Study on Flexural Bearing Capacity of Normal Section of Prestressed Concrete Beams under Chlorine Salt Erosion

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Abstract: In order to quantitatively analyze the flexural bearing capacity and prestress of normal section of concrete beams under chloride salt erosion environment, a model for analysis and analysis of mechanical behavior of concrete beams under chloride salt erosion environment is proposed based on the combined control constraints of load and stress. The stress structure model of concrete beams under chloride erosion environment is analyzed. Taking softening coefficient and shear transfer coefficient as constraint parameters and combining with the measurement results of residual tensile strength, the relationship between bearing capacity and stress is analyzed. The flexural bearing capacity and mechanical behavior of concrete beams under chloride erosion environment are analyzed. Under high stress conditions, the softening mechanics equation of concrete beams under chloride erosion environment is obtained, and the mechanism of creep generation and load distribution of concrete beams is analyzed. In order to guide the behavior of concrete beams under the environment of ecological chloride salt erosion, the bending capacity of normal section of prestressed concrete beams under chloride erosion environment can be quantitatively analyzed. The simulation results show that the model can accurately analyze the prestressing force under chloride erosion environment, improve the flexural bearing capacity of the normal section of concrete beams, and effectively guide the construction of buildings.

Keywords: Chloride erosion environment; Prestress; concrete beam; Bearing capacity

1. Introduction

The cracking of concrete beams under chloride erosion environment has been a topic of concern to researchers. The appearance of macroscopic cracks will seriously affect the durability and service life of reinforced concrete structures. Once the reinforced concrete structural members crack, the water vapor, carbon dioxide, oxygen and other substances in the outside atmosphere will enter into the internal structure of the structural members, which will lead to the corrosion of steel bars, which will lead to the spalling of the concrete layer and the reduction of the bearing capacity[1]. Therefore, how to control the crack width effectively becomes a problem to be solved in the process of popularization and application of high strength steel bar in concrete beam. Based on the above point of view. Reinforced concrete beam is widely used as a flexural member. In order to avoid bending failure, the flexural bearing capacity of normal section must be calculated and the structure can be satisfied. The calculation of beam reinforcement can be made with the help of relevant software, but the actual design work often requires the designer to calculate the results by hand quickly[2]. According to the formula of concrete structure design code, the parameters are many and the results cannot be obtained quickly. In this paper, a series of formulas for calculating the flexural bearing capacity of normal section of rectangular flexural members are derived, and the formula for calculating the area of tensile steel bar by using the coefficient of internal force arm is obtained. On the basis of the parameter analysis of the coefficient of internal force arm, the suggested value of the internal force arm coefficient is obtained[3]. Because of its well-known advantages, prestressed concrete structure has been widely used in civil engineering, and it has shown a strong vitality. However, due to the introduction of the concepts of principal internal force, secondary internal force and comprehensive internal force into the classical calculation method, the original relatively simple problems are complicated and are not easy to master by the structural designers. Because the classical calculation method is based on the assumption that the axial tension and compression stiffness of floor slab is infinite, the influence of lateral limit (lateral constraint) on the prestress transfer and calculation results is not considered. In fact, most of the statically indeterminate structures are side-limited structures, and the lateral limits of some of them are obvious. Based on the above considerations, the two-stage working principle of prestressed tendons is discussed, and the bearing capacity formula of prestressed concrete structures is established on the basis of this principle. In this way, not only the problem of secondary internal force, which is widely felt by people, is avoided, but also the problem of secondary internal force is avoided. The design calculation is simplified, and the influence of the lateral limit on the prestress transfer and the design calculation result is considered reasonably. Thus, the unification of statically indeterminate structure and statically indeterminate structure is realized in calculating the bearing capacity of prestressed concrete structure. Based on GB50010-2002, it is stipulated that the deflection of reinforced concrete and prestressed concrete flexural members under the normal service limit state can be calculated according to the stiffness of the members according to the structural mechanics method. In the same section members, the stiffness of the same bending moment section can be assumed to be equal, and the stiffness at the maximum moment in the section can be obtained. The deflection of prestressed flexural member is composed of two parts: one is deflection caused by load and the other is reverse arch caused by prestress[4]. In order to quantitatively analyze the flexural bearing capacity and prestress of normal section of concrete beams under chloride salt erosion environment, a model for analyzing the mechanical behavior of concrete beams under chloride salt erosion is proposed based on the combined control constraints of load and stress. The stress structure model of concrete beams under chloride erosion environment is analyzed. Taking softening coefficient and shear transfer coefficient as constraint parameters, it is necessary to analyze the stress structure of concrete beams under chloride erosion environment. The stress structure model of concrete beam under chloride erosion environment is analyzed.

2. Internal Structure and Load-bearing Analysis of Concrete Beams under Chloride Erosion Environment

In order to analyze the mechanical behavior of concrete beams under chloride erosion environment, Taking the actual concrete beam member model under chloride erosion environment to analyze the internal structure and mechanical behavior of concrete beam under chloride erosion environment, the stress structure of concrete beam is tested with finite element analysis software[5]. The composition of concrete beam under chloride erosion environment was analyzed. The bearing capacity analysis model and the bulk structure model were combined to carry out the force test. The relationship model between stiffness softening and shear force of concrete beam under chloride erosion environment is studied. The elastic deformation increment of energy saving ecological wall under the condition of cracks is obtained as follows:

$$\dot{H}_x^s(IR^d) := \{ f : \| f \|_{\dot{H}_x^s(IR^d)} := \| |\nabla|^s f \|_{L_x^2(IR^d)} = \| |x|^s \hat{f} \|_{L_x^2(IR^d)} < \infty \} \quad (1)$$

Where, $s \ge 0$, $\frac{1}{p} = \frac{1}{p_1} + \frac{1}{p_2} = \frac{1}{p_3} + \frac{1}{p_4}$. Considering the creep of concrete beams under the condition of uncracked chlorine salt erosion and the stiffness coefficient of concrete beams under the condition of cracking chloride salt erosion, the softening mechanics equation of concrete beams under high stress conditions is obtained as follows:

$$| f \|_{L_t^q L_x^r(I\times IR^d)} = (\int_I (\int_{IR} | f(t,x)|^r \, dx)^{q/r} dt)^{1/q} \quad (2)$$

Under uniaxial compression conditions, the constitutive relation satisfies: $u : I \times IR^d \to IR$, the tangent modulus of elasticity of concrete beams in chloride erosion environment is calculated according to the equivalent stress-strain relationship:

$$\begin{cases} u_{tt} - \Delta u + F = 0, \\ (u, \partial_t u)|_{t=0} = (u_0, u_1) \in \dot{H}_x^m \times \dot{H}_x^{m-1} \end{cases} \quad (3)$$

Therefore, the mechanism of creep generation and load distribution of concrete beams under chloride erosion environment is obtained, which can guide the analysis of stress behavior of concrete beams under the environment of ecological chloride salt erosion[6].

3. Analysis of Mechanical Behavior of Concrete Beams under Ecological Chloride Erosion

3.1. Model of bearing capacity and stress of normal section of concrete beams

Combined with the measurement results of residual tensile strength, the relationship between bearing capacity and stress is analyzed, and the analysis of flexural bearing capacity and mechanical behavior of concrete beams under chloride erosion environment is realized[7]. Hongnestad model is used to analyze the stress deformation increment of concrete beam under chloride salt erosion environment, and the compressive strength of concrete beam under chloride salt erosion environment is 0.6 ~ 0.8 Mpa. At this time, the increment of concrete beam cracking under chloride salt erosion environment is changed to be:

$$\| |\nabla|^s u \|_{L_t^q L_x^r} + \| |\nabla|^{s-1} u \|_{L_t^q L_x^r} + \| |\nabla|^m u \|_{L_t^\infty L_x^2} + \| |\nabla|^{m-1} u \|_{L_t^\infty L_x^2} \le C(\| (u_0, u_1) \|_{\dot{H}_x^m \times \dot{H}_x^{m-1}} + \| |\nabla|^{\tilde{s}} F \|_{L_t^{\tilde{q}'} L_x^{\tilde{r}'}}) \quad (4)$$

The constitutive shear transfer coefficients of concrete beams under uniaxial compression under the condition of ecological chloride erosion are obtained by the upper formula:

$$\begin{cases} u_{tt} - \Delta u + |u|^4 u = 0, \\ (u, \partial_t u)|_{t=0} = (u_0, u_1) \in \dot{H}_x^{s_c} \times \dot{H}_x^{s_c - 1} \end{cases} \quad (5)$$

Taking softening coefficient and shear transfer coefficient as constraint parameters, the nonlinear creep load-bearing stress fitting method is used to fit the stress structure of concrete beam under the environment of energy-saving ecological chlorine salt erosion. The fitting equation is obtained as follows:

$$d(t) = \begin{cases} \arctan\left(\frac{X'_2(t)}{X'_1(t)}\right), & X'_1(t) > 0 \\ \arctan\left(\frac{X'_2(t)}{X'_1(t)}\right) + p, & X'_1(t) < 0,\ t = 1, 2, \mathbf{L}, T \\ p/2, & X'_1(t) = 0 \end{cases} \quad (6)$$

Combined with the measurement results of residual tensile strength, the relationship between load and stress is analyzed, which is described as:

$$h(x) = \begin{cases} 1 & TH = \sum_{t=1}^{T} a_t h_t(x) - \frac{1}{2}\sum_{t=1}^{T} a_t \geq 0 \\ 0 & others \end{cases}$$

Where $a_t = \log\frac{1}{b_t}$, The axial stress of concrete beam model under ecological chloride erosion environment is represented. The relationship between the softening structure coefficient and the shear transfer model of concrete beams under the environment of ecological chloride erosion is obtained:

$$B(u, \partial_t u)|_{t=0} = \{u : \|u\|_{L^{10}_{t,x}} \leq a, \||\nabla|^{\frac{5}{4}} u\|_{S_{\frac{1}{4}}} + \||\nabla|^{\frac{5}{4}} u_t\|_{S_{\frac{1}{4}}} \leq b\} \quad (8)$$

The mechanical behavior of concrete beams under chloride erosion environment is analyzed by the above model.

3.2. Analysis of the flexural bearing capacity of concrete beams

Considering the buckling, fatigue, strength and other constraints of concrete beams under the environment of eco chloride erosion,the expansion of the longitudinal strength of the normal section load of a clotted soil beam may be expressed in the following form:

$$j(a, t, s, b) = \sum_{x=-\frac{P}{2}}^{\frac{P}{2}-1} j_x(a, t, b) v^{-wxb}$$

$$x = -\frac{P}{2}, \mathbf{L}, \frac{P}{2} - 1 \quad (9)$$

Combined with mortar, interface of mesoscopic material parameters. The nonlinear expansion of modulus softening coefficient of concrete under uniaxial loading is obtained as follows:

$$(z_g \bullet\bullet) z_g = \sum_{x=-\frac{P}{2}}^{\frac{P}{2}-1} N_x \left[(z_g \bullet\bullet) z_g\right] v^{-wxb} \quad (10)$$

Under chloride erosion environment, the elastic strain increment of the section of concrete beam in the stress direction is:

$$\frac{\partial z_x}{\partial b} + N_x[(z_g \bullet\bullet) z_g + (Z \bullet\bullet) z_g + (z_g \bullet\bullet) Z] + \bullet x P x = \frac{1}{Q} \bullet \overset{2}{x}\, zx \quad (11)$$

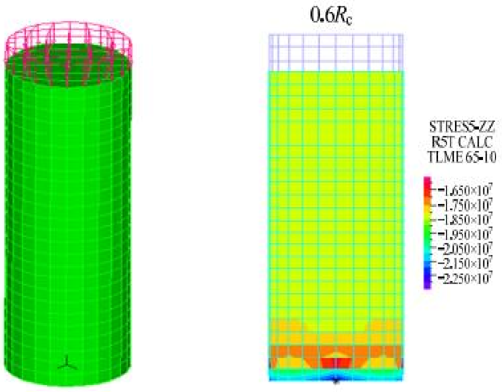
$$\bullet x \bullet z_x = 0 \quad (12)$$

Under the condition of high stress, the softening mechanics equation of concrete beam under chloride erosion environment is obtained, and the mechanism of creep generation and load distribution of concrete beam is analyzed, so as to guide the behavior of concrete beam under the environment of ecological chloride salt erosion, the quantitative analysis of flexural bearing capacity of normal section of prestressed concrete beam under chloride erosion environment is realized.

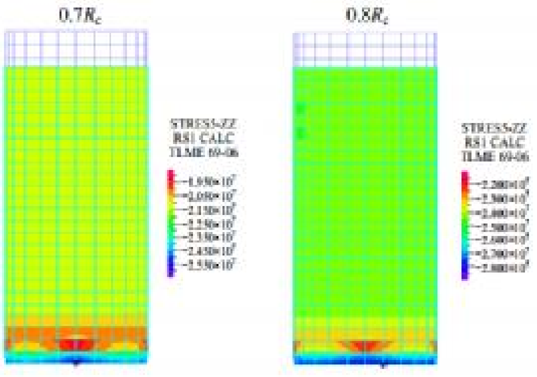
4. Experimental Test and Analysis

In order to verify the practical application value of this method in the analysis of mechanical behavior of concrete beams under chloride erosion environment, the experimental analysis of concrete beams is carried out. When the equivalent load is 1.55, the standard value of bending moment of the control section under equivalent load is 12.4. The equivalent load caused by prestress is treated as dead load, then the moment calculated according to the combination of load and short-term effect is 40N.s, considering the equivalent load caused by prestress, based on the analysis of normal section bearing capacity and prestress performance of concrete beams under chloride erosion environment, the simulation results of mechanical model are obtained by using finite element analysis method, which is shown in Figure 1.

The results of the above experiments show that the mechanical behavior of concrete beams under chloride erosion environment has partial linear creep behavior, and the stress intensity increases with the increase of positive load. In order to improve the ecological chlorine content, the stress intensity of concrete beams increases with the increase of positive load. In order to reduce the softening coefficient and improve the mechanical behavior of concrete beams under chloride erosion environment, the stress capacity of concrete beams under salt erosion environment needs to be increased.



(a) Normal section bearing capacity



(b) Prestressing force

Figure 1. Finite Element Simulation Results of Mechanical Analysis of Concrete Beam under Chloride Salt Erosion Environment

5 . Conclusions

In this paper, a model for analysis and analysis of mechanical behavior of concrete beams under chloride salt erosion environment is proposed based on the combined control constraints of load and stress. The stress structure model of concrete beams under chloride erosion environment is analyzed. The flexural bearing capacity and mechanical behavior of concrete beams under chloride erosion environment are analyzed. Under high stress conditions, the softening mechanics equation of concrete beams under chloride erosion environment is obtained, the bending capacity of normal section of prestressed concrete beams under chloride erosion environment is quantitatively analyzed. Results show that the model can accurately analyze the prestressing force under chloride erosion environment, improve the flexural bearing capacity of the normal section of concrete beams, it has effectively guidance value in the construction of buildings.

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