

Study on collaborative work performance of GFRP rebar and concrete

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Abstract:In the study ,the coordination of GFRP rebar and concrete working performance are studied from two aspects of theory and experiment. By Making 9 groups of GFRP - concrete standard drawing specimen standard drawing and three groups of reinforced concrete specimen ,Getting the damage characteristics of GFRP rebar and the bond strength - slip curve by drawing experiment, Analysing the influence factors of bond strength of GFRP rebar and concrete.The study provides a reference and theoretical basis of the application and popularization of concrete structure.

Preface

Glass fiber reinforced resin reinforcement is made up of resin and glass fiber composite.It is call "GFRP". Compared with steel, GFRP rebar has the following advantages: high strength, low quality, good corrosion resistance, small xu variables [1].In modern society,the people promotes the use of green, energy-saving building materials. So using GFRP rebar to replace the steel and the use of GFRP -concrete structure is more and more important. Ji-kai Zhou and Du Qinqing have studied the the tensile and compressive mechanical properties of GFRP rebar [2], [3]. The GFRP -concrete structure has been applied in the field of civil engineering.

The main factors of collaborative work performance

The main factors of the GFRP and concrete collaborative work performance is two.One is the linear expansion coefficient,The other is the bond strength between GFRP rebar and concrete. The linear expansion coefficient of concrete is $(7.2\sim 10) \times 10^{-6}/^{\circ}\text{C}$, the linear expansion coefficient of GFRP rebar is $(6.0-10.0) \times 10^{-6}/^{\circ}\text{C}$. The linear expansion coefficient of GFRP rebar between GFRP rebar is very close. When working environment temperature changes, temperature stress between GFRP rebar and concrete is very small, So the GFRP rebar and concrete can work together very well.

The GFRP rebar- concrete structure is made of two kinds of GFRP rebar and concrete characteristics completely different materials. As a whole inhomogeneous material, the GFRP rebar-concrete structure must ensure that GFRP rebar and concrete has reliable work performance.Oniy the cooperative work of two, the stress transfer on the boundary between GFRP rebar and concrete can be realized. And build a working stress of the structure bearing capacity needs.The Studying of GFRP rebar and concrete work performance is the basis and premise for application of GFRP rebar- concrete structure.

The GFRP rebar surface shape is similar to ordinary reinforced bar, So the composition of the bond stress of GFRP rebar and concrete are similar to ordinary rebar. It's composed of Chemical glue on, mechanical bite force and friction force [4]. But the materials properties of GFRP rebar with

ordinary steel is completely different. The GFRP rebar is resin and glass fiber composite materials. There is difference between the bonding performance of the GFRP- concrete structure and the Reinforced concrete structure The author studies the characteristics of the bonding performance of GFRP rebar and concrete By making 9 groups of GFRP rebar and concrete drawing specimens and three groups of common pull-out reinforced bar and concrete specimen. By contrast, find the differences and similarities between the two, the suggestions and prospects are proposed for the application of GFRP rebar in concrete structure.

The experiment

The appearance of two kinds of reinforced material size is the same: the outer diameter is 14mm; the inner diameter is 13.4mm;the pitch of screw threads is 0.7d; the angle between the axes and cross rib is 45° ; The surface area of the cross rib is 0.065mm² .

The test specimen meet with the specification of Canadian Standards Association(CSA)[5]. Bond anchorage length is 56mm(4d); Each group of three standard cube of concrete; concrete strength is C30. The detailed structure of the specimens as shown in Figure 1

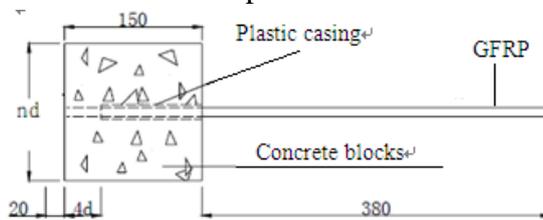


Figure 1: Schematic diagram of the sample

Experimental apparatus as shown in Figure 2. Getting the drawing force P by electronic universal testing machine. Getting the rebar free sliding displacement by the two electronic displacement meter which is Setted in the bottom of the rebar. Getting the slippage by the two electronic displacement meter which is setted in the rebar loading area.

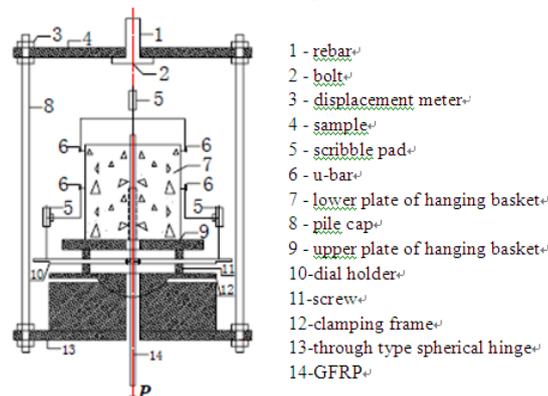


Figure 2: Schematic diagram of test unit

Collecte and analyze The experimental results

The bonding strength calculating formulas for the rebars and concrete:

$$\sigma = \frac{P}{sl} \quad (1)$$

In the equation: σ for the bonding strength of the raber and concrete, s for the perimeter of the raber, l for the bond length of the rebars and concrete, P for drawing force.

The formula for sliding displacement :

$$s = s_0 - \delta_e \quad (2)$$

In the equation: s_0 for the raber free sliding displacement, δ_e for the elastic elongation magnitude of plastic pipe Isolation.

$$\delta_e = \frac{P}{EA} L \quad (3)$$

In the equation:E for elastic modulus of raber,A for cross-sectional area of raber,L for raber length of plastic pipe isolation period.

The collections of experimental data of the 3 groups of reinforced concrete drawing specimen are shown in table1. The collections of experimental data of the 9 groups of GFRP concrete drawing specimen are shown in Table2

Group number	Specimen numbe	P (KN)	average of P (KN)	σ (Mpa)	s (mm)	average of s (mm)
G I	a	22.67	21.21	8.62	1.36	1.17
	b	18.40			0.97	
	c	22.56			1.18	
G II	a	21.87	21.90	8.90	0.99	1.45
	b	21.09			2.34	
	c	22.74			1.01	
GIII	a	18.90	20.60	8.37	1.65	1.52
	b	20.58			1.79	
	c	22.31			1.12	

Tab1.the data collections of the 3 groups of reinforced - concrete drawing specimen

The failure forms of bond between GFRP rber and concrete are GFRP rebar was uprooted because of rib concrete was cut up. The relative slip between GFRP rebar and concrete is caused by the rib concrete shear failure. That leads to bonding failure between GFRP raber and concrete. But to be in when bond damage, there was no splitting cracks in concrete specimen, That means ultimate strength of bond destruction have not reached the ultimate compressive strength of concrete.From Figure 3,we can see there are black powder on the surface of concrete. It was surface abrasion of the GFRP raber cross rib. So the bond strength between GFRP rebar and concrete is not only controlled by the strength of the concrete, and the shear strength of the GFRP rebar itself.



Figure 3: GFRP rebar surface wear

Group number	Specimen numbe	P (KN)	average of P (KN)	σ (Mpa)	s (mm)	average of s (mm)
I	a	19.90	18.87	7.66	2.46	2.47
	b	18.40			2.97	
	c	18.30			1.98	
II	a	19.80	18.27	7.42	1.99	2.44
	b	16.70			2.34	
	c	18.30			3.01	
III	a	18.90	19.53	7.93	2.65	2.85
	b	20.50			2.79	
	c	19.20			3.12	
IV	a	19.60	20.53	8.34	2.56	2.25
	b	21.80			2.15	
	c	20.20			2.04	
V	a	16.80	17.80	7.23	1.96	2.10
	b	14.70			1.89	
	c	21.90			2.46	
VI	a	15.70	16.50	6.70	2.47	2.74
	b	17.90			2.41	
	c	15.90			3.35	
VII	a	19.10	19.17	7.79	1.86	2.31
	b	15.80			1.94	
	c	22.60			3.13	
VII	a	18.30	19.73	8.02	2.76	2.87
	b	19.40			3.17	
	c	21.50			2.67	
VIII	a	17.10	18.17	7.38	2.75	2.89
	b	16.20			2.86	
	c	21.20			3.06	

Tab2:the data collections of the 9 groups of GFRP- concrete drawing specimen

From Table 1 and Table 2, the bond strength between GFRP rebar and concrete is less than the bond strength between the same shape reinforced and concrete. It means when strength of concrete was high, The shear strength of itself of GFRP rebars is the main factor affecting the bond behavior between GFRP rebars and concrete. That is completely different with reinforced concrete bond strength mainly depends on concrete strength.

According to the bond strength - slip curve[6](Figure 4),There is clearly difference between Bonding strength of GFRP rebar and concrete and the bond strength.of reinforced concrete. The stress process of GFRP raber can be divided into four stages: linear phase, friction, decline period, residual period,but The stress process of steel raber only can be divided into threer stages: cementation section, friction, extrusion section. The bond strength of GFRP rebar decreased rapidly, linearly in falling phase. The bond strength is cycle decreased In residual bonding stage.All of these are different from steel - concrete structure.These phenomena was the cause of the gripping force

and the friction force of GFRP rebar and concrete were decreased that Because the surface of GFRP tendons cross rib was woreed.

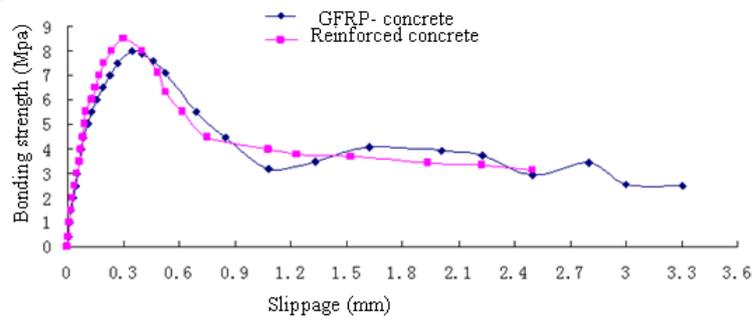


Figure 4: bonging strength-slippage curve

The conclusion

1.The coefficient of linear expansion of GFRP raber was closed to the concrete.

2.The failure mode of GFRP raber –concrete was the GFRP rebar was uprooted.The pull-out failure mode of GFRP raber was caused of the rib concrete was shear failure and the sueface of the GFRP was woreed. So the shear strength of GFRP raber have a significant influence on the bond behavior between GFRP and concrete. The shearing strength of the GFRP rebar is less than its tensile strength makes the bond strength of GFRP rebar and concrete is less than the same condition of the rebar.

3.The Bond strength- slip curve of GFRP raber was composed of four stages: linear phase, friction, decline period, residual period. The bond strength is cycle decreased In residual bonding stage ,and the decaying process began to flatten With the increase of slip.

The paper carries on the research and analysis on the cooperation work performance between GFRP raber and concrete from both aspects of theory and experiment. The result can provide reference for technical application and theoretical analysis of the GFRP rebar and concrete structure.

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