

Experimental study on Bond slip relationship of Steel sleeve

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Abstract: The assembled concrete structure is usually connected with the steel bar through the sleeve. In order to realize the optimum design of sleeve structure and develop new sleeve, the author put forward a new test method, and made 18 specimens for uniaxial tensile test. Study the influence of the strength of grouting material, diameter of reinforcing steel bar on bond slip relationship between steel bar and grouting material and its failure characteristics by experimental research. This result suggests that with the increase of age, the bond strength between steel bar and grouting material is increasing gradually, the increase speed gradually slowed down after 20 days. For CT20H sleeve, with the increase of the diameter of reinforcement, the bond strength between reinforcement and grouting material increased gradually. Conclusion: In the optimization design of the sleeve, under the premise of ensuring the smooth injection of grouting material and be convenient for the positioning of the reinforced members, reducing the inner diameter of the sleeve can improve the bond strength between reinforcement and grouting material.

key word: Assembled concrete structure; sleeve; bond slip; Constitutive relation

1 INTRODUCTION

Steel sleeve grouting connection is made of high strength, rapid hardening inorganic slurry in the connection between reinforcement and special sleeve connecting pieces. In recent years, with the development of assembled concrete structure, Both the domestic and abroad did a series studies of grouting sleeve. Huang Hejun discussed the bonding mechanism of anchoring adhesive through tensile shear test of 20 metal sleeve bonding specimens, put forward the constitutive relation of anchoring adhesive slip. It can be used as a reference finite element analysis^[1]. Wu Xiaobao did monotonic tension and one-way repeated tension test in 36 specimens, researched the influence of age (1, 4, 7, 28d) and steel type (HRB500 and HRB400) on the mechanical properties of the steel sleeve grouting connection^[2]. Shu Ruibin obtained the bond slip constitutive relation of two interface slip, including the rubber band and the plastic

tube by the anchorage experimental study on steel sleeve, through the equipartition method, they get the steel sleeve anchorage system of the rubber band interface and a rubber cylinder interface separate bond slip constitutive relationship^[3]. Wang Yuxin choose smooth and ribbed reinforcement with different corrosion rate to make concrete center pull out specimens with same strength grade, he obtained the bond slip relationship curve between corroded steel bars and concrete under cyclic loading^[4]. Zheng Shansuo made 20 trusses specimens pull-out test of bond slip behavior of solid web type steel reinforced concrete member, set up a formula about reinforced concrete bond strength and slip quantity^[5]. Xu Feng proved that the bond slip relationship is independent of the path of the lateral stress field, then concluded that changes in lateral stress field under the bond slip curve is the superposition of numerous fixed lateral stress field under bond slip curve^[6]. At the same time, foreign scholars have done some research on bond slip, Hunebum

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Kocarrived out the experiment of 54 members under cyclic loading and obtained the bond slip constitutive relationship of fiber reinforce d concrete^[7]. Kankam C respectively tested the tensile members of the low carbon steel, cold rolled steel bars and hot rolled bars with a diameter of 25mm. After analyzed, he got the relationship between the bond strength, the stress of the steel bar and the slip^[8]. Chen, G. And Baker, G studied the influence of bond slip on the crack spacing of concrete by simulation in 2003, and believed that the influence of bond slip on the crack spacing is very obvious^[9]. Belleri、Andrea et al^[10] put the grout sleeve for column and foundation connections in earthquake zones, and found that the grouting sleeve connection is similar to the traditional connection, which can ensure the ductility and energy dissipation capacity of the connection area.

So far, few people have studied the bond slip between the steel bar and the grouting material or the sleeve and grouting material. The reason was that the space in the slurry anchored bar connecting sleeve internal is too small to determine the displacement of steel relative grouting material and the sleeve relative grouting material by direct method. In this paper, we used test methods to give the bond slip relationship between the internal reinforcement grouting material in the sleeve by indirect method, and the bond slip relationship between the sleeve grouting material will be studied as a follow-up work.

2 SPECIMEN MAKING

This test grouting material comes from Beijing Jian Mao CGMJM-VI, 1d compression strength(35MPa), 20d compression strength(60MPa), 28d compression strength(85MPa); Sleeve is Beijing Jian Mao CT20H, diameter is 20mm; Special steel sleeve for reinforcement: The strength grade of reinforcement is HRB400, diameter are 16mm, 20mm and 22mm, the purpose is to determine how the steel bar diameter make the influence of reinforcement-grouting material bond slip relationship. It is made 18 specimens, 6 days of drawing test, respectively grout 1d、3d、7d、15d、20d and 28d, the purpose is to determine how the strength of grouting material make the influence of reinforcement-grouting material bond slip relationship. Test piece numbering rule "sleeve length - steel bar diameter". The specific grouping is shown in Table 1.

Table 1 Specimen grouping

Group number	Test piece number	Group number	Test piece number
1d	T160-D16	3d	T160-D16
	T160-D20		T160-D20
	T200-D22		T200-D22
7d	T160-D16	28d	T160-D16
	T160-D20		T160-D20
	T200-D22		T200-D22

The cross section size of the test block is 250mm*250mm, along the length of the reinforcement direction is consistent with the sleeve length, as shown in figure 1.

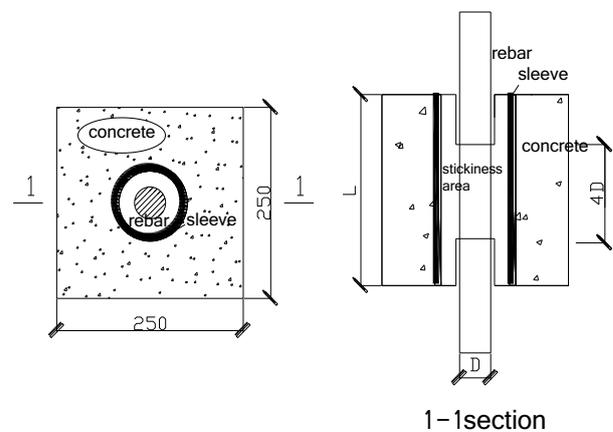


Fig. 1 Specimen shape and loading diagram

Sleeve length is 8d, d is the diameter of reinforcement, Intermediate 4d is the bond length between the reinforcement and the sleeve, the remaining 4d are distributed on both ends of the component. The advantage of this is that it can avoid the influence of the loaded end socket on the bond strength of the reinforcement-sleeve. In the specific production, according to the size of the test block to make wood mold, drill holes in the middle of the two cross cutting panels which parallel to each other. The diameter of a hole is the same as the external diameter of the sleeve, ensuring that the sleeve can be inserted into the mold smoothly from one side. The diameter of the other hole is equal to the diameter of the reinforcement, so that the steel bar can be passed through the mold smoothly. In order to facilitate grouting. at both ends of the sleeve, connected the groutig hole with outlet hole by pvc pipe.

In order to avoid the splitting failure of concrete, arrange a piece of steel mesh on both ends of the sleeves. For the convenience to fix free end displacement meter. Cut 50mm thread at one end of reinforcement, Wrap steel

bar surface with PVC pipe at a appropriate position in the other end of the reinforcement, The gap between the PVC pipe and the reinforcement is filled with the rubber mud to prevent the grouting material from entering. In order to reduce the bond strength between the PVC pipe and the grouting material, the outside surface of the PVC pipe is brushed with a mold release agent. after fixed, insert the reinforcement from one side of the sleeve, arranged the bonded reinforcement in the middle of the sleeve, used the Rubber plug to fix reinforcement in the sleeve. At the end of all preparations, mix concrete in the field, Pour into the mold, vibrate it slightly, Water and conserve for 30 days, then prepare for grouting.



Fig. 2 Specimen fabrication diagram



Fig. 3 Rebar processing diagram

After the concrete strength is stable, start grouting. According to the requirement of grouting material product specification, water cement ratio should be controlled in 3:25. First, we weigh 10kg grouting material and put it into the plastic bucket, and then weighed 1.2kG water, add slowly to the plastic bucket. Stir and water at the same time, and ensure that the grouting material just like water. Finally, use the grouting lance to extract grouting material, grout from grouting hole, when the slurry flow out from grouting hole, the grouting is successful. At the same time, in order to get the strength of grouting material, make a batch of 40mm * 40MM * 160mm test blocks. carry out the first batch of drawing tests after grouting for 1d.



Fig. 4 Injection of grouting material

3 LOADING METHOD

In order to measure the displacement of the relative grouting material before the test. the hole of Loading plate on the test block surface should not be too large, the opening diameter should be less than or equal to the inner diameter of the sleeve. To avoid the relative displacement between sleeve and test block. we use 40t hydraulic jack and reflexive force principle design, The loading device is shown in Figure 5 and Figure 6. The size of the force is obtained by the sensor. The displacement of the relative grouting material of the reinforcement in the loading end is measured by the two displacement gauge at the end of the loading end. Displacement of the free end steel bar relative to the grouting material is used to measure the free end two displacement gauge. Loading system: 0 → maximum tension → 0, the load rate range is 0.5~1.0MPa/s.



Fig. 5 Loading device diagram

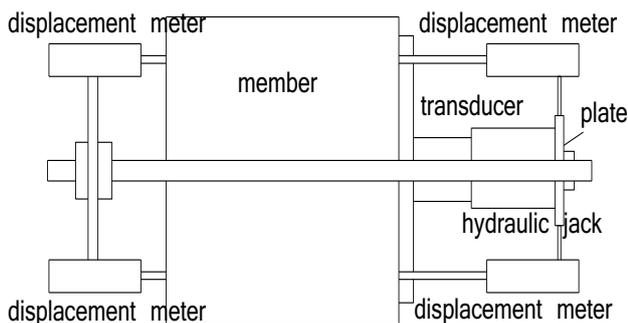


Fig. 6 Loading diagram

4 TEST CONTENT AND ULTIMATE LOAD

The test contents of the experiment are loaded end load, load displacement and free end displacement, compression strength of grouting material test block, rupture strength. The load in Table 2 is the ultimate load, Loading end displacement and free end displacement are displacement value of ultimate load. Rupture strength test block is three of each group, compression strength test block is six of each group.

Table 2 The test results

Days	number	Load(kN)	Loading end displacement(mm)		Free end displacement(mm)		Rupture strength(MPa)	compression strength(MPa)	
1d	T160-D16-I	45.29	3.0	3.1	0.5	0.6	3.1	32.6	33.5
	T160-D20-I	78.37	2.9	3.1	0.6	0.7	3.2	34.5	34.1
	T200-D22-I	100.38	3.1	3.3	0.6	0.8	3.4	35.5	34.5
3d	T160-D16-I	58.88	3.2	3.3	0.6	0.7	5.0	52.2	53.3
	T160-D20-I	101.89	2.9	3.0	0.7	0.5	5.3	54.1	54.7
	T200-D22-I	130.49	3.0	3.2	0.7	0.8	5.2	55.7	54.4
7d	T160-D16-I	72.46	3.3	3.2	0.6	0.6	5.8	61.6	64.2
	T160-D20-I	125.40	3.1	3.1	0.7	0.7	6.1	61.9	65.8
	T200-D22-I	160.61	3.1	3.2	0.7	0.8	6.6	64.0	63.6
15d	T160-D16-I	90.58	5.2	5.3	1.2	1.3	7.0	72.8	72.8
	T160-D20-I	156.79	5.4	5.5	1.3	1.3	6.9	74.8	76.1
	T200-D22-I	200.76	5.4	5.4	1.2	1.2	7.2	76.5	78.1
20d	T160-D16-I	108.70	5.3	5.3	1.3	1.3	8.0	82.8	82.8
	T160-D20-I	188.15	5.5	5.5	1.2	1.2	7.9	81.8	81.1
	T200-D22-I	240.91	5.4	5.4	1.4	1.3	8.2	80.5	82.1
28d	T160-D16-III	120.77	7.5	7.6	1.5	1.6	8.8	85.6	86.2
	T160-D20-III	209.05	7.5	7.5	1.7	1.7	8.7	86.9	85.8
	T200-D22-III	267.68	7.6	7.6	1.6	1.6	8.6	87.1	86.6

5 LOAD DISPLACEMENT CURVE

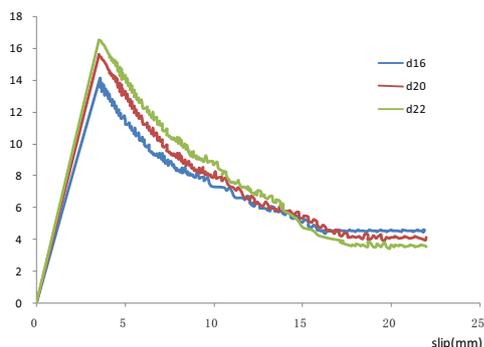


Fig. 7 The bond-slip curve of the first day

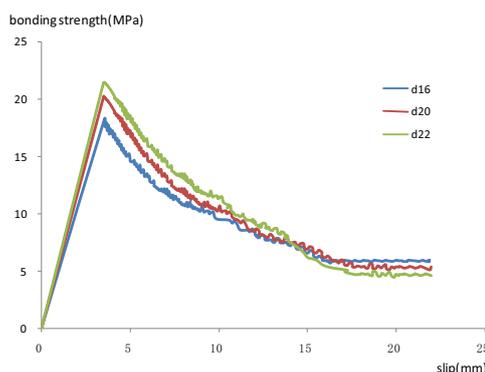


Fig. 8 The bond-slip curve of third day

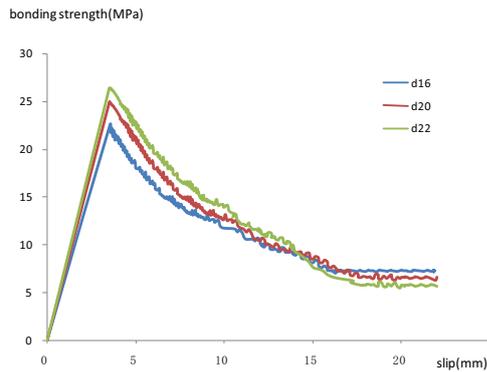


Fig. 9 The bond-slip curve of seventh day

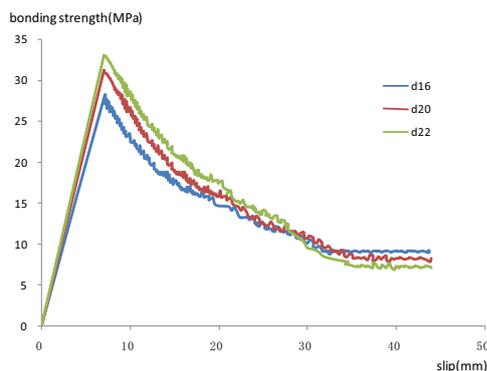


Fig. 10 The bond-slip curve of fifteenth day

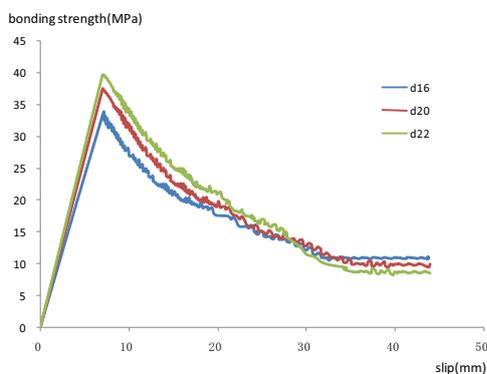


Fig. 11 The bond-slip curve of twentieth day

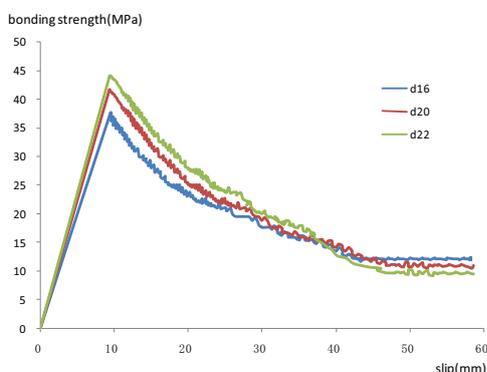


Fig. 12 The bond-slip curve of twenty-eighth day

1) with the increase of age, the bond strength between reinforcement and grouting material increased gradually, and the speed of 20d increased gradually.

2) for the CT20H sleeve, with the increase of the diameter of reinforcing steel bar, the bond strength between reinforcement and grouting material increases gradually. The reason is that the increase in the diameter of reinforcement will cause the increase of the mechanical bite force between reinforcement and grouting material. (The thickness of the grouting material between the steel bar and the sleeve is reduced, the height of the column formed after the cracking of the grouting material is reduced, and the compression strength is increased.)

3) It is possible to reduce the size of the inner diameter of the sleeve, but it is necessary to ensure the orientation of the reinforcing bar between the grouting material and the member during the construction.

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6 CONCLUSIONS