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Research Article

Study on Size Effect of GFRP Tube Concrete Steel Tube Composite Column under Axial Compression

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Abstract: FRP pipe concrete steel tube composite column (DSTC) is proposed by Professor Teng Jinguang, Hong Kong Polytech University, a new type of composite structure. In order to further study the axial compression performance of DSTC, this paper makes a deep research on the DSTC in different sizes under different conditions by the finite element simulation. According to the results of experiment and simulation, it can be known that, with the increase of the size of the specimen, the ability of resisting deformation is weakened, the effect of size effect on the mechanical properties of different concrete strength grade of DSTC is different, and the effect of size effect on the high grade concrete is less than that of the low grade concrete.
Keywords: GFRP tube concrete steel tube composite column, size effect, axial compression.

INTRODUCTION

FRP(Fiber Reinforced Plastics), is a kind of fiber reinforced composite plastic. In recent years, more and more fiber reinforced composite materials are used in the engineering [1]. The combination of FRP and concrete, on the one hand, the core concrete of three compression to improve the strength and ductility of, on the other hand, the existence of the concrete can avoid the occurrence of this kind of FRP thin-walled materials premature local buckling, give full play to the performance of materials [2]. Along with the development of FRP pipe combination structure, the new type of combination structure of DSTC has been developed, DSTC use of FRP, steel tube and concrete materials in force in the process of interaction, makes the strength is improved and can improve the plasticity and toughness properties. At the same time, the existence of the concrete can delay or prevent the local buckling of the inner tube.

Size effect refers to the material mechanics performance varies with the size. In the practical engineering application, in order to prevent the impact of this instability, we should make in-depth study on size effect. Therefore, the effects of the size of DSTC under axial compression research has important engineering significance.

SIMULATION SPECIMEN DESIGN

This chapter has designed the three conditions, respectively for the specimen size, concrete strength grade, the GFRP tube wall thickness, On the basis of meet the geometric similarity, high specimen diameter ratio of 3:1, each working condition of four different size of the specimen is designed [3, 4]. The design parameters of the specimen are shown in the following table 1.

Table 1: Design parameters of 2-1 model

Specimen number	Specimen scantling（mm×mm）	Concrete strength	FRP wall thickness (mm)	Hollow ratio	Steel pipe wall thickness (mm)
A1	100×300	C30	4	0.6	3
A2	150×450				4
A3	200×600				5
A4	250×750				6
B1	100×300	C45	4		3
B2	150×450				4
B3	200×600				5
B4	250×750				6

ESTABLISHMENT OF MODEL

In this paper, the model of DSTC specimen is established using the method of body modeling, for DSTC coat FRP pipe, the internal steel tube or intermediate sandwich of concrete can be considered as a torus, therefore, it can be directly generated by the CYL4 command in the ANSYS, and the ring body can be directly generated after the input ring and the outer diameter of the circular ring, and the starting end angle can be directly generated. The graphics of the test piece is shown in figure 1.

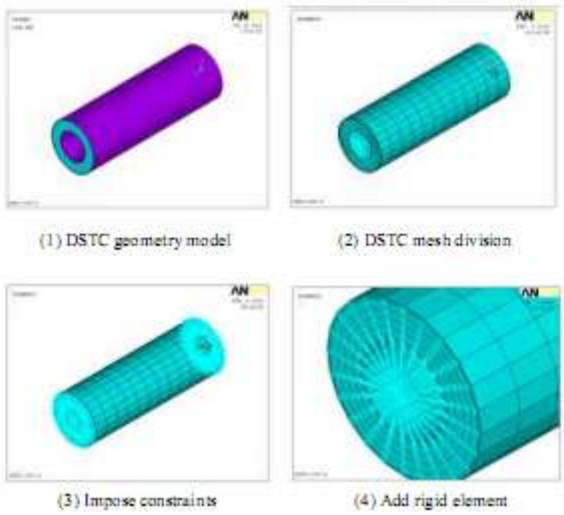

Fig-1: DSTC model

FINITE ELEMENT ANALYSIS

Limit stress variation analysis

The bearing capacity of the A group is shown in the following table 2.

According to the table 2 to see, on the basis of geometric similarity, the ultimate stress of the A group is decreased with the increase of the size of the specimen, the ultimate bearing capacity of A1 is less than A2, A3, A4, but the ultimate stress of A1 has reached 152.01MPa, far greater than the A2, A3, A4 of the ultimate stress value, the stress increment is not a constant value; According to figure 4-17 can be seen, the limit stress values of A group specimens showed a significant decrease, the curve showed a non-linear change trend. That small size test of bearing capacity and large size test piece bearing force and not in relation to the multiple, and not for trial size increases and increases to some degree, this with the experimental results consistent with the results.

Table 2: A group of bearing capacity

Test piece number	Ultimate bearing capacity (kN)	Ultimate stress(MPa)	Stress increment(MPa)
A1	721	152.01	—
A2	1090	97.76	54.25
A3	1562	77.13	20.63
A4	2135	66.62	10.51

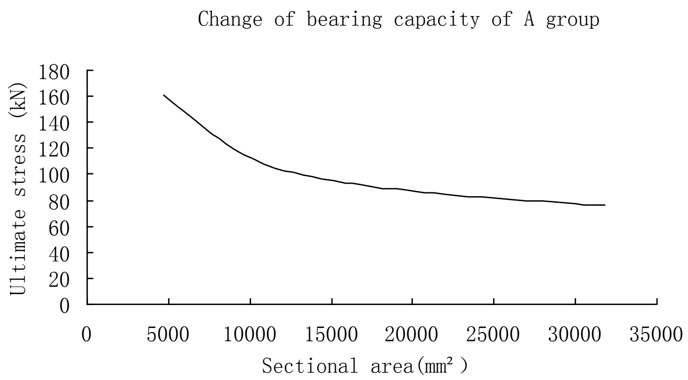

Fig-2: Change of bearing capacity of A group

Stress strain curve

The specimens of group A stress-strain curve.

From Figure 3, along with the change of specimen size, the difference between the test group A in the stress-strain curve is more obvious, the specific performance of the test piece with the increasing size of the curve gradually tends to slow, with the increase of specimen size, the strain value of specimen increases gradually, and the ability to resist deformation is decreased. Based on the results of the above analysis, the mechanical properties of the A group were affected by the change of the size of the specimen, showing the size effect.

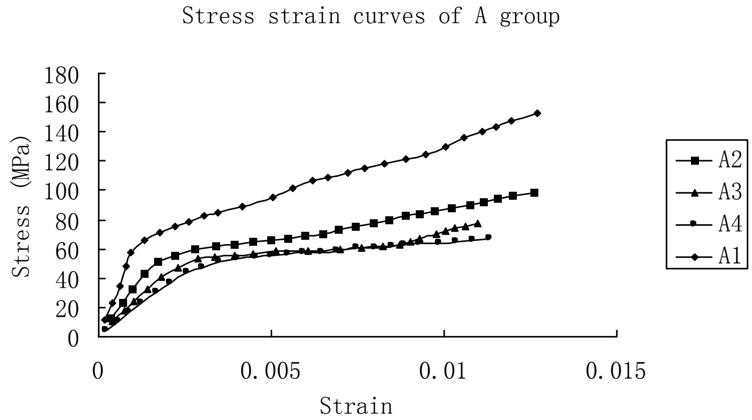

Fig-3: The specimens of group A stress-strain curve

Limit stress variation analysis

The bearing capacity of the B group is shown in the following table 3.

According to table 3 to see, on the basis of geometric similarity, the ultimate stress of the B group was decreased with the increase of the size of the specimen,B1 ultimate bearing capacity is less than the rest of the test specimens, B1 limit stress value is far greater than the rest of the test pieces, and the stress increment is not a fixed value; Figure 5 can be known, the limit stress of B group is significantly reduced, and the curve shows the trend of non-linear. The results obtained are in agreement with the A group.

Table 3: group carrying capacity changes

Test piece number	Ultimate bearing capacity (kN)	Ultimate stress(MPa)	Stress increment(MPa)
B1	761	160.45	—
B2	1187	106.46	53.99
B3	1738	85.82	20.64
B4	2415	75.36	10.46

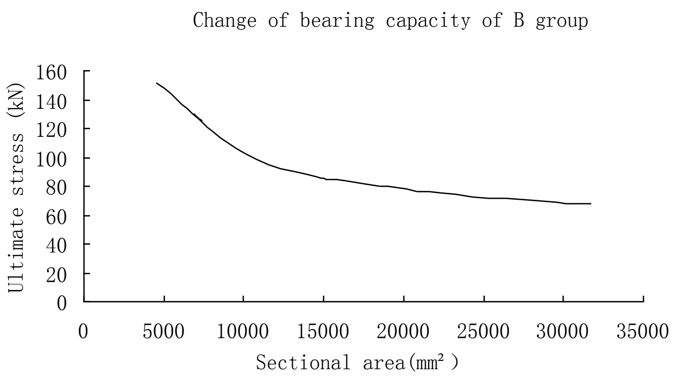

Fig-4: Change of bearing capacity of B group

Stress strain curve

The specimens of group A stress-strain curve.

As can be seen from figure 5, with the change of specimen size, in the B group, all differences between the stress-strain curves of the more obvious, the specific performance of the test piece with the increasing size of the curve gradually tends to slow, with the increase of specimen size, the strain value of specimen increases gradually, and the ability to resist deformation is decreased. Based on the results of the above analysis, the mechanical properties of the B group were affected by the change of the size of the specimen, showing the size effect.

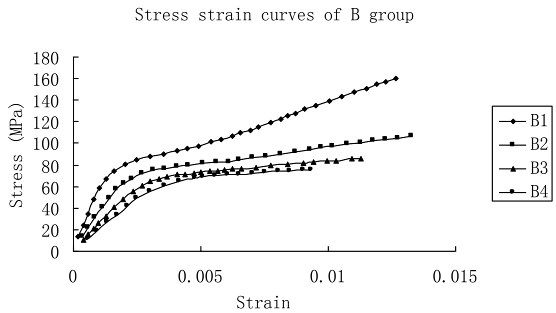

Fig-5: The specimens of group A stress-strain curve

CONCLUSION

In this chapter, first, to DSTC numerical simulation model was carried out to verify the bearing capacity and failure pattern, and, considering the specimen size, concrete strength, GFRP pipe wall thickness of the three conditions, the numerical simulation of DSTC test is carried out, and the following conclusions are obtained.

- Under different concrete strength grade, the effect of size effect on mechanical properties of DSTC is different, specific performance as the effect of size effect on the high grade concrete is weaker than the low grade concrete.
- In different condition of pipe wall thickness under the GFRP, the A group and the B group were affected by the size effect. With the increase of specimen size, the difference between the fitting curve and the fitting curve decreases gradually, increasing the GFRP tube wall thickness has certain help to enhance the capacity of specimen deformation resistance. But as the size of the specimen increases, the effect of this kind of help is weakened.

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