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Bias calculation of reinforced concrete short columns with iron tailings sand

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Abstract

The ultimate bearing capacity of short reinforced concrete columns under partial pressure is calculated by the formula of ordinary short reinforced concrete columns and the numerical simulation method, and the bearing capacity of short reinforced concrete columns under partial pressure is compared with that of reinforced concrete tests of iron tailings. The results show that the numerical simulation method and the calculation method of the ordinary reinforced concrete column bias pressure formula are used to calculate the load capacity of the iron tail sand concrete column is reasonable. The strength of iron tailings concrete has little effect on the compressive capacity of biased columns.

Keywords

Iron tail sand concrete, Bias bearing capacity, Numerical simulation, Calculated value.

1. Introduction

With the continuous development of economic construction, more and more industrial and civil buildings, the demand for concrete is increasing. Iron tailing sand can be used as fine aggregate instead of natural sand to make concrete, which can not only solve the problem of natural sand shortage, but also recycle iron tailing sand. Therefore, the use of iron tail sand in concrete instead of natural river sand can solve the problem of natural sand exhaustion, and well solve the problem of storage and utilization of iron tail sand. In recent years, scholars at home and abroad have made great progress in the study of iron tailings, which has laid the foundation for further research. In literature [2], the compressive strength, elastic modulus and stress-strain curve of iron tail sand concrete were studied. The research results show that replacing river sand with iron tailing sand can significantly improve the compressive strength of concrete, and its elastic modulus is slightly increased. When the strength grade of iron tailing sand concrete is less than or equal to C40, the stress-strain curve is similar to that of ordinary concrete; when the strength grade of iron tailing sand concrete is greater than C40, the stress-strain curve of the falling section becomes steeper than that of ordinary concrete.

Through the partial compression test of reinforced concrete short columns with iron tail sand, the influences of different concrete strengths on the characteristic values of stirrup, the strength and ultimate bearing capacity of concrete in the core area of iron tail sand concrete short columns are studied. Based on the test results of the bias performance of short reinforced concrete columns with iron tail sand, this paper uses the bias formula of ordinary short reinforced concrete columns to calculate the compressive capacity, and establishes a numerical model to simulate short reinforced concrete columns with iron tail sand to compare and analyze the compressive performance of reinforced concrete columns with iron tail sand. Experiment.

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2. Bias calculation of short column

2.1. Specimen design

The steel tail sand concrete short column with section size of 300mm ×300mm and height of 1400mm is made. The stirrup adopts HRB400 steel bars with diameter of 8mm and spacing of 100mm. HRB400 steel bar with diameter of 20mm is used for longitudinal reinforcement. The thickness of column protective layer is 30mm, and the test column reinforcement sample is shown in Figure 1.

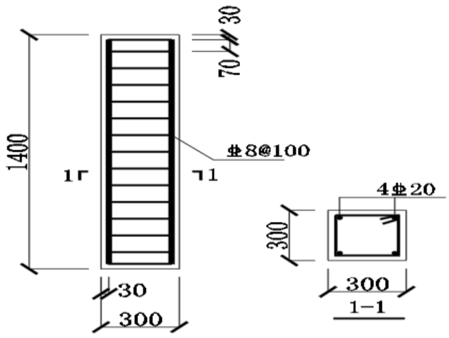

Figure. 1 Copper coated steel fiber

2.2. Calculation of normal section compression capacity of compression member

2.2.1. Basic principle

With the treatment method of bending members, the curve pressure stress force of concrete in the compression zone is replaced by an equivalent rectangular figure, the stress value is FFα1, the height of the compression zone is x, so the calculation formula of the bearing capacity of the large eccentric compression member given by the specification is as follows:

It is calculated by the formula:

$$N_{\mathrm{u}} = \alpha_1 f_c bx + f_y^{'} A_s^{'} - f_y A_s \tag{1}$$

$$N_{\mathrm{ue}} = \alpha_1 f_c bx\left(h_0 - \frac{x}{2}\right) + f_y^{'} A_s^{'}\left(h_0 - a_s^{'}\right) \tag{2}$$

$$e = e_i + \frac{h}{2} - a_s \tag{3}$$

$$e_i = e_0 + e_b \tag{4}$$

$$e_0 = \frac{M}{N} \tag{5}$$

Annotation:

N_u—Design value of compressive capacity

α_1—Coefficient

e—the distance between the point of application of the axial force and the steel bar under tension

e_i—Initial eccentricity

e_0—The eccentricity of the axial force against the center of the section

e_b—Additional eccentricity

M—Design value of bending moment of control section

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N—Design value of axial pressure corresponding to M

x—Height of concrete compression zone

2.2.2. Basic principle

In order to ensure that the stress of the steel bar in the tensile area reaches the yield strength first when the member is damaged fy, The value must be x≤xb. Where xb is the height of the concrete compression zone when the limit is broken

In order to ensure that when the member is damaged, the stress of the compressive steel bar can reach the yield strength, the member must meet $x \geq 2a'_s$. Where as is the distance between the joint force point of the longitudinal compression reinforcement and the edge of the compression zone.

2.3. Theoretical calculation result

Under the premise of meeting the applicable conditions, the eccentric compression capacity of iron tail sand concrete short columns is calculated according to the principle of eccentric compression capacity calculation of ordinary stirrup columns, and the calculation results are shown in Table 1.

Table 1 Eccentric ultimate bearing capacity of iron tail sand concrete short column

Serial number	Grade of concrete	Eccentricity /mm	Ultimate bearing capacity /KN
Z-1	WC30	150	2611
Z-2	WC35	150	3015
Z-3	WC40	150	3344
Z-4	WC45	150	3834
Z-5	PC50	150	4278
Z-6	PC30	150	2537
Z-7	PC40	150	3215
Z-8	PC0	150	4032

3. Bias test value of short column

3.1. Test result

Table 2 Eccentric ultimate bearing capacity of iron tail sand concrete short column

Serial number	Grade of concrete	Eccentricity /mm	Ultimate bearing capacity /KN
Z-1	WC30	150	3132
Z-2	WC35	150	3951
Z-3	WC40	150	4437
Z-4	WC45	150	5002
Z-5	PC50	150	5227
Z-6	PC30	150	2987
Z-7	PC40	150	4231
Z-8	PC0	150	5106

4. Numerical simulation

4.1. Numerical simulation parameter

Replacing river sand with iron tailings can significantly improve the compressive strength of concrete. The elastic modulus of iron tailings concrete is slightly higher than that of ordinary concrete. According to the simplified calculation method of elastic modulus, tensile strength and axial compressive strength of ordinary concrete proposed in Code for Design of Concrete Structures (GB50010-2010), Calculate the elastic modulus, tensile strength and compressive strength of iron tailings concrete.

$$E_c = \frac{10^5}{2.2 + \frac{34.7}{f_{cu,k}}} \tag{6}$$

$$f_t = 0.395 f_c^{0.55} \tag{7}$$

$$f_c = 0.88 \alpha_{c1} \alpha_{c2} f_{cu,k} \tag{8}$$

Where: the ratio of axial compressive strength and cubic compressive strength of α_{et} concrete with strength grade C50 and below is 0.76,αe2 is the brittleness reduction coefficient of concrete compressive strength, and the concrete with strength grade C40 is 1.0. For concrete with strength grade C80, 0.87 intermediate linear interpolation is adopted.

4.2. Stress-strain relationship of iron tailings concrete

The stress-strain relationship of iron tailings concrete is adopted by Kang Hongzhen:

$$y = \begin{cases} \alpha_a x + (3 - 2\alpha_a) x^2 + (\alpha_a - 2) x^3 & x \le 1 \\ \dfrac{x}{\alpha_d (x-1)^2 + x} & x > 1 \end{cases} \tag{9}$$

$$\alpha_d = \begin{cases} 0.157\, f_c^{0.785} - 0.905 \text{强度等级小于等于} c40 \\ 0.195\, f_c^{0.785} - 0.905 \text{强度等级大于} c40 \end{cases} \tag{10}$$

Among them: $x=\varepsilon/\varepsilon_p, y=\sigma/\sigma_p, f_c$ Compressive strength of concrete, α_a is the shape parameter of the ascending section,α_d is the shape parameter of the descending section.

Based on the compressive strength of iron tail sand concrete cube with different strengths, the stress-strain curves of iron tail sand concrete with different strengths are drawn by using the simplified calculation method of ordinary concrete elastic modulus, tensile strength and compressive strength and the stress-strain relationship of iron tail sand concrete proposed by Kang Hongzheng [5], as shown in Figure 2.

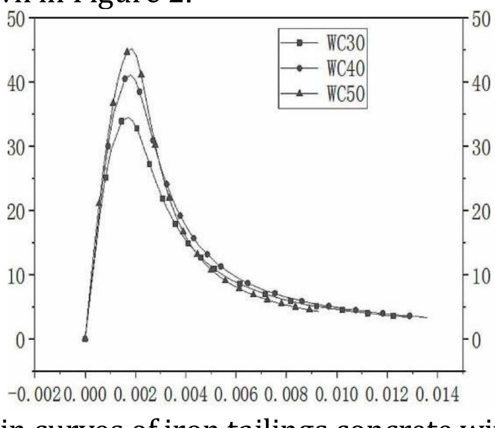

Figure. 2 Stress-strain curves of iron tailings concrete with different strengths

As can be seen from Figure 2, the stress-strain curve of concrete with strength WC50 is steeper than the descending section of the stress-strain curve of concrete with strength WC40 and WC30.

4.3. Establishment of numerical simulation model

The reinforcement skeleton is built into the concrete beam, the concrete is simulated by eight-node linear hexahedron element, and the reinforcement is simulated by two-node linear three-dimensional truss element. The numerical model is established by ABAQUS, as shown in Figure 3.

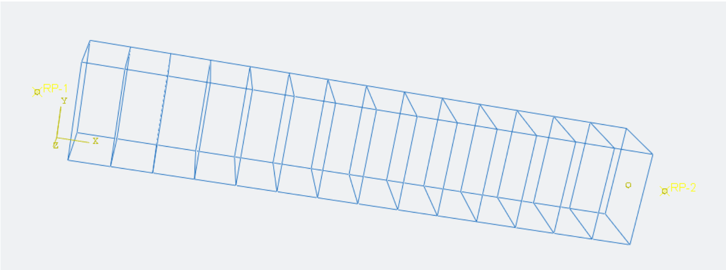

Figure. 3 Numerical simulation model of iron tailings concrete column

4.4. Numerical simulation result

A numerical simulation model was established by ABAQUS to obtain the simulated compressive capacity, as shown in Table 3.

Table 3 The simulated axial ultimate bearing capacity of iron tailings column

Serial number	Grade of concrete	Eccentricity /mm	Ultimate bearing capacity /KN
Z-1	WC30	150	2808
Z-2	WC35	150	3213
Z-3	WC40	150	3543
Z-4	WC45	150	4034
Z-5	PC50	150	4478
Z-6	PC30	150	2596
Z-7	PC40	150	3407
Z-8	PC0	150	4132

5. Analysis of column bias bearing capacity

According to the test results of the bias performance of reinforced concrete columns with iron tail sand and the comparison between the ultimate bearing capacity calculated by the bias formula of ordinary reinforced concrete short columns and the ultimate bearing capacity obtained by numerical simulation, the comparison diagram is drawn, as shown in Figure 4

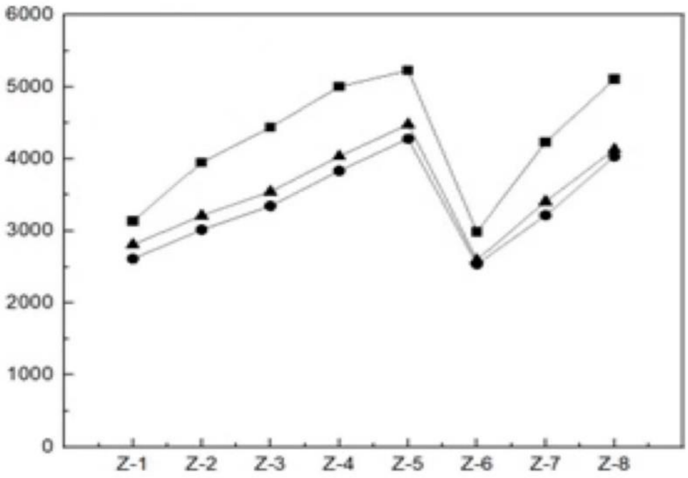

Figure. 4 Comparison diagram of experimental, calculated and simulated ultimate bearing capacity of biased column

As can be seen from Figure 4, the shape of the curve drawn by the ultimate bearing capacity obtained from the calculated value and the simulated value is similar, and the simulated value is slightly higher than the calculated value, with little difference between the two, and the experimental value is greater than the simulated value and the calculated value. The ultimate bearing capacity calculated according to the general reinforced concrete column bias formula did not consider the strength of the stirrup in concrete. The stress-strain curve of the concrete compression was adopted in the ascending and horizontal sections of the parabola, and the stirrup in the finite element simulation model participated in the model calculation, so the simulated value was slightly higher than the calculated value. In the finite element simulation, the compressive stress-strain curve and damage of iron tail sand concrete used in ordinary concrete generally work with cracks, and the stiffness will degrade under pressure, which has a great impact on the simulated yield load. During the simulation, the elastic modulus, tensile strength and axial compressive strength of iron tail sand concrete are calculated according to the simplified calculation method of ordinary concrete elastic modulus, tensile strength and eccentric compressive strength. The yield stress of steel bar is 360MPa specified in the code, resulting in conservative parameters used, so the ultimate bearing capacity obtained in the experiment is larger. The ultimate bearing capacity of the column calculated by the formula and simulation has a reliable reserve. Therefore, it is effective to use finite element method to simulate the ultimate bearing capacity of iron tail sand reinforced concrete column, and reasonable to use ordinary reinforced concrete column bias formula to calculate the ultimate bearing capacity of iron tail sand reinforced concrete column.

6. Conclusion

(1) It is reasonable to calculate the ultimate bearing capacity of short columns of iron tail sand concrete by numerical simulation method and ordinary reinforced concrete column axial compression formula calculation method.

(2) The ultimate compressive capacity of short concrete columns with iron tailings instead of natural sand is roughly the same as that of ordinary concrete short columns. Based on the analysis of compressive capacity, it is suitable for iron tailings to replace natural sand.

(3) The numerical simulation is closer to the test value than the formula calculation, and the calculation of bearing capacity is more applicable.

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