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Simulation and calculation analysis of reinforced concrete columns with iron tailings sand

Xin Liu, Zhinian Yang, Linxiao Zhang

School of North China University of Science and Technology, College of Civil and Architectural Engineering, Hebei 063000, China

1101695469@qq.com

Abstract

The ultimate compressive capacity of concrete column was analyzed and compared by the axial compression formula of concrete column and the numerical simulation method, and the ultimate bearing capacity of reinforced concrete was compared with that of iron tail sand. The results show that the ultimate bearing capacity obtained by the numerical simulation method is reasonably slightly higher than the calculated value, and the strength of iron tailings concrete has little effect on the compressive bearing capacity of columns, and its compressive strength is higher than that of ordinary concrete.

Keywords

Iron tail sand concrete, Numerical simulation analysis, Calculated analysis, Compression calculation.

1. Introduction

With the continuous increase of buildings in recent years, the amount of concrete has been increasing, which has led to the continuous reduction of natural sand and is showing signs of depletion. Iron tailings can be used as fine aggregate instead of ordinary river sand to make concrete, which can not only solve the shortage of natural river sand, but also recycle iron tailings. In recent years, many scholars at home and abroad have made a lot of research results on the mechanical properties of iron tailings concrete, which provides a reference for the application of iron tailings concrete in engineering[1-2].Therefore, the use of iron tail sand in concrete instead of natural river sand can solve the problem of natural sand depletion, and solve the storage and utilization of iron tail sand. Tailings are the waste generated in the process of mineral development, the storage of such waste requires the occupation of precious land resources, management also needs to waste a lot of human resources, it is very inconvenient to deal with, more serious is that waste tailings often contain heavy metal ions and toxic substances, the surrounding water sources, land and other ecological environment has brought a serious threat. Always threatening the health and life safety of surrounding residents, the United States, the former Soviet Union and other large investments in tailings recovery, and achieved certain economic benefits, but also to avoid environmental damage. Tailings for China is already a burden, China's tailings storage is increasing year by year, and showing an increasing trend, in contrast, some Western countries recycling waste tailings still exist in the mineral resources, the comprehensive utilization of tailings has reached 60%[3-4].

The influence of different concrete strength on the characteristic value of stirrup, the strength of concrete in core area and the ultimate bearing capacity of reinforced concrete column with iron tail sand is studied through the simulation test. In this paper, based on the test results of the compressive performance of reinforced concrete columns with iron tail sand, the ultimate compressive capacity is calculated by using the value of its concrete compressive capacity and substituting the axial compression formula of ordinary reinforced concrete columns, and a numerical model is established to simulate the reinforced concrete columns with iron tail sand, and the relationship between the two is analyzed to see whether it meets the requirements.

2. Bias calculation of short column

2.1. Specimen design

Make a cross-sectional size of 400mm×400mm and a height of 2100mm.The stirrup adopts HRB400 steel bars with a diameter of 10mm and a spacing of 100mm.HRB400 steel bar with diameter of 20mm is used for longitudinal reinforcement. The thickness of the protective layer of the column is 30mm, and the reinforcement sample diagram of the test column is shown in Figure 1.[5-6]

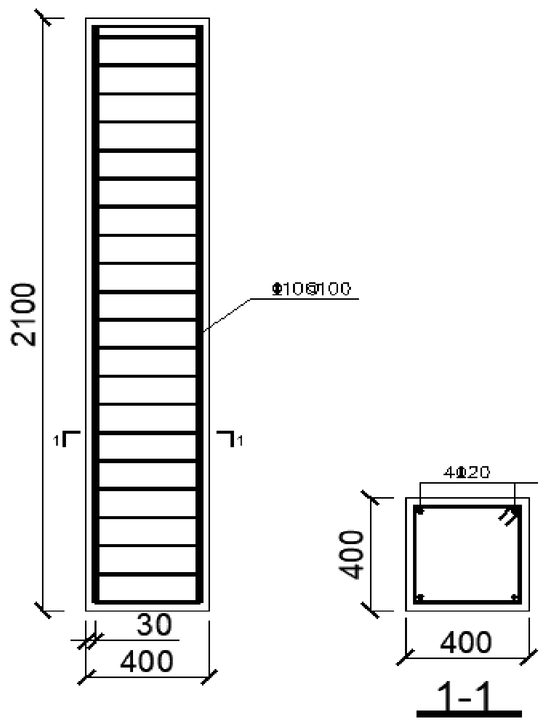

Figure. 1 Test Reinforcement Diagram

2.2. Calculation of normal section bearing capacity of compression member

2.1.1 Basic principle

The bearing capacity calculation formula of axial compression members given in the Basic principle specification is as follows:

$$N_u = 0.9\varphi(f_c A + f_y As') \tag{1}$$

Annotation:

N_u — Is the design value of axial pressure bearing capacity, and the unit is kN;

0.9 — Is the reliability adjustment factor;

φ — Is the reliability adjustment factor;

f_y — Is the design value of compressive strength of steel bar, the unit is MPa;

f_c — Is the design value of concrete compressive strength, the unit is MPa;

b — Is the beam width of a rectangular section, and the unit is mm;

h — Is the height of a beam with a rectangular section and the unit is mm;

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As'—Area of steel bar in tension area, unit is mm^2;

A—Is the cross-sectional area of the component, in mm^2;

2.1.2 Application Conditions

The diameter of the longitudinal bar in the column should not be less than 12mm, in order to prevent concrete cracking, the reinforcement ratio of the longitudinal bar should not exceed 5%, while the minimum reinforcement ratio of one longitudinal bar is 0.2%, and the net spacing is appropriate to 50mm to 300mm.The diameter of the stirrup shall not be less than 6mm and greater than d/4, where d is the diameter of the longitudinal rib. The stirrup spacing must be less than 400mm and the minimum of the short side size of the member and 15d.

2.3. Theoretical calculation result

The axial pressure bearing capacity of iron-tail sand concrete column is calculated according to the principle of normal section compression capacity of ordinary stirrup column under axial compression, and the calculation results are shown in Table 1.

Table 1 Axial Ultimate Load Values of Iron Tailings Sand Concrete Columns

Serial number	Grade of concrete	Ultimate load value/KN
Z-1	WC30	2859
Z-2	WC40	3735
Z-3	WC50	4354
Z-4	PC30	2653
Z-5	PC40	3534
Z-6	PC50	4121

3. Bxial compression test value of column

3.1. Test result

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

Serial number	Grade of concrete	Ultimate load value/KN
Z-1	WC30	3356
Z-2	WC40	4564
Z-3	WC50	5234
Z-4	PC30	3235
Z-5	PC40	4764
Z-6	PC50	4983

It can be seen from the test results in Table 2 that compared with ordinary concrete columns, the ultimate compressive capacity of iron tail sand concrete columns is higher than that of ordinary concrete columns, and the strength of the two columns is roughly the same. Therefore, it is reasonable to replace natural sand by iron tailings ore.

4. Numerical simulation of reinforced concrete columns with iron tailings

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.

$$E_c = 10^5 / \left(2.2 + 34.7 / (fcu, k)\right) \tag{2}$$

$$f_t = 0.395 f_c^{0.55} \tag{3}$$

$$f_c = 0.88 \alpha_{c1} \alpha_{c2} f_{cu,k} \tag{4}$$

Among them: strength grade C50 and below, α_{et} the ratio of axial compressive strength of concrete to cubic compressive strength is taken as 0.76 . α_{e2} is the brittle reduction coefficient of concrete compressive strength. For concrete with strength grade C40, take 1.0. For concrete with strength grade C80, take 0.87 as the intermediate linear interpolation.

4.2. 4.2 Stress-strain relationship of iron tailings concrete

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

$$y = \begin{cases} \alpha_a x + (3 - 2\alpha_a) x^2 + (\alpha_a - 2) x^3 & x \le 1 \\ \dfrac{x}{\alpha_d (x-1)^2 + x} & x > 1 \end{cases} \tag{5}$$

$$\alpha_d = \begin{cases} 0.157 f_c^{0.785} \text{-} 0.905 \text{Strength level } \le \text{c40} \\ 0.195 f_c^{0.785} \text{-} 0.905 \text{Strength level } > \text{c40} \end{cases} \tag{6}$$

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.

4.3. Establishment of numerical simulation model

Establish a numerical model using ABAQUS, as shown in Figure 2.

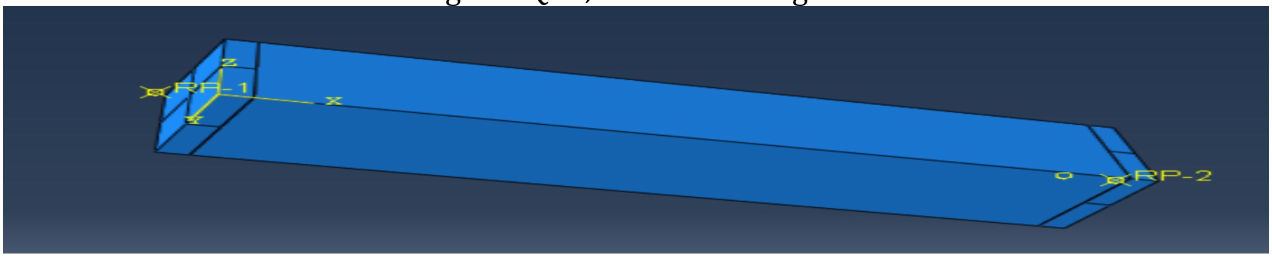

Figure. 2 Numerical simulation model of iron tailings concrete column

4.4. Numerical simulation result

Establish a numerical simulation model using ABAQUS to obtain the simulated yield strength, as shown in Table 3.

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

Test piece number	Grade of concrete	Ultimate load value/KN
Z-1	WC30	3053
Z-2	WC40	4026

Z-3	WC50	4547
Z-4	PC30	2865
Z-5	PC40	3726
Z-6	PC50	4349

5. Analysis of column bias bearing capacity

Based on the experimental results of the compressive resistance of reinforced concrete columns with iron tailings sand, as well as the comparison between the ultimate bearing capacity calculated based on the axial compression formula of ordinary reinforced concrete columns and the yield load obtained from numerical simulation, a comparison diagram is drawn, as shown in Figure 3

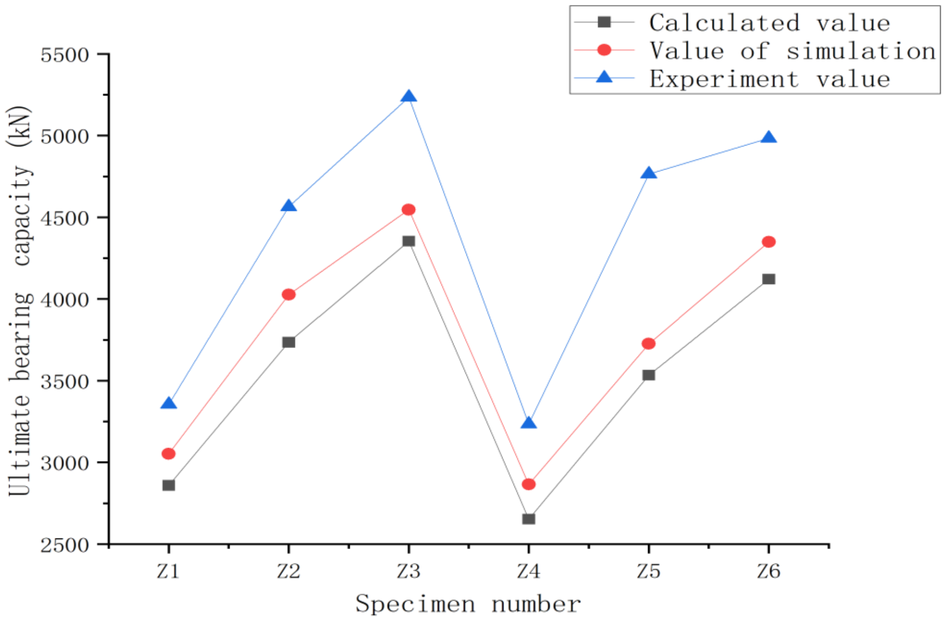

Figure. 3 Comparison diagram of experimental, calculated and simulated ultimate bearing capacity of biased column

From Figure 3, it can be seen that the curve trend is roughly the same, and the numerical difference is within a reasonable range. The simulated values are not significantly different from those calculated using the formula for calculating the ultimate bearing capacity of columns, at around 7%.Due to the fact that the ultimate bearing capacity calculated according to the axial compression formula of ordinary reinforced concrete columns only considers the bearing capacity of concrete and longitudinal bars, without considering the strength of the stirrups in the concrete, the finite element simulation model takes into account the influence of the stirrups during calculation, so the simulated value is slightly higher than the calculated value, which is more reasonable. During finite element simulation, the compressive stress-strain curve and damage of iron tailings sand concrete are generally affected by the use of ordinary concrete, and the columns generally work with cracks. When compressed, the stiffness will deteriorate, which has a significant impact on the simulated yield load; The reason why the experimental value is greater than the simulated value is that the compressive strength of concrete used in the calculation is 360Mpa, which is relatively conservative and retains more of its true bearing capacity. Therefore, it is greater than the simulated value, but still within a reasonable range.

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6. Numerical simulation

(1) The ultimate bearing capacity under numerical simulation is slightly greater than the value calculated by the column axial compression formula, about 7%, which is reasonable and meets the requirements.

(2) Compared with ordinary concrete columns, the ultimate compressive bearing capacity of iron tailings sand replacing natural sand concrete columns is roughly the same. Based on the analysis of compressive bearing capacity, iron tailings sand replacing natural sand is suitable.

(3) The numerical simulation results are lower than the experimental values, but still within a reasonable range, meeting the requirement of simply replacing the experimental values with simulated values.

(4) The difference between numerical simulation, calculated values, and experimental values is not significant and meets the requirements.

References

[1] Li Zhuang. Study on Mechanical properties of iron tailings concrete [J]. Sichuan Cement, 1020, (020,(02):10.

[2] Yao Lei, Li Xiaozhi, Lu Mingxing. Effect of iron tailings on concrete performance [J]. Concrete and Cement Products, 2019, (10):97-100.

[3] Xu Yunyun, Kang Hongzhen. Comparison of elastic modulus determination of iron tail sand concrete and ordinary concrete [J]. Shanxi Architecture, 2018,44 (36):233-234.

[4] Wang Dongwei. Study on Structural mechanical properties of iron tailings concrete [D]. Tangshan: Hebei United University, 2013.

[5] Kang Hongzhen, Zhang Kai, Ma Weihua, et al. Experimental study on full stress-strain curve of iron tailings concrete under axial compression [J]. Journal of Building Structures, 2015,36 (s2):373-378..

[6] Zhang Kai. Experimental study on axial compression performance of iron tailings concrete short column [D]. Tangshan: North China University of Science and Technology, 2021

[7] Zhang Longsheng. Experimental study on flexural stiffness and crack of simply supported iron tailings concrete beams [D]. Chengdu: Southwest Southwest Jiaotong University, 2015.