DOI: 10.21276/sjet

Scholars Journal of Engineering and Technology (SJET)
Sch. J. Eng. Tech., 2017; 5(4):174-177
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(An International Publisher for Academic and Scientific Resources)
www.saspublisher.com

ISSN 2321-435X (Online)
ISSN 2347-9523 (Print)

Research Article

Simulation of the mechanical properties of concrete column confined by GFRP cloth with different reinforcement ratio based on ANSYS

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Abstract: In this paper, ANSYS finite element software was used, and the 3 kinds of reinforcement ratio of the specimens were analyzed by finite element method. The effect of reinforcement ratio on the mechanical properties of GFRP cloth reinforced concrete columns under axial compression was studied. The results showed that the ultimate compressive strength of reinforced concrete columns confined by GFRP cloth was improved with the increase of reinforcement ratio, and the size effect of GFRP steel bar was slightly improved.
Keywords: reinforcement ratio; GFRP cloth; ANSYS; ultimate compressive strength.

INTRODUCTION

In practical engineering, reinforced concrete columns are widely used, but the new composite columns are also developing [1]. For more than ten years, many scholars have put into the research work of GFRP sheet-constrained concrete members. The combination of these components effectively reduces the structural weight and slows down the aging of concrete columns. Through ANSYS finite element analysis software, The mechanical properties of reinforced concrete columns with GFRP cloth under different reinforcement ratios were studied. The influence of the reinforcement ratio on the ultimate compressive strength and the stress - strain of the composite structure is analyzed [2].

Simulation Specimen design

In order to study the mechanical properties of GFRP beam reinforced concrete columns under different reinforcement ratios. According to the reinforcement ratio of 2.1%, 2.8%, 3.8% were divided into A, B, C three groups of specimens, And the same kind of reinforcement ratio of the specimen meets the geometric similarity, that is, the strength of concrete grade are C30 with GFRP cloth volume configuration rate of 0.087,Specific parameters are shown in Table 1.

Table-1: Simulation specimen parameter table

Specimen number		Specimen scantling (mm×mm)	Concrete strength	Reinforcement Ratio (%)	Total thickness of GFRP sheet (mm)	GFRP sheet volume allocation rate ρ
A	A1	120×360	C30	2.1	2.601	0.087
	A2	160×480	C30	2.1	3.468	0.087
	A3	200×600	C30	2.1	4.335	0.087
B	B1	120×360	C40	2.8	2.601	0.087
	B2	160×480	C40	2.8	3.468	0.087
	B3	200×600	C40	2.8	4.335	0.087
C	C1	120×360	C50	3.8	2.601	0.087
	C2	160×480	C50	2.8	3.468	0.087
	C3	200×600	C50	2.8	4.335	0.087

$\rho=4n\cdot t/D$; n=layers of GFRP sheets; t=thickness of single layer of GFRP sheet; D=diameter of Specimen.

Establishment of model

The finite element model established in this paper is a separate model, without considering the slip between materials, the concrete adopts SOLID65 unit [3-5], GFRP cloth adopts shell41 unit, and the steel bar adopts link8 unit.

Finite element analysis

Ultimate compressive strength analysis

The ultimate compressive strength of specimens with different reinforcement ratio is shown in table-2.

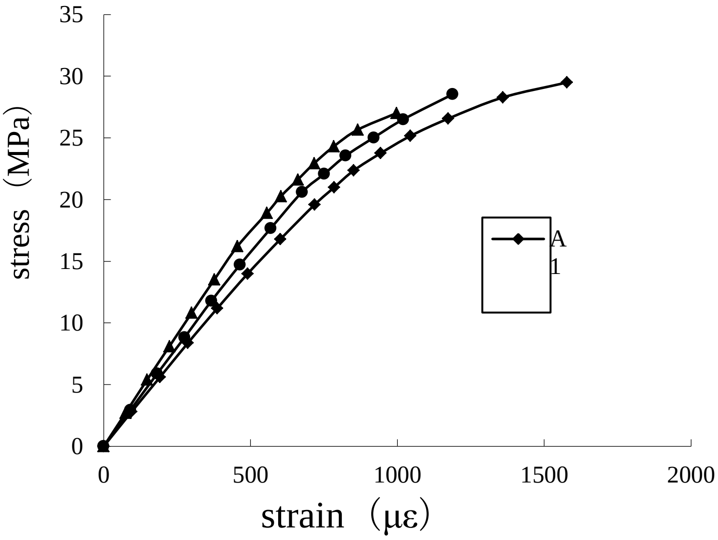
Table-2: Ultimate compressive strength of specimens

Specimen scantling (mm ×mm)	Specimen number	Reinforcement Ratio （%）	Ultimate bearing capacity (KN)	Ultimate compressive strength（Mpa ）	Decrease amplitude (%)
120×360	A1	2.1	500	44.23	—
	B1	2.8	515	45.56	3
	C1	3.8	539	47.68	4.66
160×480	A2	1.2	843	41.95	—
	B2	1.8	877	43.64	4.03
	C2	2.4	924	45.98	5.36
200×600	A3	1.2	1272	40.51	—
	B3	1.8	1328	42.29	4.4
	C3	2.4	1416	45.09	6.63

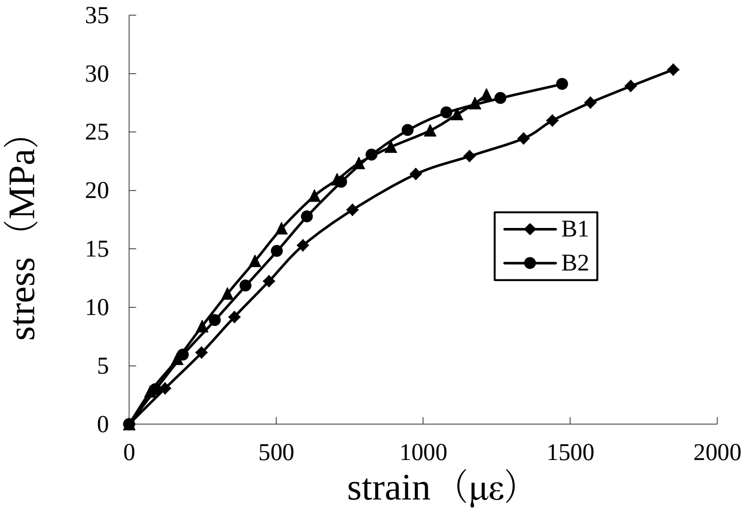
According to the table 4-1, we can see that the ultimate compressive strength of the specimens of the same size of B group is increased by 3%, 4.03%, and, respectively, with the ultimate compressive strength of A group as the reference, The ultimate compressive strength of the same size C group was increased by 4.66%, 5.36%, and 6.63%.There are some differences in the ultimate compressive strength of specimens with different reinforcement ratio. With the increase of the size, the ultimate compressive strength of the specimens with the ratio of 2.4% is smaller. The results show that the discreteness of concrete is much larger than that of steel bars, and the higher ratio of reinforcement will make the size effect of the specimen slightly improved.

Stress strain curve analysis

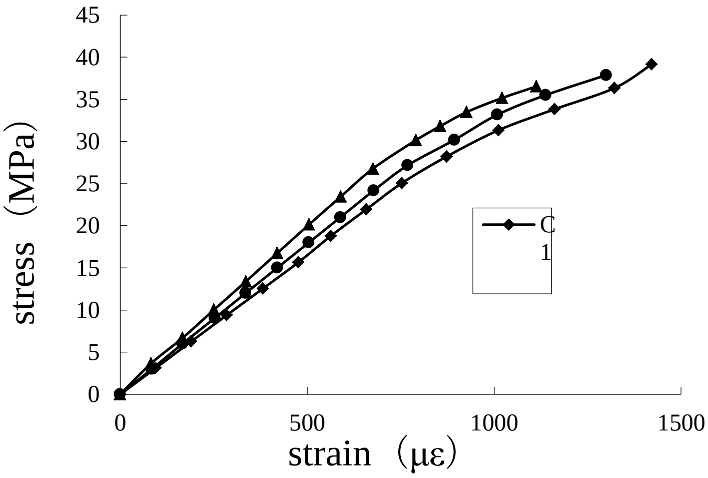
The axial stress strain of the specimens with the simulated reinforcement ratio of 1.2%, 1.8% and 2.4%, respectively, is shown in figure 1.



Stress strain curves of specimens in group A



Stress strain curves of specimens in group B



Stress strain curves of specimens in group C

Fig-1: stress-strain curves of specimens with different reinforcement ratio

Figure 1 shows: the geometry of GFRP confined similar specimens with axial stress-strain curves is different. The larger is the size of the specimen, the greater is the slope of the curve. The smaller the strain value corresponding to the same stress is. The larger the size, the greater the stiffness of the specimen, the better the effect of GFRP; The ultimate compressive strength and ultimate strain decrease with the increase of the size, which shows that the size of the specimen is restrained by the geometric similarity of GFRP reinforced concrete columns. The comparison of 1 (a), (b) and (c) of the three groups of specimens of the stress-strain curves of specimens of the same size, the reinforcement ratio is high, the curve is flat, the ultimate compressive strength and ultimate strain is larger, the better the ductility test.

CONCLUSION

In this paper, the numerical simulation of the axial compression of 9 reinforced concrete columns with GFRP sheets is carried out, and the ultimate compressive strength, stress nephogram and stress-strain curves are analyzed. The main conclusions are as follows

- When the reinforcement ratio of the specimen's increases, the ultimate compressive strength of reinforced concrete columns confined by GFRP sheets is improved to a certain extent and the size effect of the reinforced concrete columns confined by GFRP is slightly improved.
- For the same size of the specimen, the higher the rate of reinforcement, the ultimate strain is greater, while the ductility of the specimen is also better.
- The bigger the specimen size is, the worse the ductility is. It is suggested that the influence of the size on the ductility and the influence of the change of ductility on the test results should be taken into consideration in the study

of the mechanical properties of the large size composite components.

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