(-\lambda_2 + 2\lambda_3 + \lambda_4) - (\lambda_1 + 2\lambda_2 + \lambda_3 + 2\lambda_4)(2\lambda_1 - \lambda_2 + \lambda_3)} + \frac{\alpha l (\beta_2^2 - \gamma_2^2) \cot \frac{2\pi}{\alpha} x}{4\pi} \quad (48)$$

$$P_u = Q = \frac{Q_{up}}{Q_{down}} \quad (49)$$

Among them, P_u is the ultimate bearing capacity of highway pavement

4 Engineering example

Hydropower station is part of Huaneng Lancang River Hydropower Limited by Share Ltd, located in the town of Yunnan province. But the Yunnan province power fruit town summer rainfall along the mountain road, although the foundation treatment is good, But still by the rain, flash floods and other erosion, resulting in the suspension, which directly affects the people's lives and property safety, but also directly affect the work of the bridge hydropower station operation, construction safety. This article is entrusted by the project of gongguoqiao hydropower station , using Gongguoqiao observation data given by the Ministry of hydropower station project, combined with the theoretical derivation, explored the inner mechanism of the fracture problem, in order to provide reference for practical engineering

4.1 Ultimate bearing capacity

A set of data for the selection of Gongguoqiao provided: given the relevant size: $l=5m$, $b=4m$, $h=0.3m$; for crack, $a' = 0.0537m$, $b' = 0.0068m$, $E(i) = 1.013304780919523$, $z = -0.145m$, $\theta = 90^\circ$; $\gamma = 25kN/m^3$, $E = 31GP$, $\mu = 0.15$, $K_{IC} = 0.51kN/cm^{1.5}$, $M = 1.1$, $k = 33MPa/m$, the design axle load is $100kN$; Suspension degree R has a variety of vacant value, but 0.106 , 0.132 , 0.157 , 0.198 , 0.254 , 0.259 , 0.301 , 0.378 , 0.382 , 0.400 in Gongguoqiao hydropower station is the most

common. The ten set of values calculated by this method, and compared the measured data between fruit bridge project given by the Ministry, in order to verify the applicability of this method.

Defined error

$$\varepsilon = \frac{\sqrt{(value_1 - value_2)}}{value_1}$$

(50)

Among them, Value₂ is the calculated value, and value₁ is the measured value.

Fig.5. Comparison between calculated and measured values.

It can be seen in Figure 5, the calculated results are in agreement with the measured values, numerical value coincide basically: the maximum error is 0.0558842193609138, the minimum error is 0.0015798513235351, the average error is 0.03254999, indicating the applicability of this formula is excellent for practical engineering problems.

In addition, we can draw the following conclusions: first, with the change of the R, the ultimate bearing capacity of concrete pavement is reduced, and the numerical relationship between the two is as follows:

$$\begin{aligned} P_u = & 19.7111 + (149.733 + 578.026 \cos R) \cot R \\ & + 3.0797(0.948186 + R)^{\frac{17}{35}} \cot \sin R \csc(0.899379 + R^{\frac{1}{8}}) \\ & - 14.7877R(0.948186 + R)^{\frac{17}{35}} \cot \sin R \csc(0.899379 + R^{\frac{1}{7}}) \\ & + 191.282 \csc R \csc(R^{\frac{5}{6}} + R) \csc[\sec R] - 170.909 \sec R \\ & + 10.2009R^{\frac{33}{14}} \sec R + R^{\frac{109}{35}} \csc(R^{\frac{1}{6}} + |R|) \\ & (0.608975 \cos R - 0.00244245 \tan R) - 85.3396R^{\frac{52}{35}} \sin R \tan R \end{aligned}$$

(51)

Among them, 0<R<0.5; secondly, when the hanging ratio of R is 0.3, ultimate bearing capacity is less than 100kN, the bearing capacity of the concrete at this time is less than that of the design axle load, may suddenly occur brittle fracture when driving, it will take a serious threat to traffic safety. According to equation (51) is calculated, when the hanging ratio of R is 0.243177, the ultimate bearing capacity is just equal to 100kN, if the suspension R is greater than 0.243177, the R is not allowed to travel; thirdly, according to equation (51) is calculated, when the hanging ratio R is greater than 0.5 and P_u is less than or equal to 0, When the floating ratio of R is greater than or equal to 0.5, the road is not broken, directly overturning

4.2 Crack size

Another set of data provided by the selection of Gongguoqiao: given the relevant size: l=5m, b=4m, h=0.3m; E=31GP, $\mu=0.15$, $\gamma=25\text{kN/m}^3$, $K_{IC}=0.51\text{kN/cm}^{1.5}$, M=1.1, k=33MPa/m, the design axle load is 100kN; suspended R is 0.198. Crack the values in Table 1; using the method of this paper to calculate the different values in Table 1and compared with the measured data, at the same time, the applicability of this method is verified by exploring the effect of crack size on the ultimate bearing capacity of Pu. (Table 1)

Table.1 Crack size.

a'/m	b'/m	θ	E(i)	z/m	calculated value /kN	measured value /kN	ε
0.050111	0.005017	90	1.00889	-0.152	129.153	127.17	0.015354
0.050111	0.010091	90	1.02917	-0.15324	129.328	135.261	0.045876
0.050111	0.015146	90	1.05731	-0.15393	129.481	129.183	0.002301
0.050111	0.020176	90	1.09193	-0.15467	129.612	128.678	0.007206
0.050111	0.025061	90	1.13152	-0.15525	129.721	135.252	0.042638
0.10035	0.005017	90	1.00264	-0.15567	120.471	118.357	0.017548
0.10035	0.010091	90	1.00896	-0.15668	120.647	126.082	0.045049
0.10035	0.015146	90	1.01794	-0.15756	120.8	125.452	0.03851
0.10035	0.020176	90	1.02909	-0.1582	120.931	122.037	0.009146
0.10035	0.025061	90	1.04177	-0.15833	121.039	125.448	0.036426
0.151123	0.005017	90	1.00128	-0.15858	98.3125	97.2247	0.011065
0.151123	0.010091	90	1.0044	-0.15991	98.4879	95.604	0.029282
0.151123	0.015146	90	1.00891	-0.15999	98.6408	96.0239	0.02653
0.151123	0.020176	90	1.01456	-0.16098	98.7720	101.262	0.02521
0.151123	0.025061	90	1.02104	-0.16124	98.8803	102.527	0.03688
0.201529	0.005017	90	1.00076	-0.16189	78.0032	76.7015	0.016688
0.201529	0.010091	90	1.00265	-0.16343	78.1786	77.4246	0.009645
0.201529	0.015146	90	1.00541	-0.16367	78.3315	80.351	0.025781
0.201529	0.020176	90	1.00889	-0.16376	78.4627	80.7021	0.028541

From Table 1 we can see that the calculated results are in agreement with the measured values, the formula deduced in this paper has excellent applicability to practical engineering problems.

In addition, the following conclusions can be drawn from table 1: first, a' or b' becomes larger, the ultimate bearing capacity of concrete pavement is reduced, the numerical relationship among the three is

$$\begin{aligned} P_u = & 216.302 - 3784.33a'^2 + 449912a'^5 - 1.34562 \times 10^6 a'^6 - 199.175b'^2 \\ & + 23679.6b'^5 - 70821.9b'^6 \\ & + 24.2517 \ln a' + 1.2764 \ln b' \end{aligned} \tag{52}$$

Among them, $0 < a' < 0.25\text{m}$, $0 < b' < 0.025\text{m}$ "; secondly, according to the formula (52) shows that the size of crack perpendicular to the direction of the impending greater influence on ultimate bearing capacity, the size of the crack parallel to the floating direction has little influence on the ultimate bearing capacity, a' and b' varied in the same range and the change of the same magnitude, resulting in the change a' of P_u caused by a is 19 times of the value of b'

caused by P_u . Simultaneous formula (49) found that this is because the bending moment caused by the dead weight of the suspended part is relatively large.; thirdly, No matter what the value of b' , when the long axle crack length is greater than 0.1M, the limit bearing capacity is less than 100kN, indicating that the bearing capacity of the concrete is far less than the design load, it may suddenly occur brittle fracture driving and take a serious threat to traffic safety, so, if the long axle crack length is greater than 0.1M, are not allowed to travel.

5 Conclusion

In this paper according to the Winkler assumption, the suspended pavement is equivalent to the non-suspended pavement, in accordance with the 3D fracture model of crack generation, through the establishment of special boundary conditions of suspended highway stress field and crack contains general ized mathematical model, so based on the principal Gongguoqiao hydropower station project department and provided the data and the generalized mathematical model to do comparison, results show that:

With the R larger than the left, the ultimate bearing capacity of concrete pavement is reduced, when the suspended ratio of R is greater than 0.243177, the ultimate bearing capacity is less than 100kN; this condition is not allowed to drive.

No matter what a' and b' became larger, the ultimate bearing capacity of concrete pavement is rapidly reduced. However a' and b' change the same amplitude, resulting in the change of value is 19 times the value of the change and moment for the shear plane is far greater than the role of torque for the shear surface.

No matter what the value, if the crack length and half shaft length greater than 0.1M, the ultimate bearing capacity is less than the design of axle load 100kN; it is not allowed to travel.

Under various conditions, the calculated results and measured results show the same trend. The more important is that the generalized mathematical model proposed in this paper is suitable for the fracture problem of the suspended concrete pavement.

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