

# Study on the Mechanical of TRC permanent formwork's cement-based materials

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**Abstract.** The TRC permanent template can be made very thin because it does not require a steel protective layer. Therefore, it puts forward higher requirements for cement composite materials. In order to get the best performance of cement base composite material mixture ratio, this article by controlling the chopped glass fiber content, water/cement ratio and contrast research of cement composites compressive strength, flexural strength and splitting tensile strength. The results show that the fiber content has a good effect on improving the mechanical properties of materials, but it should be controlled around 5%. Hydrocolloidal ratio is 0.33 and cement-sand ratio is 0.3, and water-binder ratio is too large to cause bleeding.

## 1. Introduction

Textile Reinforced Concrete (TRC) combines multi-axial fiber textiles with fine concrete to give full play to the advantages of each component. And the fiber braid does not require a concrete protective layer, so the TRC sheet can be as thin as 1 cm. However, it requires sufficient strength and rigidity for cement-based composites and good mixing properties. Domestic scholars have studied lately on fiber reinforced mesh reinforced concrete, but there have been many advances. Shen linghua and Xu shilang's research on the interfacial properties of fiber bundles and fine concrete showed that both epoxy resin and pre-stress could improve the mechanical properties of fiber reinforced concrete reinforced concrete, and proposed the concept of critical distribution rate <sup>[1]</sup>; Yin shiping's research on the mechanical properties of TRC in harsh environments showed that TRC template could better resist the adverse effects of chloride, freeze-thaw and other harsh environments, but even after epoxy treatment, the tensile strength of carbon fiber bundles cannot get fully played <sup>[2-3]</sup>; Xun Yong, Sun wei confirmed that the alkali-resistant glass chopped fibers could better the mechanical properties of TRC plates through experiments <sup>[4-6]</sup>.

The application and promotion of TRC permanent formwork requires that it must have certain strength and rigidity. This paper mainly improves the mechanical properties of TRC materials by controlling the mix ratio of cement-based composite materials, thus laying a foundation for the next permanent formwork test.

## 2. Experimental materials

### 2.1 Fine aggregate

The fine aggregate selected for the cement-based composite material is river sand. The apparent density of the sand measured is 2.738 g/cm<sup>3</sup>, the bulk density is 1.6 g/cm<sup>3</sup> and the fineness modulus is



2.7. The maximum particle size is 2mm, which is medium sand with a mud content of 0.94% and a water content of 2.04%.

### 2.2 Cement matrix

The cement used in this test is the “Conch” brand 42.5 grade portland cement produced by Conch.

### 2.3 Glass fiber

Chopped glass fiber fibers can better constrain the development of cracks in cement-based materials. Therefore, the alkali-resistant glass fibers with a length of 15 mm are selected and their physical properties are shown in Table 1.

Table 1. Basic mechanical properties of chopped glass fiber

filament ( $\mu\text{m}$ )	diameter	density ( $\text{g}/\text{cm}^3$ )	strength (MPa)	of extension	elasticity (MPa)	modulus
15		2.7	2800		82	

### 2.4 Fly ash and water reducing agent

Fly ash is selected from Grade II fly ash produced by Yancheng Power Plant. The water reducing agent is JM-PCA (I) polycarboxylate superplasticizer (Water reduction capacity is 18% to 22%) produced by Nanjing Subote New Material Co., Ltd.

## 3. Experimental design and production

There are many factors affecting the strength of cement-based composites. According to the preliminary test, three factors of water-binder ratio, glass fiber content and cement-sand ratio are selected as the main research objects; different levels are selected for each factor; other factors are relatively unchanged. The glass fiber content (the ratio of glass fiber mass to cementitious material) is 2%, 4%, 5%, 6% respectively; the water-binder ratio (the ratio of the water consumption of concrete to the mass of all cementitious materials) is 0.30, 0.30, 0.45 respectively; the cement-sand ratio (the ratio of concrete cement to sand quality) is 0.15, 0.30, 0.45 respectively. According to the above ratio of materials, the total number of test pieces is 36 sets. According to the "Code for Design of Masonry Mortar Mixing Ratio" (JGJT 98-2010) and "Test Method for Mechanical Properties of Mortar for Steel Wire Mesh" (GBT7897-2008), the flexural strength, compressive strength and splitting tensile strength test were tested respectively. The specimen code uses fiber content-sand ratio-water-binder ratio, such as 2-0.15-0.3, which indicates that the fiber content is 2%, the cement-sand ratio is 0.15 and the water-binder ratio is 0.3.

### 3.1 Flexural strength test

According to the "Code for Design of Masonry Mortar Mixing Ratio" (JGJT 98-2010) and "Test Method for Mechanical Properties of Mortar for Steel Wire Mesh" (GBT7897-2008), the sample size is 40×40×160mm prismatic shape, each set of 3 test pieces. After the test piece is completed, it is cured for 28 days (temperature  $(20 \pm 2)^\circ\text{C}$ , relative humidity 95% or more). The flexural test requires that the test piece must not have obvious defects, and the loading speed is controlled at  $50\text{N} \pm 10\text{N}$  per second. The test results were calculated as the arithmetic mean of each of the three test pieces. When one of the three measured values exceeds 10% of the average value, the intermediate value is taken as the test result of the resistance strength; when the two exceeds the intermediate value by 10%, the test results of this group are invalid. The test results are shown in Figure 1.

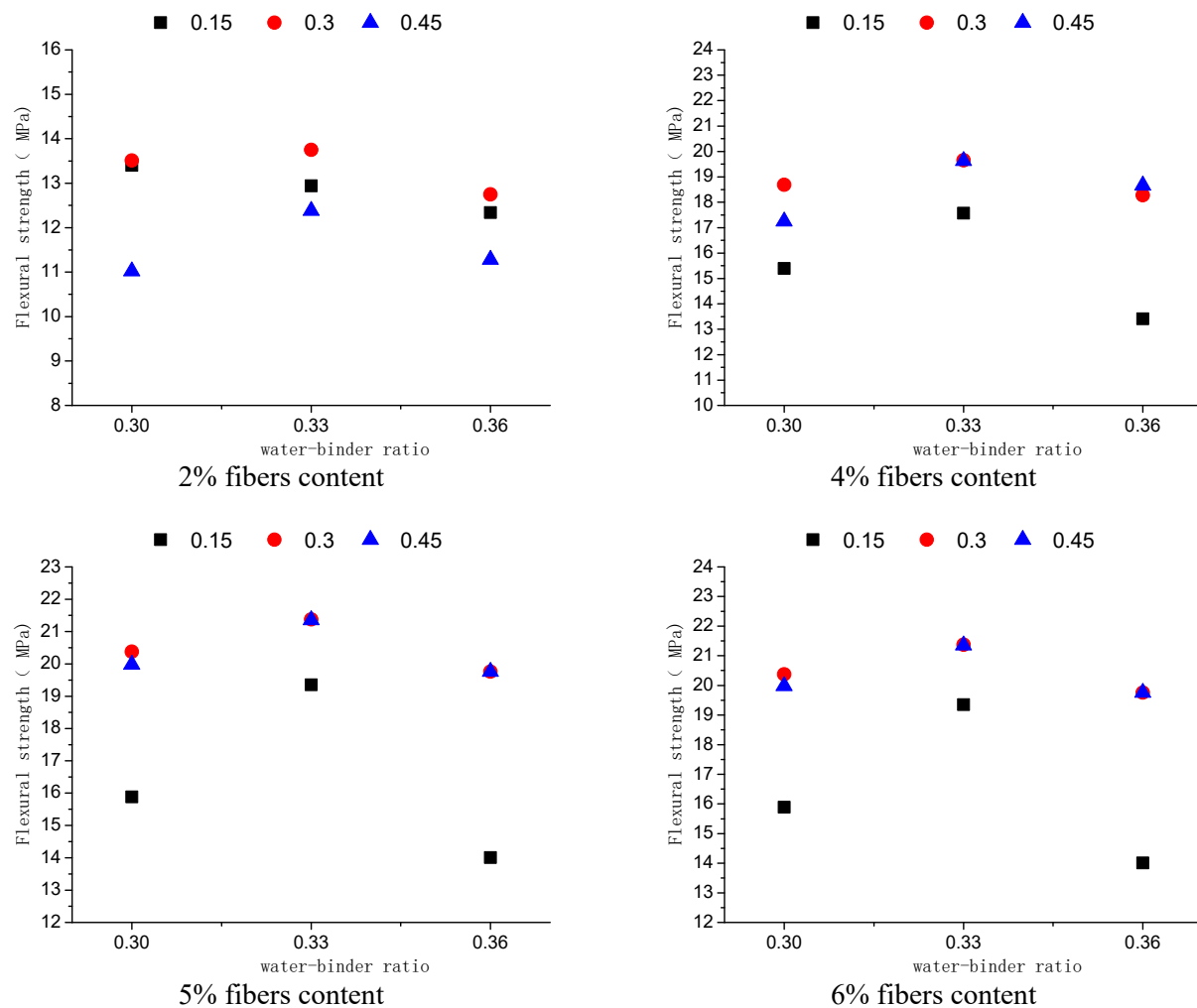


Figure 1. Flexural strength of different fibers content

(1) The fiber content has an excellent effect on improving the flexural strength of the cement composite. From 2% of the 13.5% MPa (No. 2-0.3-0.33) to 22.41 MPa (No. 5-0.3-0.33), the increase is about 60%, but when the fiber content increases to 6%, the effect of 5% enhancement is weakened. The main reason is the coupling force of the chopped fibers incorporated into the cement composite. When the fiber content is too high, the sliding effect between the fibers will reduce the folding resistance of the overall material.

(2) When the cement-sand ratio is 0.3 and the water-binder ratio is 0.33, the cement composite has the highest flexural strength.

(3) When water-binder ratio is relatively small, the mixing performance of the material is poor, so it is necessary to properly incorporate a certain water reducing agent to improve the mixing performance.

### 3.2 Compression test

The test piece after the fracture of each set of flexural strength test was used, and the pressure receiving surface was 40×40 mm, and the test pieces should belong to different prisms. The test machine loading speed should be controlled at  $2.4 \pm 0.2$  KN per second. The test results are shown in Figure 2.

It can be seen from Fig. 2 that: (1) under the same conditions of water-binder ratio, the compressive strength first increases with the increase of the fiber content, and then decreases (> 5%). The reason is

the same as the flexural strength test; (2) under the same conditions of fiber content and water-binder ratio, the compressive strength of the test piece is the largest at the water-binder ratio of 0.33. The water-binder ratio is too large to increase the fluidity of the mixture, but it will cause bleeding and reduce the material strength.

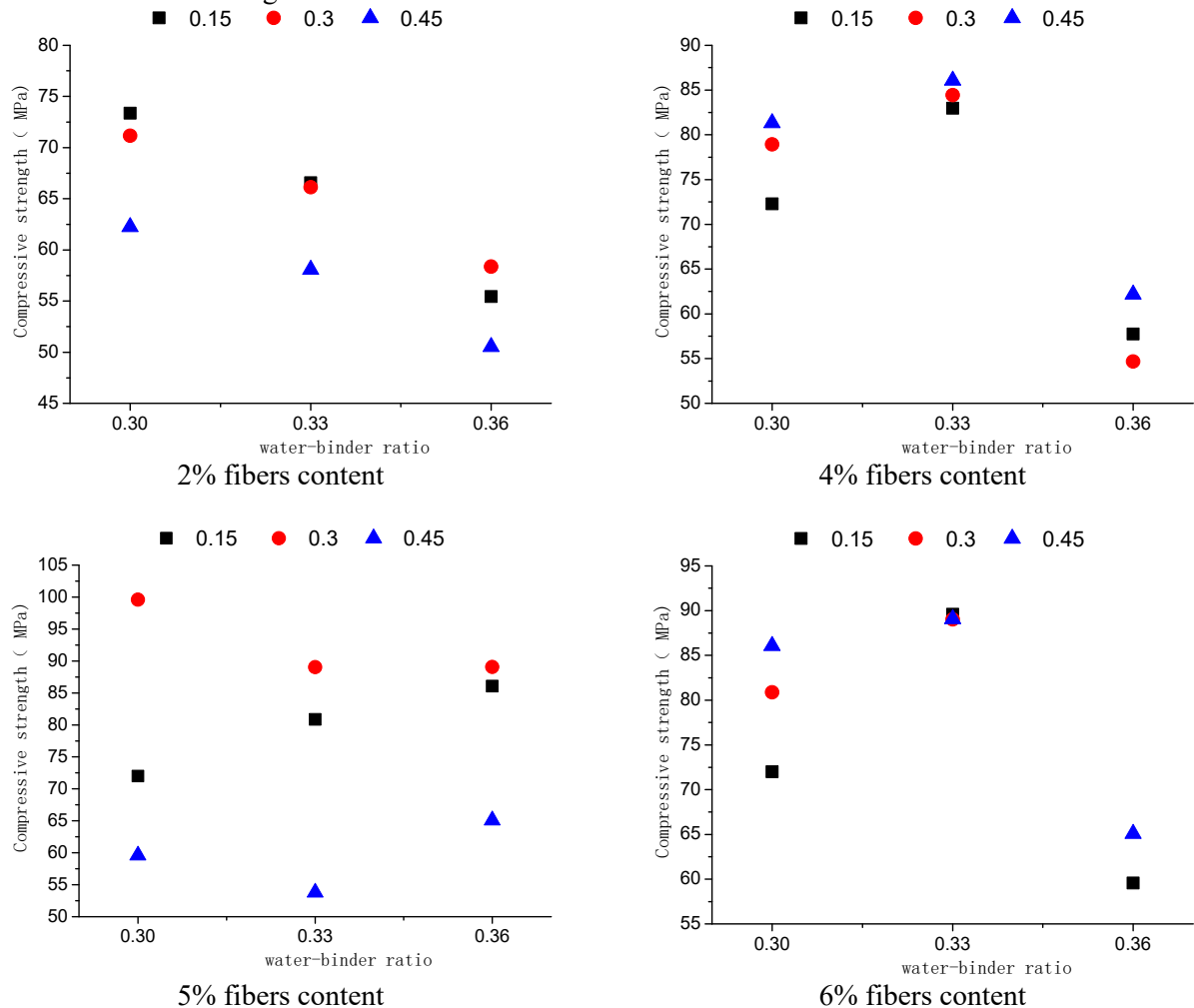


Figure 2. Compressive strength of different fibers content

### 3.3 Splitting tensile strength test

The test piece after the fracture of each set of flexural strength test was used, and the pressure receiving surface was 40×40 mm, and the test pieces should belong to different prisms. The test results are shown in Figure 3. It can be seen from Fig. 3 that : (1) under the same conditions of water-binder ratio, the compressive strength increases first with the increase of the fiber content, and then decreases (> 5%), wherein the 5-0.3-0.3 test piece has the highest strength (12.02MPa), which is 220% higher than the strength of 2-0.45-0.3 test piece (3.75MPa); (2) the splitting tensile strength of the test piece gradually decreases with the increase of water-binder ratio; (3) the cement-sand ratio is the highest at 0.3.

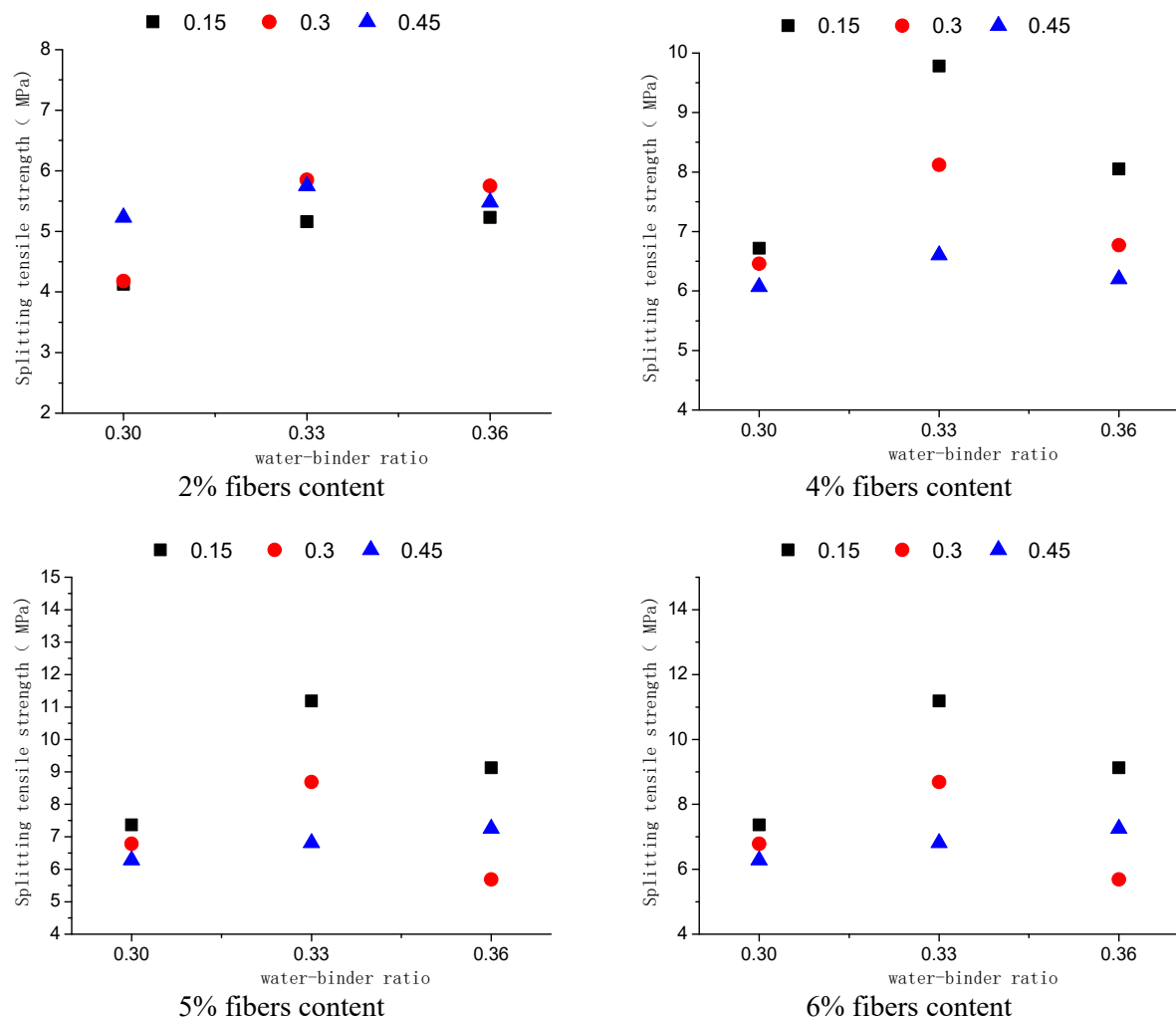


Figure 3. Splitting tensile strength of different fibers content

#### 4. Conclusions

Through the tests on the flexural strength, compressive strength and splitting tensile strength of different fiber content, mortar ratio and water-binder ratio test pieces, the following conclusions can be drawn:

- (1) When the fiber content is 5%, the cement-sand ratio is 0.3, and the water-binder ratio is 0.3, the strength of the material is the highest. Also, the appropriate addition of the water reducing agent is beneficial to the workability of the concrete material.
- (2) Chopped fibers can effectively improve the toughness, crack resistance and mechanical properties of concrete.
- (3) Controlling the water-binder ratio can improve the mechanical properties of cement-based materials.

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