Experimental Study on Shear Resistance of Prefabricated Prestressed Masonry Structure Along Joint Section

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Abstract. In order to enhance the shear strength of mortar - laid through joints in traditional masonry structures and in combination with the development of prefabricated buildings, a new type of prefabricated prestressed masonry structure is proposed. By connecting the through joints with sleeves and wrapping the masonry with geotextiles, and comparing with traditional mortar - laying methods, double - shear tests were carried out on a total of 18 masonry components of six masonry types. The shear - resistance mechanism along the through - joint cross - section and its influencing factors were explored. The test process revealed the shear - resistance performance of the structure and the failure mode of the through - joint cross - section, and clarified the force characteristics and distribution laws. The research shows that the shear strength of the new masonry structure is greatly improved when prestress is applied and wrapping materials are used. At the same time, a calculation formula for the shear strength of this masonry structure is proposed. This research provides a theoretical basis and practical guidance for the design and application of prefabricated prestressed masonry structures.

Keywords: Prefabricated prestressed masonry; Shear strength; Through-hole cross-section; Destruction mode

1 Introduction

Prefabricated prestressed masonry, as an innovative building structure form, integrates the characteristics of efficient construction of prefabricated buildings, the optimization effect of prestressing technology on the structural performance, and the many advantages of masonry materials. In recent years, it has become a research hotspot in the field of architecture[1-3]. The shear test of the through joints in masonry, as the weakest part of the entire masonry structure[4],with the further improvement of the requirements for the safety performance of buildings in today's society, traditional mortar masonry has gradually been phased out.

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Methods such as improving the strength of the mortar, changing the shape of the masonry, and increasing the friction between the through joints are all effective ways to improve the shear strength of the through joints in masonry.

The improvement of the mortar strength mainly involves adding special materials to the mortar, such as PP fiber, high-strength fiber, PET, etc.[5-8].The results show that adding materials such as fibers to the mortar can effectively improve the shear strength and ductility of the through joint structure in masonry, and delay the relative slip at the interface between the block and the mortar [9,10].

China has been using the mortise and tenon joint structure to build buildings since a long time ago. The mortise and tenon joint structure can also be used in masonry to achieve the goal of improving the shear strength of the through joints in masonry[11].The research and development of perforated bricks, interlocking blocks, and interlocking blocks have all reached the mature stage[12-14] .The research shows that changing the shape of the masonry improves the connection efficiency between the blocks, and the connection structure between the blocks effectively increases the shear strength of the through joints[15,16].

In addition, methods such as setting ring beams[17,18] and increasing the roughness of the contact surface[19] can effectively increase the friction between the through joints, and also play the role of increasing the shear strength of the through joints.

This study is based on "CN 117552368 A-A Prefabricated Masonry Structure for the Infrastructure Construction of Water Conservancy Projects and Its Preparation Method"[20],and proposes a new type of prefabricated prestressed masonry structure. In order to explore the shear resistance of the new masonry structure at the through joint section, a series of experimental studies were carried out.

Currently, there are three methods for the shear test of masonry along the through joints. The "Standard for Test Methods of Basic Mechanical Properties of Masonry" (GB/T50129—2011T) [21]recommends using the nine-brick double-shear test. The American standard (ASTME519/E519M-15)[22]stipulates that a square masonry specimen with a side length of 1200mm and a single-brick thickness should be fabricated, and the diagonal compression loading method should be adopted. The European Union standard (EN 1052-3:2002E)[23]recommends using the three-brick double-shear test.

This paper analyzes the masonry structure with reference to the "Standard for Test Methods of Basic Mechanical Properties of Masonry" (GB/T50129—2011T)[21],and determines a through joint shear test method suitable for this masonry structure.

Table 1. Concrete and mortar material parameters

	Mix proportion/kg (Cement :Sand : Gravel: Water)	Average value of compressive strength/Mpa	Strength grade
block	1: 1.95: 3.05: 0.56	31.22	C30

mortar	1: 6.60: 0: 1.10	7.60	M7.5

2 Overview of the Experiment

2.1 Basic Materials

The prestressed masonry materials used include cement, sand, gravel, and admixtures, etc., and it is ensured that they comply with the "Standard for Test Methods of Performance of Ordinary Concrete Mixtures" (GB/T 50081-2002)[24].P.O 42.5 ordinary portland cement is selected as the cement. The fineness modulus of the sand is 2.5, and the mud content is controlled within 3%. In order to improve the fluidity and anti-segregation property of the concrete, a polycarboxylic acid-based high-performance water reducing agent is used, and the dosage is controlled between 1% and 2%. Concrete blocks with a strength of C30 are fabricated. The strength grade of the mortar used is M7.5. The mortar mix proportion is designed in accordance with the "Code for Mix Proportion Design of Masonry Mortar" (JGJ98—2000)[25],and the strength of the mortar is measured according to the provisions of the "Standard for Test Methods of Basic Properties of Building Mortar" (JGJ70—2009)[26].The parameters of the concrete and mortar materials are shown in Table 1.

2.2 Masonry Assembly

In this study, different connection methods of the through joints and the presence or absence of prestress application were compared. Concrete blocks were fabricated using a specific mold as shown in Figure 1. Hemispherical grooves were provided on the surface of the blocks, and a screw rod (with a diameter of 10mm) was vertically inserted through the blocks in three mutually perpendicular spatial directions of X, Y, and Z. After wrapping the concrete blocks with polypropylene fiber (with a unit area of 200g/m², a breaking strength of 11KN, and a thickness of 2.0mm), the polypropylene fiber was pressed into the grooves by a hemispherical gasket (with an inner diameter of 55mm) that fits the grooves and a nut (with an inner diameter of 10mm). By tightening the nut, prestress can be applied to the concrete specimens. Connection structures were set at the ends of each screw rod for the connection between the blocks. The assembled masonry structure for the shear test of the through joints is shown in Figure 2.

Fig. 1. Concrete block mold

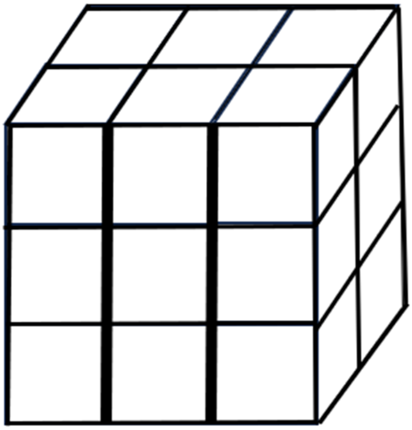


Fig. 2. Masonry structure

Table 2. Test plan and number

Number	Shape of the Block	Strength of the Concrete	Connection Method	Wrapping Material
ZS	Cube	C30	Mortar	No
ZT	Cube	C30	Sleeve	No
ZST	Cube	C30	Thimble mortar	No
ZSY	Cube	C30	Mortar	Yes
ZTY	Cube	C30	Sleeve	Yes
ZSTY	Cube	C30	Thimble mortar	Yes

The specific manufacturing steps are as follows:

1.Prefabricate the mold and preset the connecting mechanism inside the mold.

2.Uniformly mix the aggregates and pour them into the mold, and vibrate thoroughly.

3.Finish the surface of the concrete, and cover it with a cloth layer during the initial setting stage to prevent surface cracking.

4.After the initial setting, remove the mold, take out the integral block formed by the connecting mechanism and the concrete, and continue the curing for 28 to 30 days.

5.Assemble multiple blocks through connecting pieces.

6.Put the wrapping material over the blocks and seal the opening.

7.Adjust the connecting mechanism to apply prestress to the wrapping material.

8.Place the assembled masonry specimen under natural conditions for curing for 28 days, and then conduct a shear resistance test.

3 Test Scheme and Loading

3.1 Block Preparation

This experiment adopts the method of controlling variables to conduct a comparative analysis of the influence of different connection methods on the shear resistance performance of the through joints of masonry. The connection methods studied include:

1.Traditional mortar connection (S).

2.Mortar sleeve connection (ST).

3.Sleeve connection (without mortar) (T).

All the tests use cube blocks with the strength of C30, and some of the test blocks are externally wrapped with geotextile (denoted as Y). In order to reduce the test errors, three groups of each type of test block are fabricated for experimental analysis.

The test scheme and numbering are shown in Table 2.

3.2 Test Loading

The test uses a YYAW405000 microcomputer-controlled electro-hydraulic servo pressure testing machine, with a maximum test force of 5000KN, as shown in Figure 3.

The selection of the specimen scale needs to meet the requirements of practical engineering. The size of the concrete block is specified as 200mm×200mm×200mm, and 18 blocks are assembled to form a double-shear specimen. The internal steel bars are configured with a specification of Φ10mm. The loading method is designed as a uniform and continuous loading mode, and a servo hydraulic loading device is used to ensure that the specimen is subjected to a uniformly distributed shear force. Before the experiment starts, two steel plates with a thickness of 10mm are first placed on the lower platen of the testing machine, and then the specimen is installed. The center line of the specimen should coincide with the axes of the upper and lower platens of the testing machine. Finally, another 10mm-thick steel plate is placed on the top of the specimen. The size of the three steel plates is 20mm×40mm×10mm, aiming to provide height difference support for the strain that occurs during the shear process of the masonry. The edges of the steel plates should align with the mortar joints. The contact between the upper and lower platens of the testing machine and the steel plates should be close and tight.

Fig. 3. Pressure testing machine

The selection of the specimen scale needs to meet the requirements of practical engineering. The size of the concrete block is specified as 200mm×200mm×200mm, and 18 blocks are assembled to form a double-shear specimen. The internal steel bars are configured with a specification of Φ10mm.

The loading method is based on the test of the shear strength of the new prefabricated prestressed concrete block along the through joint section (GB/T50129-2011 Standard for Test Methods of Basic Mechanical Properties of Masonry)[21], and a double-shear test is used to study the shear resistance characteristics of the masonry structure. In order to more realistically simulate the stress conditions encountered in actual use, each group of specimens is tested three times repeatedly to ensure the reliability and repeatability of the data. The shear test should adopt a uniform and continuous loading method, and impact should be avoided. The loading rate should be controlled so that the specimen is damaged within 1min to 3min. When one shear surface is damaged, the specimen is considered to be damaged, and the failure load value and the failure characteristics of the specimen should be recorded. The loading rate is set at 0.25 kN/s until failure occurs. During the test process, the system records the force and displacement of the masonry, and observes and records its failure mode. The test loading method is shown in Figure 4.

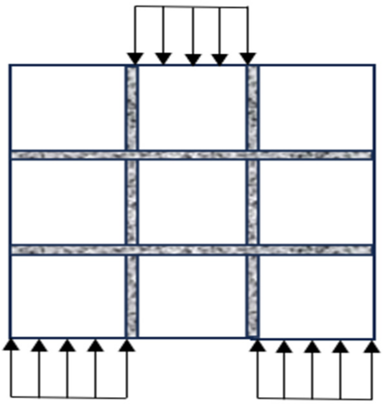


Fig. 4. Test loading method

4 Test Results and Analysis

4.1 Test Phenomena

(1) For the specimens connected by mortar, from the start of loading to failure, there is no obvious failure omen in the specimens. When the load is increased to about 75% of the ultimate load, cracks begin to appear in the masonry. At this time, the spacing of the through joints becomes larger, and a small amount of solidified mortar begins to fall off. When the load is continuously increased to the ultimate load, the specimen suddenly cracks and undergoes brittle failure. Judging from the failure results, the failure of the masonry is divided into two types: single-shear failure and double-shear failure.

(2) For the specimens connected by sleeves, the failure mode is as follows. When the applied shear force is small, there is basically no obvious change in appearance. There is no relative displacement between the steel bars and the concrete or other connecting materials, and there is no crack appearance or expansion at the through joints.

As the shear force continues to increase, when it reaches a certain level, subtle cracks may begin to appear at the through joints, the spacing of the through joints begins to increase, and the steel bars begin to produce slight slippage relative to the concrete.

When the shear force continues to increase and approaches the shear ultimate bearing capacity of the specimen, the cracks at the through joints will rapidly expand and extend, and the width of the cracks will increase significantly. The concrete will begin to peel off and break from the cracks, exposing the internal steel bars.

While the concrete cracks are expanding and failing, the shear force borne by the steel bars also reaches the ultimate state. Eventually, the steel bars will be cut off or broken. At this time, the specimen completely loses its shear resistance, the load value on the testing machine will suddenly drop, and the specimen fails.

(3) For the specimens wrapped with geotextile, at first, there is no obvious deformation of the geotextile: The geotextile tightly wraps the block. Under the action of a

small shear force, there is no obvious change in the appearance of the geotextile, which still maintains its initial flatness and integrity, and fits closely with the surface of the block without any looseness, slippage or wrinkles.

As the shear force increases, the geotextile develops local wrinkles at some stress concentration

parts of the block, near the through joints or at the corners of the block, and there is slight slippage between the geotextile and the block: Due to the deformation of the block and the development of cracks, the adhesive force between the geotextile and the block will be gradually weakened, and slight relative slippage begins to occur, with a relatively small amount of slippage.

When the shear force continues to increase and approaches the shear ultimate bearing capacity of the specimen, the tensile force borne by the geotextile will reach its ultimate strength. The geotextile will be broken or torn at the through joints or other weak parts. The tear opening is generally neat or serrated, and at the same time, the sound of the geotextile breaking can be heard.

When the shear force is continuously applied, the cracks at the through joints of the block will rapidly expand and penetrate, forming a macroscopic failure surface. A large relative displacement will occur between the blocks, and the blocks will appear broken, fall off, etc. Eventually, the specimen completely loses its shear resistance.

The failure modes of each group of tests are shown in Figure 5.

4.2 Formula Derivation

The role of polypropylene fiber in prestressed masonry is similar to that of external reinforcement materials, such as the case of FRP (Fiber Reinforced Polymer) reinforcement. In the research of FRP-reinforced masonry, the additional shear resistance provided by FRP is usually considered. Therefore, the calculation formula of shear strength will be based on the original shear strength of masonry, plus the contribution provided by polypropylene fiber. This includes the prestress, elastic modulus, cross-sectional area of the polypropylene fiber, as well as the wrapping method (such as the number of wrapping layers, spacing, etc.).

Therefore, the total shear strength $V_{total}=V_{masonry}+V_{pp}$, where $V_{masonry}$ is calculated using the shear strength formula of ordinary masonry structures, and V_{pp} needs to be determined according to the effect of prestress.

According to the Code for Design of Masonry Structures (GB 50003-2001)[[27]],the calculation formula for the shear strength of ordinary masonry is:

$$V_u = F_{V0} + 0.18\sigma_k \tag{1}$$

In the formula: Vu is the shear strength of the through joint;Fv0 is the average value of the shear strength of the masonry along the through joint section without prestress (determined by the strength of the mortar and the block);σk is the external compressive stress perpendicular to the direction of the through joint.

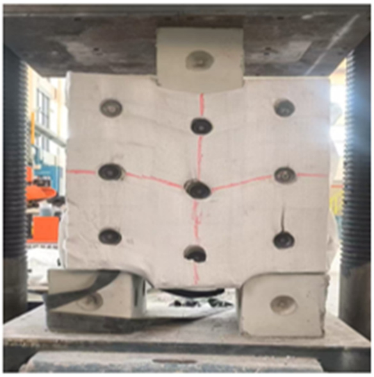
(a) The overall damage of ZS masonry

(b) The overall damage of ZYS masonry

(c) The overall damage of ZT masonry

(d) The overall damage of ZTY masonry

(e) The overall damage of ZST masonry



(f) The overall damage of ZSTY masonry

Fig. 5. Damage situation of each test group

For the prestress applied through the polypropylene fiber, the elastic modulus E of the polypropylene fiber is determined to be approximately 1250 Mpa through the tensile test of the polypropylene fiber. The elongation of the polypropylene fiber in the direction perpendicular to the through joint is

$$\Delta L = (\pi - 2)rn \tag{2}$$

According to Hooke's Law

$$F_1 = E \quad A_1 \frac{\Delta L}{L} \tag{3}$$

It can be concluded that the prestress applied to polypropylene under these conditions.

$$\sigma k = \frac{F_1}{2A_1} \tag{4}$$

In the formula; E is the elastic modulus of the polypropylene fiber; A1 is the cross-sectional area of the wrapping material.

When the vertical shear test of the masonry is carried out, the elongation of the polypropylene fiber in the direction of the principal stress is 4 times the deformation of the masonry structure. Substituting it into the above formula, the acting force provided by the polypropylene fiber under the shear condition can be obtained, Therefore, the formula for the shear strength of the through joints of the prefabricated prestressed masonry is

$$\mathrm{V_u} = \mathrm{F_{V0}} + 0.18\sigma_\mathrm{k} + \frac{2\eta\mathrm{nE}A_2\mathcal{E}}{A} \tag{5}$$

In the formula:η is the efficiency coefficient of the prestressed polypropylene fiber (taken as 0.5 through calculation in this paper)Ɛ is the strain of the polypropylene fiber when the stress reaches the maximum: n is the number of layers of the polypropylene fiber wrapping;A2 is the area of the polypropylene fiber in contact with the through joint surface: A is the shear area of a specimen.

Table 3. Results of shear strength test

Specimen Grouping	Number	Test Failure Load/kN	Shear Strength/10-2Mpa	Average Strength/10-2Mpa	Formula-Inferred Shear Strength/10-2Mpa
	1	48.0	10		
ZS	2	50.0	10.4	10.3	_
	3	51.0	10.6		
	1	59.6	12.4		
ZX	2	60.8	12.7	12.7	_
	3	63.0	13.1		

	1	68.0	14.2		
ZSX	2	70.5	14.7	14.6	_
	3	71.0	14.8		
	1	89.0	18.5		
ZSY	2	91.0	19.0	18.9	19.0
	3	92.0	19.2		
	1	96.5	20.1		
ZXY	2	97.2	20.3	20.4	20.3
	3	99.8	20.8		
	1	111.0	23.1		
ZSXY	2	113.0	23.5	23.5	22.7
	3	114.0	23.8		

Based on the formula of the test method for the shear strength of masonry along the through joint section proposed in the Standard for Test Methods of Basic Mechanical Properties of Masonry Structures GB/T 50129 - 2011, the magnitude of the shear stress of the masonry structure can be directly determined.

$$F_{v,i} = \frac{N_v}{2A} \quad (6)$$

In the formula: N_v is the shear failure load value of the specimen; A is the shear area of a specimen. The test results and the results inferred specimen. The test results and the results inferred from the formula are shown in Table 3.

4.3 Analysis of the Stress-Strain Curve

The stress-strain curve of the through-joint shear of mortar ZS generally exhibits the characteristics of the following stages, each stage having a different shape and significance. The stress-strain curve of the through-joint connected by mortar has the following stages(Summarize the stress-strain curves of all the specimens in this test, as shown in Figure 6.):

Elastic Stage: In the initial stage of loading, the pressure-deformation relationship is linear, and the curve is approximately a straight line. During this stage, the mutual connection of particles inside the mortar does not undergo obvious rupture, and the mortar (specific description) has elastic properties. After unloading, the strain can be completely recovered. As the stress increases, the strain increases proportionally.

The slope of the curve represents the shear elastic modulus of the mortar in the elastic stage, and the stress value in this stage is relatively small.

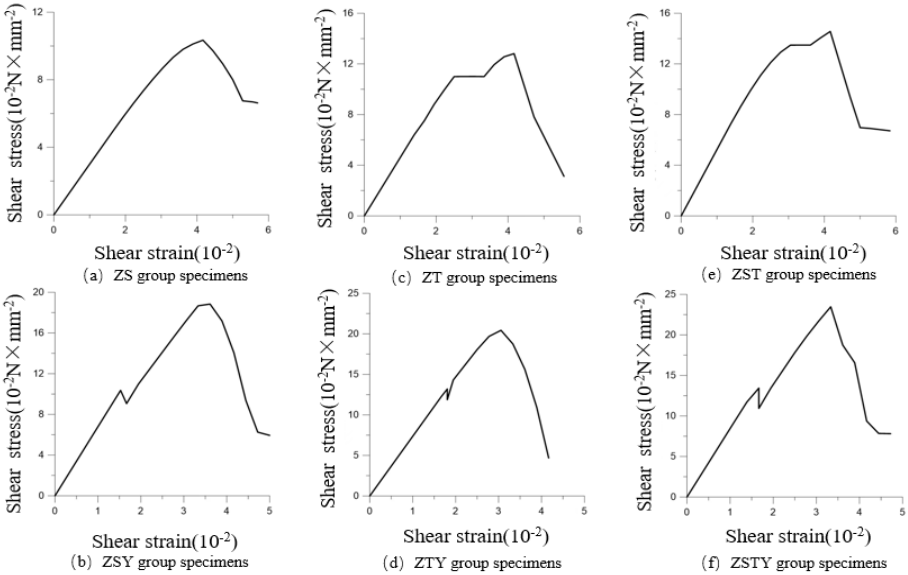


Fig. 6. Stress-strain curve

Elastoplastic Stage: When the stress is continuously increased, the curve begins to deviate from the straight line, and the growth of strain starts to be greater than that of stress. Some small cracks and relative slips between particles begin to occur inside the mortar, and it starts to exhibit certain characteristics of plastic deformation. Even if unloaded, there is still a certain irreversible plastic strain. At this time, the slope of the curve decreases, indicating that the shear stiffness of the mortar gradually decreases.

Failure Stage: When the peak stress is reached, the cracks in the mortar expand rapidly and penetrate to form an obvious shear failure surface, and the shear resistance decreases. The stress-strain curve reaches the peak and enters the descending stage. In the descending stage, as the strain continues to increase, the stress gradually decreases, and the bearing capacity of the mortar gradually decreases until it is completely destroyed.

Residual Stage: When the stress decreases to a certain extent, the rising speed of the curve slows down, and it enters the residual stage. In the residual stage, although the mortar has been damaged, it can still bear a certain shear stress, and this shear stress is called the residual shear stress. The magnitude of the residual shear stress is related to factors such as the components of the mortar, the mix ratio, and the degree of damage.

The characteristics of the through-joint of the sleeve ZT can be described in the following stages:

Elastic Range: When loading starts, there is a proportional relationship between the stress and the strain, that is, the strain increases proportionally with the increase of the stress. At this time, the connection part of the steel bar is in the stage of elastoplastic deformation, and the relative position change between the atoms inside the steel bar or among its various components is recoverable. The relationship between its stress and strain is approximately a straight line, and the slope of the straight line is the elastic modulus of the material. During this period, the connection of the steel bar can effectively transfer the stress, and there is no obvious damage or destruction.

Elastoplastic Stage: When the stress is continuously increased, the degree of deviation of the curve from the straight line gradually increases, the growth of strain becomes slower and slower, while the stress increases faster and faster, and it is in the elastoplastic stage. Some microscopic damages or local slips have occurred inside the steel bar joint. Due to these microscopic changes, the deformation of the material does not satisfy Hooke's law, and it begins to exhibit certain plastic characteristics.

Yield Stage: For steel bars with an obvious yield point, after the stress reaches a certain value, the strain increases sharply, but it hardly affects the stress or only increases slightly. There is a horizontal or gently inclined straight line in this section of the curve, and this section is the yield stage. At this time, the weak links of the connector first produce plastic development deformation, and obvious and irreversible deformation begins to appear.

Strengthening Stage: After the yield stage, when the strain continues to increase, the ability of the material at the connection position of the steel bar to resist deformation continues to increase, and the stress increases with the rise of the strain and enters the strengthening stage. The crystal structure inside the material is adjusted and reorganized, and the work hardening phenomenon occurs, enabling the material to withstand greater stress. However, in this stage, the plastic deformation of the material is also continuously accumulating, and the damage at the connection position will also increase continuously.

Failure Stage: After the stress reaches the ultimate strength of the material, the curve drops, and it enters the failure stage. In this stage, the damage of the connection part of the steel bar is very serious, and it breaks, causing the connection part to lose its bearing capacity. The stress drops rapidly, and the strain still continues to increase until it is completely destroyed.

The shear stress-strain curve of the block wrapped with polypropylene generally has the following stages and characteristics:

Elastic Stage: When the applied stress is small, the stress-strain curve is a straight line during the loading process, and the block wrapped with polypropylene undergoes elastic deformation as a whole. The polypropylene and the block work together to resist the shear force. In this stage, there is no large relative displacement or damage phenomenon at the interface between the inside of the block and the polypropylene and the block. As the stress increases, the strain increases linearly accordingly. The slope of the curve in this stage represents the shear stiffness. The larger the slope, the stronger the ability to resist deformation in the elastic stage.

When the shear force is large and it enters the elastoplastic transition stage, the stress-strain relationship curve no longer has a good linear relationship, that is, under the same shear force, the increase rate of the strain is greater than that of the stress.

At the same time, there may be a slight relative displacement between the polypropylene and the block (or small cracks appear in the weaker parts of the block); at this time, the deformation of the material is no longer all reversible deformation, that is, a certain degree of irreversibility begins to occur, manifested as the gradual decrease of the curve slope, and the shear stiffness begins to decay.

Stress Drop Stage: When the applied shear force reaches a certain extent, a small-scale displacement occurs in the through-joint structure of the masonry. At this time, the stress will decrease. However, due to the restraint of the polypropylene, its strain has a small displacement or does not occur.

Plastic Stage: After entering the obvious plastic stage, when the stress reaches a certain level, the relative sliding between the polypropylene and the block is more significant at this time, the cracks inside the block are further extended, and even penetrate. At this time, more of the energy consumption comes from the plastic deformation of the material. Although the stress gradually increases over time, the strain increases rapidly, and the curve becomes gentle. At this time, the shear resistance of the material mainly depends on friction and the residual structural strength.

Failure Stage: After the stress reaches the peak value, the curve begins to decline. The block system wrapped with polypropylene is damaged, and the polypropylene is broken and torn. In the failure stage,as the strain continues to increase, the stress decreases rapidly until the material completely loses its shear bearing capacity, and the curve drops to a relatively low level, indicating that the system can no longer bear the shear force.

Through the above analysis, the stress-strain curves of the specimens of the mortar and the sleeve connection conform to the various stages exhibited by this material under the action of the shear force. Under the condition of applying prestress to the polypropylene, its performance in resisting the shear force has been greatly improved.

4.4 Discussion

(1) Compared with the traditional masonry structure, the prefabricated prestressed masonry structure conforms to the general trend of today's social architecture. It has unified specifications and dimensions, adopts standardized connection methods, and can be quickly assembled, which greatly shortens the construction time. By wrapping the masonry with polypropylene, customization can be directly completed in the factory, and its transportation is convenient.

(2) Compared with the masonry structure with through joints connected by traditional mortar, applying prestressed geotextile can significantly improve the shear resistance of the through joints of the masonry structure. When using sleeve connection, the failure surface is mainly the fracture of the steel bars at the connection, which is closely related to the strength of the steel bars.

(3) The correlation coefficient between the experimental value and the calculated value can be calculated according to the Pearson correlation coefficient formula, and its definition is:

$$r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}} \tag{7}$$

In the formula, r is the correlation coefficient, x is the calculated value, y is the inspection value, $\bar{x}$ is the average value of the calculated values, and $\bar{y}$ is the average value of the inspection values.

The calculation result of the equation is $0.9<r=0.987<1$, which indicates an extremely strong correlation and verifies the accuracy of the current shear strength equation for through joints.

5 Conclusions

Based on the through joints of masonry with six connection structures, the main conclusions are as follows:

(1) The main failure of the mortar - masonry through - joint specimens is the bond failure between the block and the mortar interface, including two types: single - shear failure and double - shear failure.

(2) The failure mode of the sleeve - connected masonry through - joint is mainly the misalignment and fracture of the steel bars at the connection part. The shear strength of the through - joint connected by the sleeve is 23.9% higher than that of the traditional mortar through - joint, and the shear strength of the through - joint connected by the sleeve and mortar is 40.8% higher than that of the traditional mortar through - joint.

(3) Applying prestressed geotextile can effectively improve the shear resistance of the masonry through - joint. Under the condition of applying prestress, the shear strength of the masonry is increased by an average of 80.6%.

(4) A calculation formula for the shear strength of the masonry under the wrapping condition is proposed. The calculated values are in good agreement with the experimental average values, which can provide a reference for the shear strength of this masonry structure.

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