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Analysis on the Ductility Performance of Reinforced Concrete Coupling Beams in Shear Wall Structure

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Abstract. Coupling beam, the first line resisting earthquake, is directly related to the overall performance of the shear wall structure. Using the large general finite element analysis software ANSYS, the coupling beam span-depth ratio is 2~3 different reinforcement scheme in finite element analysis. Analysis on the ductility performance of reinforced concrete coupling beams in shear wall structure in three fields: the concrete strength grade, the longitudinal reinforcement ratio and the stirrup ratio, provides a basis for the design of the structure and to provide a reference for similar studies.

The Preface

Coupling beam, as the important member connecting shear walls, is in the first line resisting earthquake. Since the coupling beam is much important, it should be paid more attention to the design of it. Seismic performance of the best design method of coupling beam of shear wall structure is one of the most focus problems by engineers related in regulations[1][2].At present, the research for coupling beams whose span-depth ratio is between 2~3 is still not perfect. It still takes experience design methods in project. So the span-depth ratio in 2~3 even beams of finite element simulation analysis has an important practical significance for engineering design.

Model design: Section size b×h =200 mm×800 mm, clear span ln =2200 mm, concrete strength grade are C30, longitudinal reinforcement strength grade HRB400, volume reinforcement ratio was 2.0%, the stirrup strength grade for HPB300, stirrup rate was 0.8%. Load all adopt the monotonic loading, loading area is located in the top of the model. On two pieces of wall limb respectively on load of 5 N/mm2 downward vertical, axial compression ratio of 0.3. Horizontal load direction is horizontal to the right, adopt the method of step by step loading, each basic maintain uniform load, until the model reach ultimate bearing capacity [3[4], as shown in the Fig.1 and Fig.2.

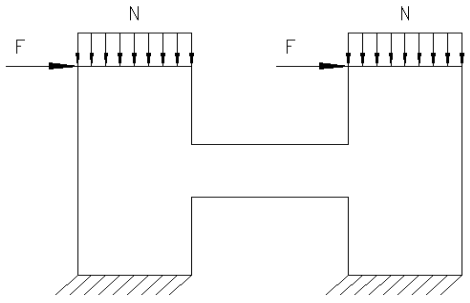

Fig.1 The picture of force diagram

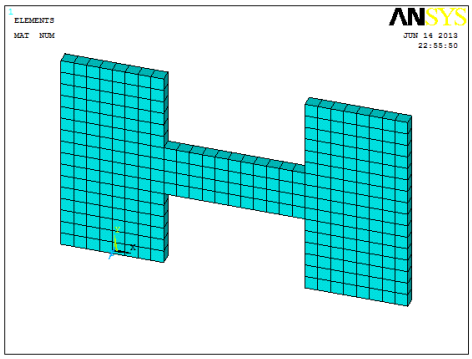

Fig.2 The picture of coupling beam model and mesh

The influence of the concrete strength grade on coupling beam ductility

Coupling beam shear walls with different strength grade of concrete materials:C30, C40, C50 and C60, respectively corresponding to the model named CB-C30, CB-C40, CB-C50 and CB-C60. Other conditions remain unchanged, increase the strength grade of concrete, compared under the condition of different strength grade concrete member ductility performance.

ANSYA analysis concluded that the ductility of the model of finite element calculation results shown in Tab.1, analysis results contrast diagram as shown in Fig.3 and Fig.4.

Tab.1 Loading contrast

model number	cracking displacement (mm)	yield displacement (mm)	ultimate displacement (mm)	ductility coefficient
CB-C30	0.19	3.46	6.25	1.81
CB-C40	0.31	3.98	6.4	1.61
CB-C50	0.26	4.18	6.62	1.59
CB-C60	0.23	5.49	8.09	1.47

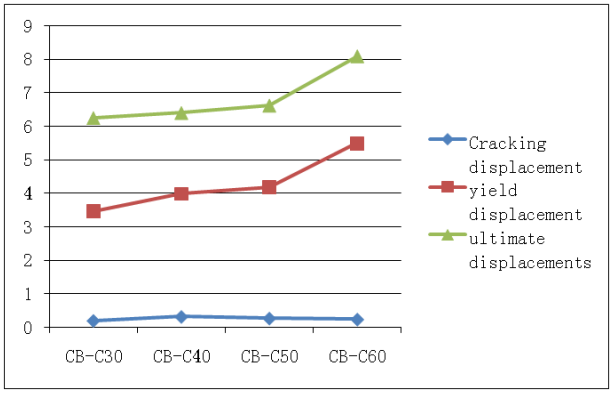

Fig.3 The displacement curve of the different model

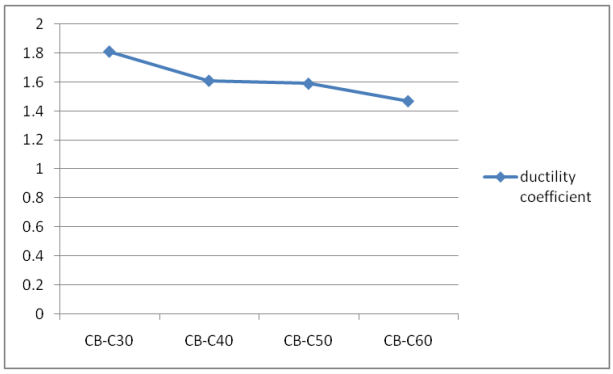

Fig.4 The ductility coefficient curve of the different model

From the different models of displacement and ductility contrast curve can be seen that the concrete strength grade changes on the performance of coupling beam ductility and deformation capacity is: In keeping the ratio of longitudinal reinforcement and depth of reinforcement and stirrup ratio under the condition of invariable, with the improvement of concrete strength grade, the four models of cracking displacement change is not obvious, the basic level crack displacement curve, showed the change of concrete strength grade to cracking displacement effect is not obvious; the four models of yield displacement and ultimate displacement are showing a more obvious rising trend. In terms of increasing amplitude model CB-C60 increases more obviously, the rest of the model of yield displacement and ultimate displacement amplitude is stable; the four models of the trend of the ductility coefficient decreased gradually. Explain the structure bearing capacity, its ductility is falling.

The influence of the longitudinal reinforcement ratio on coupling beam ductility

Coupling beam shear walls with different longitudinal reinforcement ratio and volume are respectively 1.2%, 1.4%, 1.6%, 1.8% and 2.0%, and the corresponding model named CB-1.2, CB-1.4, CB-1.6, CB-1.8and CB-2.0. Other conditions remain unchanged, increase the longitudinal stress steel reinforcement ratio, the volume is under the condition of different reinforcement ratio of component ductility performance.

ANSYA analysis concluded that the ductility of the model of finite element calculation results shown in Tab.2, analysis results contrast diagram as shown in Fig.5 and Fig.6.

From the different models of displacement and ductility contrast curve can be seen, reinforcement ratio of longitudinal reinforcement volume changes on the performance of coupling beam ductility and deformation capacity is: In keeping the stirrup ratio and concrete strength grade under the condition of invariable, with the increase of reinforcement ratio of longitudinal

reinforcement volume; displacement of five models of crack and yield displacement change are not obvious, the crack displacement and basic level, the yield displacement curve shows that change of longitudinal reinforcement volume reinforcement ratio on the cracking displacement and the influence of the yield displacement is not obvious; the limit displacement of five model presents a relatively obvious rising trend. In terms of increasing amplitude of CB-1.4 to CB-1.6 obvious increase, the rest of the model limit displacement increase much; the ductility of the model are also increasing, but the growth rate is different. With CB-1.2, CB-1.4, CB-1.6 compared to CB-1.8 model CB-2.0 the ductility of the best.

Tab.2 Loading contrast

model number	cracking displacement (mm)	yield displacement (mm)	ultimate displacement (mm)	ductility coefficient
CB-1.2	0.34	2.43	3.68	1.51
CB-1.4	0.41	2.6	5.61	2.16
CB-1.6	0.3	2.82	6.51	2.3
CB-1.8	0.45	2.86	8.36	2.92
CB-2.0	0.46	2.88	9.43	3.28

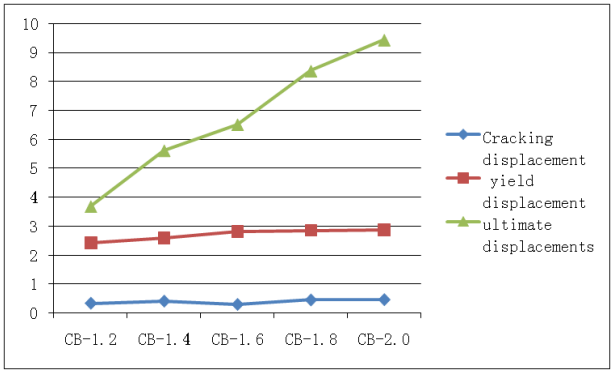

Fig.5 The displacement curve of the different model

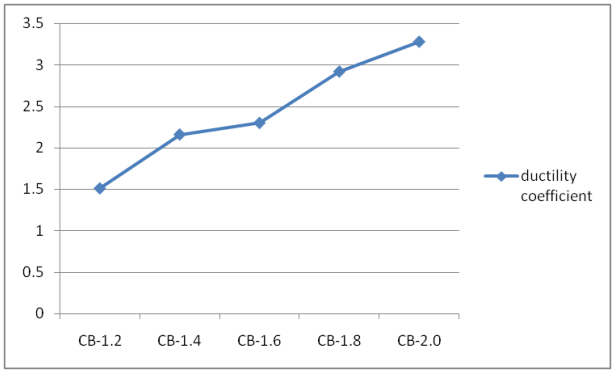

Fig.6 The ductility coefficient curve of the different model

The influence of the stirrup ratio on coupling beam ductility

Shear wall beam with different reinforcement ratio, respectively, 0.8%, 1.0%, 1.2%, 1.4% and 1.6%, and the corresponding model named CB-0.8, CB-1.0, CB-1.2, CB-1.4 and CB-1.6. Other conditions unchanged, accordingly increase the rate of reinforcement, reinforcement compare in different rate under the condition of member ductility performance.

ANSYA analysis concluded that the ductility of the model of finite element calculation results shown in Tab.3, analysis results contrast diagram as shown in Fig.7 and Fig.8.

From the different models of displacement and ductility contrast curve can be seen that changes in the rate of reinforcement effect on ductility and deformation capacity of coupling beam is shown as: Under the condition of the longitudinal reinforcement ratio unchanged, with the increase of stirrup ratio, five models of cracking displacement change are not apparent, cracking displacement curve of the basic level, that change the stirrup ratio of cracking displacement effect is not obvious; five models of yield displacement and ultimate displacement are showing a more obvious rising trend. In terms of the increase amplitude, the yield displacement increases steadily, the limit displacement increase amplitude is more noticeable; the ductility of the model are also increasing, but the growth rate is different. And the ductility of the CB-0.8 the worst, CB-1.0, CB-1.2 and CB-1.4 three models remain steady upward trend, and the ductility of the CB-1.6 the best model.

Tab.3 Loading contrast

model number	cracking displacement (mm)	yield displacement (mm)	ultimate displacement (mm)	ductility coefficient
CB-0.8	0.21	2.55	5.16	2.02
CB-1.0	0.23	3.71	7.19	1.94
CB-1.2	0.24	3.88	7.42	1.91
CB-1.4	0.26	4.33	7.99	1.84
CB-1.6	0.27	4.42	8.1	1.83

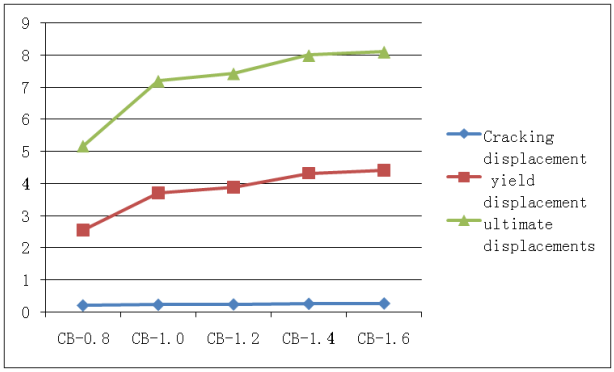

Fig.7 The displacement curve of the different model

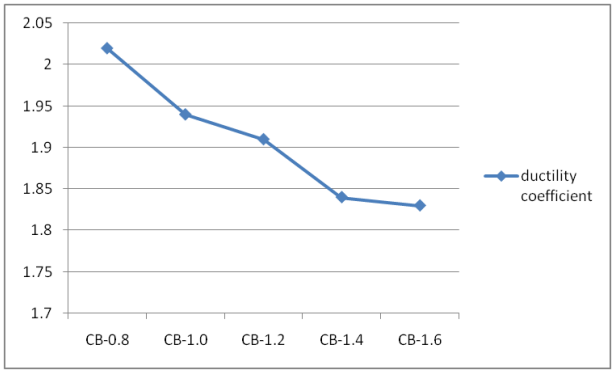

Fig.8 The ductility coefficient curve of the different model

Conclusions

Using the large general finite element analysis software ANSYS, the coupling beam span-depth ratio is 2~3 different reinforcement scheme in finite element analysis, through the comparison and analysis, the following conclusions:

When the concrete strength grade improves the ductility coefficient of structures showed a decreasing trend, its ductility decreases.

When longitudinal reinforcement volume reinforcement ratio increases, the ductility of the structure performance is only on a small scale, slow increase, the range is not big. Advice when designing this kind of coupling beam longitudinal reinforcement satisfies the structural requirements.

When volume stirrup ratio increases, the ductility of the structure performance increase, increase rate is not obvious. Advice when designing this kind of coupling beam and encryption stirrup area meets the structural requirements.

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