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Mechanical behaviour of slenderness CFST filled with DCLs under axial compression

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Abstract. The demolished concrete lumps (DCLs) has been demonstrated to replacement partial coarse aggregates when casting concrete. The experimental studied involved 12 CFST columns. Each columns diameter was 159mm, the length of specimens was 2000, 2200 and 2400 mm. The Diameter-to-thickness (D/t) ratio was 79, 53 and 40. The replacement ratio of FC by DCLs was 0, 20, 40 and 60%. Test results indicated that the slenderness ratio was the most sensitive factor on the bearing capacity of slender columns under axial compression, followed by D/t ratio, and the DCLs replacement ratio was smallest factor. The ultimate bearing capacity decreased slightly with increasing DCL replacement ratio.

Keyword: DCLs CFST Axial compression slenderness

1. Introduction

Concrete-Filled Steel Tube (CFST) columns has been widely used in the civil engineering fields[1]. With the acceleration of global urbanization and the rapid development of civil engineering construction, a large number of abandoned concrete had been produced while building, rebuilding and expanding all kinds of buildings on a large scale, which seriously pollutes the environment. In addition, the rapid increase in aggregate demand had resulted in excessive development, which had led to the exhaustion of resources and the great destruction of the ecological environment, so that the contradiction between the sustainable development of concrete and aggregate demand has become increasingly prominent [4-5].

In order to reduce the cost of producing recycled aggregate (RA), The demolished concrete lumps (DCLs) had been demonstrated to replace some coarse aggregates when casting concrete. [5-8]. This method could reduce energy consumption.

However, few studies have focused on the sensitivity of factors affecting mechanical behaviour of slender circular steel columns filled with DCLs and FC under axial compression. This research was carried out on the basis of Bo Wu's study. The Orthogonal design method was adopted in this experiment. This study aims to investigate the sensitivity of factors affecting mechanical behaviour of slender circular steel columns filled with DCLs and FC under axial compression..

2. Experimental program

2.1. Materials and specimen details

The replacement ratio of FC by DCLs was 0, 20, 40 and 60%. 1Aa0, 5Bb0 and 9Cc0 were control specimens that were designed without DCLs in FC. The D/t ratio in these tests. According the EC4,

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the slenderness ratio (λ=4L/D) was obtained. The slenderness ratio was 50, 55 and 60. The details of the specimens are shown in Table 1.

Table 1. Detail of the test specimens Formatting sections

Specimen	L / mm	D / mm	t / mm	D / t / %	λ	η / %	N / kN
1Aa0	2 000	159	2	79	50	0	890
2Aa1	2 000	159	2	79	50	20	890
3Ac2	2 000	159	4	40	50	40	1 266
4Ab3	2 000	159	3	53	50	60	1 081
5Bb0	2 200	159	3	53	55	0	1 042
6Bb1	2 200	159	3	53	55	20	1 042
7Ba2	2 200	159	2	79	55	40	857
8Bc3	2 200	159	4	40	55	60	1 220
9Cc0	2 400	159	4	40	60	0	1 178
10Cc1	2 400	159	4	40	60	20	1 178
11Cb2	2 400	159	3	53	60	40	1 006
12Ca3	2 400	159	2	79	60	60	827

2.2. Material properties

The DCLs were obtained from one batch beams, The cube (150 × 150 ×150 mm) compressive strength of original beams was 34.6. The approximate size of DCLs were range from 30mm to 80mm. The DCLs physical properties were list in Table 3. The cube (150 × 150 ×150 mm) compressive strength of DCLs was listed as Table 4 and Table 5.

Table 2. Mechanical properties of steel tubes

Thickness /mm	f_y / MPa	f_u / MPa	E_s /MPa
2	345.6	414.0	2.04×10^5
3	314.2	401.3	2.08×10^5
4	332.7	407.6	2.17×10^5

Table 3. DCLs physical properties

Apparent density kg/m^3	Packing density kg/m^3	Clay percentage /%	Water absorption /%
2957	2130	2.1	7.03

Table 4. The mixture proportion

DCLs replacement ratio (%)	Cement ($kg.m^{-3}$)	sand ($kg.m^{-3}$)	Fine aggregate ($kg.m^{-3}$)	DCLs ($kg.m^{-3}$)	Water ($kg.m^{-3}$)
0	380	794	1 096	0	180
20	380	794	219	877	180

40	380	794	438	658	180
60	380	794	658	438	180

Table 5. Concrete compressive strengths

	Compressive strength (MPa)	Standard deviation (MPa)	Coefficient of variation (%)
28-day	35.1	0.8	2.9
Testing day	40.5	0.6	1.8

3. Test resultsand discussion

3.1. General behavior and failure mode

In order to reduce the influence of eccentricity on the specimen, the upper surface of the specimen was polished smoothly before loading. At the beginning of loading, the deformation of the specimen was not obvious, it was in the stage of elastic work, and the increase of deflection was approximately proportional to the load. With the increase of load, the specimens showed slight deformation, but not very obvious. When the specimen was loaded to the ultimate bearing capacity of 60%~80%, the lateral deflection at mid-height of the specimen increased rapidly, and the specimen entered the stage of elastic-plastic work. The steel tube restrained the concrete, the core concrete in the state of three-dimensional compression.

Fig.1. Potograph of specimens failure mode

3.2. Load strain response

With the increased of load, the convex side and concave side strains of the specimens were increased, and the convex side strain was larger than the concave side strain. When the applied load was about 60%~80% of the ultimate bearing capacity, the specimens began to enter the elastic-plastic stage. The increase of convex side and concave side strains were accelerated, and the slope of load-strain curve decreased, and the concave side deformation of the specimen increased. The convex side and concave side strains were large at mid-height of the specimens. After reaching the ultimate bearing capacity, the specimens entered the plastic stage, and the stress fall, the strain increased sharply, and the bearing capacity decreased rapidly.

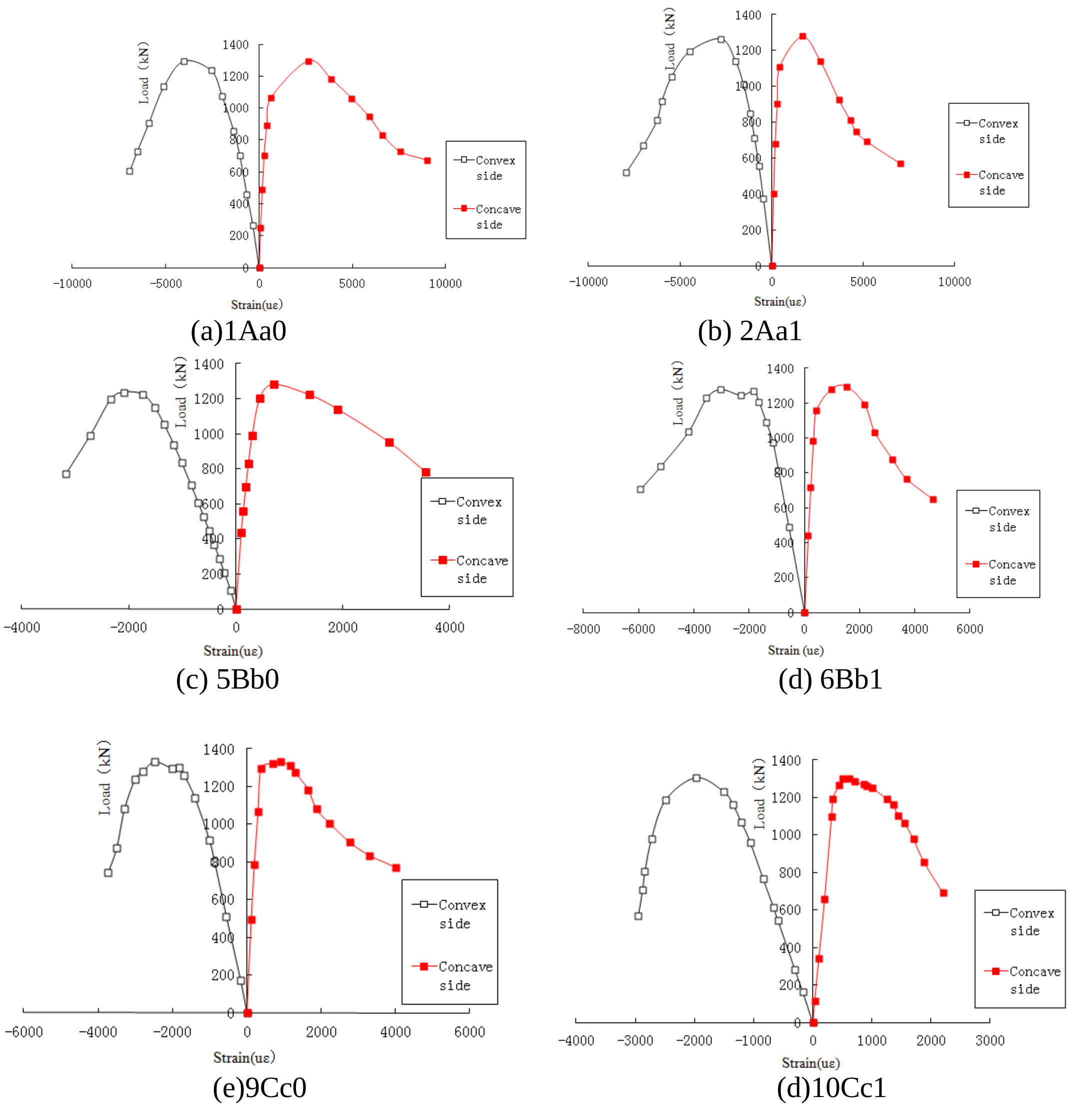

Fig.2 Load strain response of the specimens

Compared with column 1Aa0 and 2Aa1, the slope of load-strain relationship curve of column 1Aa0 ascending section was about 1.3, while column 2Aa1 was about 1.6, thus column 2Aa1 ascending section was steeper. Similarly, the descending section of column 2Aa1 was steeper than that of column 1Aa0. The ultimate bearing capacity of column 2Aa1 was about 98% of column 1Aa0. When the FC was replaced by DCLs, the rising and falling sections of the load-strain relationship curve were steeper, and the ultimate bearing capacity did not change significantly.

4. Conclusion

The mechanical behavior of CFST filled with DCLs under axial compression was presented. The following conclusions are drawn from the test results:

(1) Through comparative analysis, it could be seen that whether there were DCLs had no obvious effect on the mechanism and failure mode of the slender columns, and the failure of the specimens went through three stages: elastic stage, elastic-plastic stage and plastic stage. All the 12 specimens were destroyed by instability failure, and the ultimate failure form was arch. Through comparative analysis of load-strain relationship curve and load-displacement relationship curve, the following basic rules can be obtained: compared with CFST slender columns without DCLs, the rising and falling sections of the curve were steeper and the ultimate bearing capacity was slightly lower for the specimens with DCLs.

(2) The bearing capacity decreased by 7% with DCLs replacement ratio increased from 20% to 40%, , and the effect was not obvious.

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