Effect of Different Parameters on Axial Compressive Behavior of Angle Steel Confined Reactive Powder Concrete Short Columns

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Abstract: This paper presents the mechanical performance of angle steel confined reactive powder concrete (ARRPC) short column under axial compression. A series of analysis were carried out on eleven specimens using RPC, batten plate spacing and slenderness ratio as parameters. The steel model the simplified bilinear constitutive model and RPC model was defined by the nonlinear constitutive model considering hoop effect, then the static simulation of ARRPC short column was carried out by ANSYS. The outcomes of analytical procedures mostly match well with the experimental results, so the rationality of the material constitutive model and the finite element model was verified. Based on this, the static behaviour analysis of eleven groups of ARRPC short column was carried out, and the load-displacement curves of the specimens were obtained. The effect of different parameters on the ultimate bearing capacity of the specimens was investigated. The numerical investigations show that when RPC strength is high, the specimens exhibit relatively large bearing capacity, while slenderness ratio and batten plate spacing increase, the ultimate bearing capacity of the specimen decreases. Finally, it can help propose the calculation formula of the bearing capacity of composite columns.

1. Introduction

Reactive powder concrete (RPC) is a new type of concrete material developed after high strength and high performance concrete. It is a kind of cement-based composite material with high strength, high toughness, high density and high durability. So far, the RPC mix ratio has been studied at home and abroad. J Dugat [1] and O Bonneau [2] had carried out experimental studies on the mechanical properties of RPC, such as stress-strain curve, compressive strength, bending strength, elastic modulus, Poisson ratio, fracture energy and so on. According to the axial compression test of angle steel reinforced concrete short column, the failure mode and the load-displacement curve of the specimens were obtained by W F Zhang [3], the formula for calculating its axial load strength was put forward. W F Zhang [4] carried out the eccentric compression short column test of angle steel confined high strength concrete. By observing the failure phenomenon and failure process of the specimen, a simplified formula for calculating the eccentric bearing capacity of this kind of specimen was put forward. As can be seen from
the above studies, the mechanical property of RPC confined angle steel is seldom studied, so finite element software ANSYS is used to simulate and analyze ARRPC short column under different parameters in this paper. The effect of different parameters on the axial compression behavior of this kind of short column is obtained, which lays a foundation for the formulation of the axial compression bearing capacity of this kind of short columns.

2. Finite element model and verification

2.1 Specimen design

In order to study the axial compressive behavior of ARRPC short column, 11 ARRPC short columns were designed with RPC, slenderness ratio and batten plate spacing as control parameters. The specific values are shown in table 1. In this table, $H$ stands for the height, $L$ stands for the section size of specimens. The shape size and section form of specimen A2 are shown in figure 1.

| Groups | Specimens | $H_{/\text{mm}}$ | $L_{/\text{mm}}$ | $H/L$ | Batten plate spacing $/\text{mm}$ | $f_{cu}/\text{MPa}$ | Batten plate |
|--------|-----------|-----------------|-----------------|-------|-------------------------------|-----------------|------------|
| A      | A1        | 600             | 200×200         | 3     | 100                           | 101             | Q235       |
|        | A2        | 600             | 200×200         | 3     | 50                            | 101             | Q235       |
|        | A3        | 600             | 200×200         | 3     | 20                            | 101             | Q235       |
| B      | B1        | 450             | 150×150         | 3     | 50                            | 101             | Q235       |
|        | B2        | 450             | 150×150         | 3     | 20                            | 101             | Q235       |
|        | C1        | 600             | 150×150         | 4     | 100                           | 101             | Q235       |
|        | C2        | 200             | 150×150         | 4     | 50                            | 101             | Q235       |
|        | C3        | 600             | 150×150         | 4     | 20                            | 101             | Q235       |
| D      | D1        | 600             | 200×200         | 3     | 100                           | 101             | Q345       |
|        | D2        | 600             | 200×200         | 3     | 50                            | 101             | Q345       |
|        | D3        | 600             | 200×200         | 3     | 20                            | 101             | Q345       |

Figure 1. Size and section form of A2.

2.2 Material constitutive model

The bilinear model without considering the strengthening effect is chosen as the constitutive model of steel, and the modified Mander model [5-6] is used as the core constrained RPC compressive constitutive model considering hoop effect in this paper.
2.3 Establishment of finite element model
SOLID45 and SOLID65 are chosen to simulate steel and RPC [7-8], so the geometric model is established by the solid modeling method. It is assumed that RPC is fully bonded to the steel [9-10]. The grid is divided reasonably, and the column bottom is fixed. The load is exerted by the displacement mode, so the finite element model is established.

2.4 Verification of finite element model
In order to verify the correctness of the establishment of finite element model in this paper, numerical simulation was carried out on the existing test specimens of angle steel confined concrete (ARCC) short columns under axial compression [11]. The load-displacement curves of the specimens were obtained. Compared with the load-displacement curves obtained from tests, both match well, so the reasonability and the correctness of the establishment of finite element model are verified. It is shown in figure 2.

![Comparison of finite element results and test curves.](image)

3. Parameter analysis

3.1 RPC
The load-displacement curves of four groups of ARRPC short columns are compared with those of angle steel confined concrete short columns under axial compression [12], which are shown in figure 3. The bearing capacity of composite specimens with RPC is improved obviously, which fully reflects the superior performance of RPC.
3.2 Batten plate spacing

When the column is bearing longitudinal pressure, the RPC will anamorphic stretching horizontally and the batten plate will be subjected to tensile stress due to the extrusion of the core RPC. Comparison of the load-displacement curves with different batten plate spacing are shown in figure 4. It can be seen with increasing of the distance of horizontal batten plate, the bearing capacity of ARRPC short columns under axial compression decreases gradually.

Figure4. Comparison of the load-displacement curves with different batten plate spacing.
3.3 Slenderness ratio
Comparison of the load-displacement curves with different slenderness ratios are shown in figure 5. It can be seen with increasing of slenderness ratios, the stiffness and ultimate bearing capacity of ARRPC short columns decrease.

![Figure 5. Comparison of the load-displacement curves with different slenderness ratios.](image)

4. Conclusion
Compared with the existing experimental data of concrete short columns confined by angle steel, the rationality of the finite element model was verified. Based on this, numerical simulation analysis of 11 groups of specimens was carried out. The load-displacement curves and the behavior of different parameters on the bearing capacity of specimens under axial compression were obtained. With the increasing of strength of RPC, the bearing capacity of specimens under axial compression will increase. On the contrary, with the increasing of slenderness ratio and batten plate spacing, the bearing capacity of specimens under axial compression decreases gradually.

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