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Experimental Study on Shear Connectors in Steel-concrete Composite Structures Based on Measured Data

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ABSTRACT. *Steel-concrete composite structures have been widely used in developed countries such as various countries. China's composite structures started relatively late, but since the reform and opening up, such structures have been studied extensively. The role of shear connectors is to prevent the horizontal sliding and separation of the two at the interface, so that steel structures and concrete structures with very different elastic moduli form a whole and work together. The ideal design of shear connectors should provide sufficient and complete combined action for the structure and focus on testing the shear resistance of channel steel shear connectors of reinforced concrete slabs under monotonic loading. The types of shear connectors in steel-concrete composite structures are further studied.Based on the measured data, based on the existing common shear connectors, the type, function and design requirements of the shear connectors can be divided into the linearity before the external load reaches the yield bearing capacity. The stage, the load is increased from the yield bearing capacity to the plastic phase of the ultimate bearing capacity and the failure phase.*

KEYWORDS: *Measured data; Steel-concrete composite structure; Shear connectors.*

1. Introduction

In the comprehensive evaluation of mass concrete temperature control construction, the factors involved are complex and diverse. At present, the evaluation methods of mass concrete temperature control construction are mostly conclusion-oriented [1]. Therefore, this paper uses the measured data to quantify the indicators in the construction process [2]. In general, concrete materials are arranged in the compression zone of the structure and steel in the tension zone of the structure, so as to give full play to the compression of concrete materials and the tension

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advantages of steel. As the connector connecting steel and concrete materials, it is the key for this structure to play its full role [3]. Steel-concrete composite beams work together through shear connectors, which are located on the interface between steel and concrete and are the key components of steel-concrete composite beams [4]. The technical feature of the connection is that a single piece or two or more open-hole corrugated steel plates are welded along the direction of the steel web on the flange plate, and the steel bars pass through the holes in the corrugated steel plate, and the concrete in the hole of the broken steel plate and the steel bar together Form reinforced concrete shear pins. In order for steel and concrete to work together, it is necessary to provide a shear connection between the two. With the increasing use of composite structures, the study of shear connectors has received increasing attention [5].

In the design of composite beams, shear connectors are generally used to transfer longitudinal shear force to the interface of steel concrete. The performance of channel steel shear connectors in concrete slabs under monotonic low-cycle fatigue load is studied experimentally [6]. Concrete material has high strength and good durability; concrete can be mixed with different materials and additives in the preparation process, so that concrete can meet the use of different environmental conditions; slag, fly ash and other industrial wastes can be used in the production process of concrete, which has good environmental protection performance [7]. The design of the joint is critical. It must be considered whether the longitudinal horizontal shear force between the steel and concrete materials can be effectively controlled to ensure that there is no relative displacement between the two different materials during the operation of the structure. Therefore, it is necessary to reasonably Design shear connectors [8]. The most prominent feature of the steel-concrete composite structure is the use of shear connectors to combine two different materials, steel and concrete, to form an organic whole. The commonly used shear connectors are: studs, square steel, channel connections, PBL connectors, etc. There are various forms of shear connectors. The choice of connectors should be considered in combination with materials, manufacturing processes, welding techniques, site conditions, etc., and the bearing capacity of the connectors is generally determined by experiment [9]. The force transmission mechanism and mechanical performance of the steel-concrete beam joint are the focus of the research on the mechanical behavior of this kind of structure.The steel-concrete joint is a weak point of the main beam stiffness and is easy to form a weakness of the structural system. By measuring the natural frequency, damping ratio, vibration mode, dynamic shock coefficient and dynamic response of the bridge structure, the overall stiffness and performance of the bridge structure are objectively analyzed and evaluated [10].

2. Materials And Methods

The initial longitudinal cracks along the sawtooth direction appear in the concrete slab in the shear span area. Thereafter, with the increase of load, the cracks gradually penetrate, and the cracks almost coincide with the longitudinal center line of the

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concrete slab. The structure has good working performance, is in elastic working state, has a certain safety reserve, and the bearing capacity meets the requirements. In the process of arranging sensors, according to the shape of the structure mode, the measuring points are arranged in the parts with large displacement to avoid the nodes of each mode as far as possible. Horizontal shear force is resisted by inclined folded plate of corrugated steel plate and reinforced concrete pin. Reinforced concrete pin also plays a role in resisting pull-out force. Compared with composite structures, the number of non-composite connectors is only a small number of bolts, and the role of bolts in non-composite structures is not considered in the design. However, bolts actually play a role when subjected to load, especially when concrete shrinkage and creep occur, the role of bolts is particularly obvious. The results of the trial were introduced as the basis for the development of the specification. The study also found that if the overall shear strength of the shear joint is resistant to the ultimate compressive strength of the concrete, then the amount of interface slip between the steel beam and the concrete slab will not cause a large bending moment of the composite beam Impact.

The shear capacity of flexural bar connectors is mainly obtained by anchoring with concrete. When the length of anchorage structure meets the requirements, the main factors of shear capacity are the section area of the flexural bar and the yield strength of the steel bar. Elastic connectors generally refer to single cylindrical head bolts or ordinary welded steel bars. When the number of elastic connectors is large, they tend to be rigid connections. The bearing capacity of bolts is given in tabular form, as shown in Table 1. The slip between steel beam and concrete is very small, the curve is close to the straight line under the measured data, and the shear rigidity of the steel plate shear component with openings is very large. The overall curve of the component is analyzed, and the load-slip curve of the component is approximately linear at this stage. Because of the bond between reinforcement and concrete, with the increase of the distance from the crack section, the tensile stress is re-established in concrete, while the tensile stress of reinforcement decreases with the increase of the distance from the crack section. When there is a sufficient length l from the crack section, the yield stress of the concrete tensile stress increases. The measured data includes the signal conditioner required for dynamic signal testing, as well as all hardware for sampling control and computer communication, and provides easy-to-use control software, signal processing and analysis software, and modal analysis software. For high-strength bolts, in addition to the high strength of the material, a large pre-tension is usually applied to the bolts to cause compression between the connecting members, so that the direction of the vertical bolts has a large frictional force, and the pressing force and the friction force are shearing. The transmission of force has a great influence.

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Table 1 Bearing capacity of stud connectors

Studs		Strength grade of various coagulation for bolt bearing capacity			
Stud diameter	Stud full height	C20	C30	C40	C50
13	68	47	49	53	59
16	72	62	71	80	92
19	73	75	77	89	96
25	98	120	121	134	149

Concrete is hardened by cement, water, sand and various admixtures or admixtures. It is a building material with complex composition and various properties. For a long time, linear elasticity theory has been used to analyze the stress or internal force of reinforced concrete structures, and ultimate state design method has been used to determine the bearing capacity stiffness and crack resistance of members. Relative slip occurs at the interface of composite beams after natural bonding failure. It can be seen from the graph that relative slip develops relatively slowly in the elastic stage. The vibration sensor is located at the maximum response position of the bridge structure, such as the middle section of the main span and the middle section of the side span. According to the requirements and purposes of dynamic load test, and according to the bridge structure, the layout of acceleration sensor is determined. The resultant force at both ends of the reinforcing bar is balanced by the bond stress between the reinforcing bar and the concrete. In fact, due to the stress points of the steel bars and the different bonding effects between the steel bars and the concrete in different areas, the uneven distribution of the bonding force is caused. The load at the time of the crack is very close to the damage load. The failure state is that the steel bar pulls out the concrete and causes the specimen to be destroyed. When the load acts on the concrete, the compressive stress generated by the load is evenly distributed. When the limit state is reached, the concrete between the two joints will be crushed or sheared due to the large slip stiffness of the rigid joint.

3. Result Analysis and Discussion

Open-hole steel plate shear connectors have higher shear capacity than studs because they transmit shear force through concrete pins in the holes, and because the diameter of the holes is generally larger. The establishment of shear connectors can not only improve the stress condition of steel-concrete composite structure, but also play an important role in improving the bearing capacity and stiffness of the structure. It is the key to ensure the combination effect of the two structural materials. For a long time concrete was considered to be completely brittle. Under the measured data, the strength limit of the relationship curve has not been reduced. With the improvement of the test equipment and methods, the entire process can now be measured. After the

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specimen reaches the ultimate load, the curve has a slowly changing process. At this time, the load slowly decreases, and the slip continues to increase, causing the final load of the specimen to not be destroyed. However, whether it is cracking after first cracking or sudden damage, the measured strain is always the tensile strain at the concrete surface of the joint. The bottom of the concrete cushion is in direct contact with the foundation soil and belongs to the first type of boundary condition. Since the model is built with 1/4 of the actual size, the inner side of the cushion concrete and the foundation soil is a symmetry plane, and the other side of the model. It is a heat insulation surface.

For a considerable period of time, the tensile failure of concrete is considered to be completely brittle. It is found from the measured data that concrete is under tension. The curve also has a descending section. The complete stress-strain curve under axial tension is shown in Figure 1. It can be seen from the development process of cross-section strain that in the early stage of loading, the distribution of cross-section strain basically conforms to the assumption of flat cross-section, and the strain varies approximately in a straight line, which indicates that the bending curvature of concrete slabs and steel beams is basically the same. With the increase of load, it is used as the bond element between steel bar and concrete to simulate the bond-slip relationship between steel bar and concrete. The element is a spring element with non-linear function, which can be input into a generalized force-deformation curve to define its non-linear behavior. The unit consists of 2 nodes and can be used in 1D, 2D or 3D analysis. Although the flange and web of the channel have a ferrule effect, the concrete reinforcement is small and the concrete cannot be well connected to the joint. Coordinating the work, crushing the mixed soil inside the joint, resulting in sudden cracks. The connecting piece connecting the steel to the concrete is subjected to the vertical separation between the two, and the connecting piece needs to have a vertical deformation, so the shearing connecting piece itself is also subjected to a certain pulling force.

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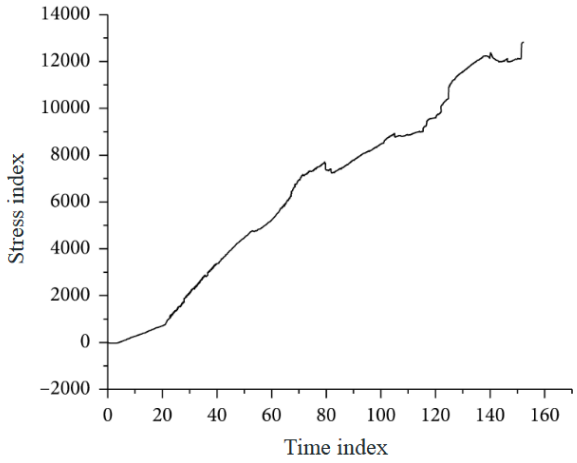

Fig. 1 Uniaxial tension stress-strain curve on coagulation

Because the bolt connection is generally located at the upper flange of the steel beam, it is located at the bending compressive stress zone of the compressive flange and the shear zone of the interface between concrete and steel plate. It is observed that the steel bars have yielded when the ultimate bearing capacity is reached. Therefore, he regards the influence of the through steel bars as the lateral binding force, and therefore regards the yield force of the steel bars as the binding force when the ultimate bearing capacity is reached. There are many factors affecting the shear performance of perforated corrugated plate shear parts, such as concrete strength, diameter of through steel bar, aperture, reinforcement ratio of common steel bar, location of opening, spacing of opening, thickness of steel plate, parameters of perforated corrugated plate (angle, wavelength). In defining boundary conditions, the bottom surface of fully constrained concrete cushion is defined, and the two symmetrical surfaces of the 1/4 model are symmetrically constrained. The acceleration of gravity is applied to concrete and reinforcement materials by using cyclic sentences. The strain of the transverse steel bar is very small, and the bearing is almost zero. However, after the longitudinal crack occurs, the strain gap in the half span is widened, and the strain of the steel bar near the loading point is the largest. The strain at the bearing is greatly increased when it is close to the ultimate load. The difference between the elastoplasticity of the strain hardening and the ideal elastoplasticity is that the yield surface is no longer a fixed surface, when the concrete stress exceeds the initial yield surface. After that, a new subsequent yield surface will be produced instead of the initial yield surface, and the subsequent yield surface will harden as the plastic strain increases.

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4. Conclusion

In this paper, the test of shear connectors in steel-concrete composite structures with measured data is studied. However, when approaching the ultimate load, the longitudinal strain of concrete at the middle line of the beam increases sharply, and the structural strength meets the design load grade requirements, but when approaching the ultimate load, the longitudinal strain of concrete at the middle line of the beam increases sharply. The dynamic performance of the bridge can be judged to meet the requirements. In addition, the modal frequencies of each order are higher than those of theoretical calculation, but all of them are acceptable. It shows that the maximum crack width calculated by finite element method, the maximum measured crack width and the maximum crack width calculated by traditional method are close to each other. After the concrete is cracked, the load-concrete is in a curve relationship (ie, entering the inelastic phase); as the load increases, the strain curve develops very quickly and gently. The main factors such as concrete strength, bore diameter and through-reinforcing steel are considered comprehensively. The bearing capacity design value can be obtained by multiplying the ultimate bearing capacity by a factor. The coefficient should take into account various sub-coefficients, safety factors etc. and can also refer to the design criteria of relevant norms at home and abroad.

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