Numerical study of high-strength concrete column confined with high-strength stirrups under axial compression

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Abstract. In order to study the deformation and stress distribution of confined concrete, the axial compression behavior of high-strength concrete column confined with high-strength stirrups is simulated through through nonlinear finite element program. The finite element model reflect the confining effect of high-strength stirrups in specimen.The calculated results shown that the deformation of stirrups is not equivalent in the cross section and the longitudinal section and the confined stress and axial stress of concrete is not uniform in the cross section.

1. Introduction

The mechanical properties of concrete columns with stirrups have been studied widely in recently years, whereas the research result of concrete member confined with high-strength stirrups is still few [1-2]. Due to the test conditions and measurement methods, the distribution of internal stress and deformation in components could not well measured. In this paper, ABAQUS software was adopted to simulate the whole load process of high-strength concrete columns confined with high-strength stirrups. The calculated results are compared with the experimental results, and the stress characteristics of concrete and stirrups are analyzed.

2. Specimens Details

A total of 10 confined concrete specimens, each with a 200mm×200mm square cross section and 600 mm in height, were tested under concentric compression. Concrete compression strength, fc, measured by standard cube specimens (150×150×150mm) were 51.5 MPa and 57.4 Mpa respectively. The details of specimens are given Table 1 [3].

Table 1. Specimens Details.

Unit no.	f_c, MPa	Longitudinal reinforcement			Transverse reinforcement			
		No. of bars	Diameter mm	f_y MPa	Diameter mm	Spacing mm	f_{yh} MPa	ρ_v %
HC-1A	57.4	4	12	335	6.7	35	1143	1.91
HC-2A	57.4	4	12	335	6.7	45	1143	1.49
HC-3A	57.4	4	12	335	5	25	1183	1.49
HC-4A	57.4	4	12	335	5	35	1183	1.07

3. Numerical Model

The 3D8R solid elements was used to simulate concrete material. The constitutive relationship of the core concrete adopted the confined concrete model in literature [4]. The constitutive relationship of the cover concrete adopted concrete model in the concrete structure design specification. The T3D2 Reinforcement was used to simulate longitudinal reinforcements and stirrups. The constitutive relationship stress-strain model of steel was elastic-plastic model. An embedded contact adopted between concrete and steel. The bottom of the column was fixed, and an equal displacement was applied to the top of column. The numerical model is shown in Fig 1

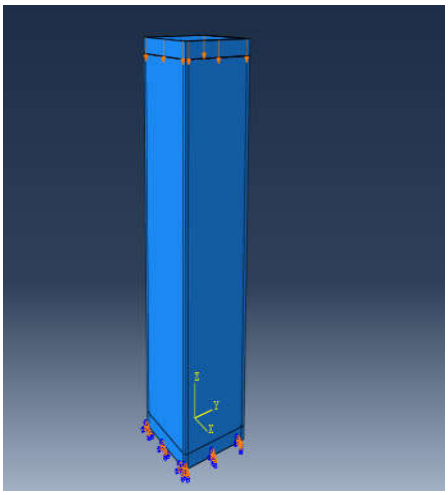


Figure 1. Numerical Model.

4. Result and Discussion

4.1. Calculated result

Figure 2 shows the comparison of the stress-strain curve of specimens between the numerical results and the test curves. It can be seen that the specimen is in the elastic stage before reaching the 80% of peak stress, and the confined effect of the stirrup is not fully developed. The finite element results of the peak stress and the elastic stiffness of specimens are closed to test value. For the descending section, the trend of numerical simulation results are consistent with the experimental results, the numerical simulation results showed flatter and higher residual strength.

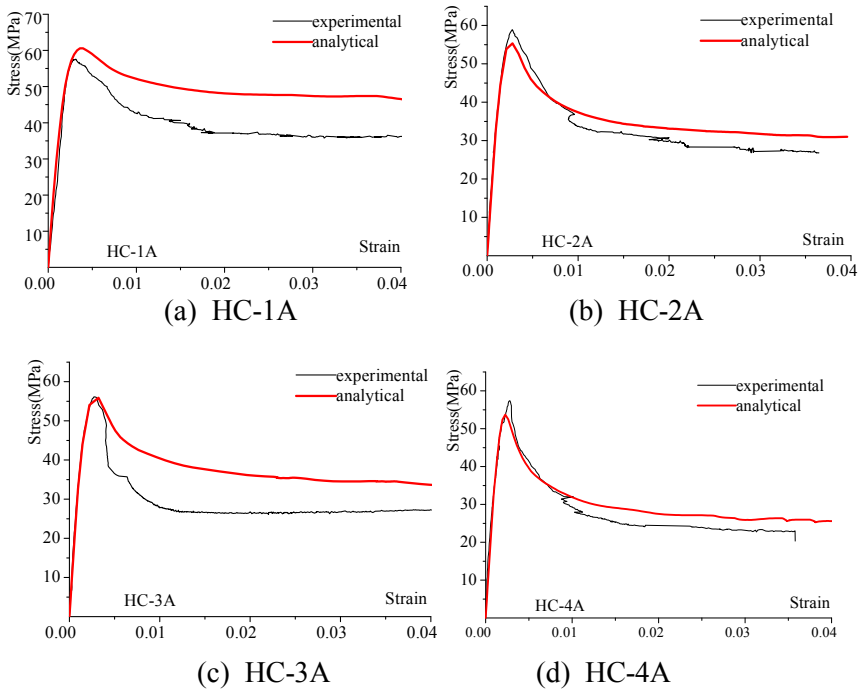


Figure 2. Comparison of Test curve and Simulated Result

4.2. Deformation of stirrups

The stirrups deformation is shown in Fig. 3 when specimen reached the peak load. The deformation of stirrups is not equivalent in both cross section and longitudinal section of specimen. In cross section, the maximum deformation occurs at the midpoint of the leg of stirrups, whereas the deformation of leg corner of stirrups is the smallest. This is one of difference characters between square stirrups and hoop ties. In longitudinal section, the stirrups deformation in middle part is larger than that in the end of the specimen.

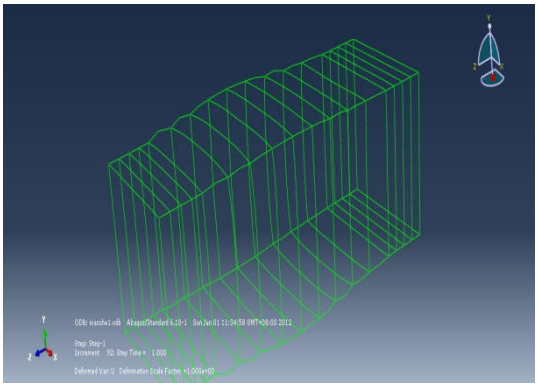
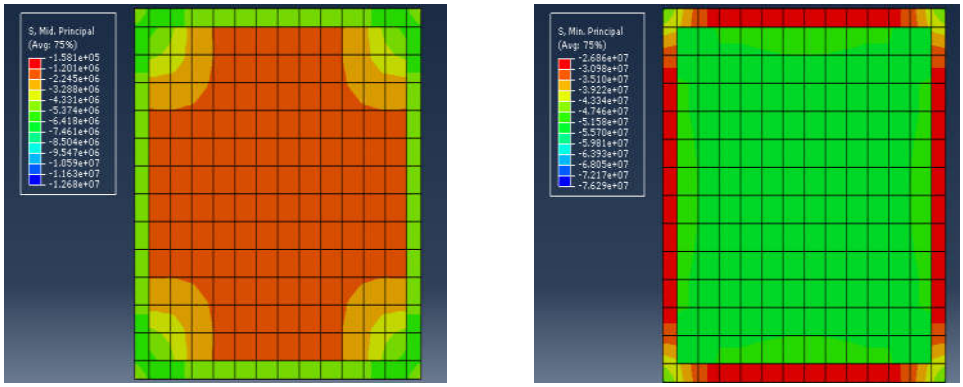


Figure 3. Deformation of stirrups.

4.3. Stress Distribution of Concrete

Figure 4 show the distribution of confined stress and axial stress at peak load of specimen H4A. It can be seen that the confined stress is relatively higher in the corner of cross section and the confined stress is lower in the middle part of the cross section. The distribution pattern of axial stress is similar to the confined stress in the in the cross section, but the its distribution is relatively uniform.



(a) confined stress (b) axial stress

Figure 4. Stress Distribution of Concrete

5. Conclusion

The axial compression behavior of high strength concrete column confined with high strength stirrups is simulated through nonlinear finite element program. The main conclusions are as follows:the finite element model could simulate the mainly mechanical property of test specimens. The deformation of stirrups is not equivalent in the cross section and the longitudinal section of specimen, the maximum deformation occurred at the midpoint of the leg of stirrups in cross section, the stirrups deformation in middle part was larger than that in the end of the specimen in the longitudinal section. The confined stress and axial stress of concrete is not uniform in the cross section, the confined stress is relatively higher in the corner of cross section; the distribution pattern of axial stress is similar to the confined stress in the in the cross section.

Acknowledgments

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