Experimental research on behavior of axially circular CFRP steel tubular confined recycled aggregate concrete long columns

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Abstract. In order to reveal the mechanical properties of CFRP recycled aggregate concrete long columns under axial compression load, we designed 7 experimental members for the test. The specimens parameters are recycled coarse aggregate replacement percentage, slenderness ratio and layers of CFRP jackets. According to the test, the failure process and patterns were obtained, and the curve of load-displacement were measured. The influence of recycled coarse aggregate replacement ratio, slenderness ratio, layers of CFRP on the bearing performance of CFRP circular steel tubular confined recycled aggregate concrete long columns were analysed.

1. Introduction
According to many literatures, it can be concluded that compared with traditional concrete, recycled concrete has low strength and small elastic modulus, but its deformation performance is slightly larger than that of ordinary concrete[1][5]. In this age of composite structure development, in order to make up for the lack of bearing capacity of recycled concrete columns, many experts and scholars have designed the composite structure of recycled steel tube concrete[6][7]. The high pressure, ductility and fire resistance of steel tube can solve some shortcomings of recycled concrete to a large extent. But the recycled concrete filled steel tube at the same time of study, we found that the recycled concrete filled steel tube column waterproof, moisture proof performance is the disadvantage of insufficient, in this study we joined the CFRP sheet material, to a large extent, alleviate the steel tube of waterproof, moisture proof performance disadvantage, and the radial of CFRP sheet parcel ability, can effectively slow the deformation and failure of recycled concrete filled steel tube column. There is no doubt that CFRP reinforced recycled concrete column with steel tube is a new composite column with broad prospects. It can not only reduce the pollution of construction waste, but also make full use of the advantages of materials. This column has significant economic, social and environmental benefits.

2. Experimental Program
In order to study the regenerated concrete column reinforced with CFRP sheet, a total of 7 experimental components were designed in this test, and 3 influencing parameters were designed, respectively: replacement rate of regenerated coarse aggregate, slenderness ratio of specimens, and number of cladding layer of CFRP sheet. In the specimens, the replacement rates of recycled coarse aggregate are 0%, 50% and 100%, the water-cement ratio of concrete is 0.38 and its design strength is C30, as shown in table 1. The number of CFRP cladding layers is 0, 1 and 2. The ultimate tensile strength and elastic modulus of CFRP sheet obtained by the test conducted by the manufacturer are...
4210MPa and 255GPa. The lengthen and fineness ratios of steel tubes are 40, 48 and 56. After the steel tubes are processed and tested that the yield strength is 273 MPa and the ultimate tensile strength is 351 MPa and the elastic modulus is 202GPa. Experimental components are represented by FC-1, FC-2, FC-3, FC-4, FC-5, FC-6, and FC-7 respectively. Component parameters are shown in table 2.

### Table 1. Configuration parameters of recycled concrete

| Replacement rate (%) | Recycled coarse aggregate (kg/m³) | Cement (kg/m³) | Sand (kg/m³) | Natural coarse aggregate (kg/m³) | Water (kg/m³) |
|----------------------|----------------------------------|----------------|-------------|----------------------------------|--------------|
| 0                    | 0                                | 500            | 479         | 1231                             | 190          |
| 50                   | 615.5                            | 500            | 479         | 615.5                            | 190          |
| 100                  | 1231                             | 500            | 479         | 0                                | 190          |

### Table 2. All relevant parameters

| Specimen No. | D /mm | L /mm | t /mm | $f_{cu}$/Mpa | Slenderness ratio $\lambda$ | The numbers of CFRP Sheet | Replacement rate/% |
|--------------|-------|-------|-------|--------------|----------------------------|--------------------------|-------------------|
| FC1          | 100   | 1200  | 2.5   | 26.6         | 48                         | 1                        | 0                 |
| FC2          | 100   | 1200  | 2.5   | 16.9         | 48                         | 1                        | 50                |
| FC3          | 100   | 1200  | 2.5   | 12.9         | 48                         | 1                        | 100               |
| FC4          | 100   | 1000  | 2.5   | 12.9         | 40                         | 1                        | 100               |
| FC5          | 100   | 1400  | 2.5   | 12.9         | 56                         | 1                        | 100               |
| FC6          | 100   | 1200  | 2.5   | 12.9         | 48                         | 0                        | 100               |
| FC7          | 100   | 1200  | 2.5   | 12.9         | 48                         | 2                        | 100               |

3. Test Results and Discussion

3.1. Failure pattern

The specimen was placed in the center on the pressure plate for axial compression test. The specimen underwent three failure stages, namely elastic stage, elastoplastic stage and failure stage. At the early stage of loading, the specimen is in the elastic stage without obvious deformation. With the increase of load, concrete inside the specimen expands outwards under compression. As the load continued to increase, the middle part of the specimen buckled and the specimen bent. When the load increases continuously, CFRP sheets will break due to buckling of specimens. When the ultimate bearing capacity of the experimental component is reached, the failure degree of the specimen is aggravated and the failure speed of the specimen is accelerated, and the fracture of CFRP sheet wrapped in the periphery is aggravated. Failure of experimental components is shown in figure 1.

![Figure 1. Typical failure of specimen](image-url)
3.2. Load—Deflection Relationship

According to the data recorded in the experiment, load and deflection data of two typical test columns are selected to draw a graph, as shown in FIG. 2. It can be seen from figure 2 that the specimen is in the elastic stage at the initial stage of compression, and with the increase of load, the specimen is in the elastic-plastic stage and gradually develops to the failure stage. In addition, it can be concluded from figure 2 that when the recycled coarse aggregate of the specimen column increases, its compression bearing capacity continuously decreases.

![Figure 2. Typical load-deflection relationship](image)

4. Conclusions

According to the recorded test phenomena and data, CFRP sheet, steel tube and recycled concrete can be well combined and become a practical composite structure. With the decrease of the replacement rate of coarse aggregate of recycled concrete, the reduction of the length and slenderness ratio of test column and the increase of the number of CFRP cladding layers, the bearing capacity of specimens increases. The recycled concrete column reinforced with CFRP sheet also goes through three failure stages, namely the elastic stage, the elastoplastic stage and the failure stage.

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