Research on the application of adjustable secondary structure template strengthening device

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Abstract. With the continuous progress of construction engineering technology, the optimization of structural strengthening methods has become the key to improve building safety and economic benefits. This study focuses on a new type of adjustable secondary structure formwork reinforcement device, through the traditional pulling screw and tightening reinforcement method to carry on the economic benefit comparison, analysis of its cost benefit and social benefit. It is found that although the initial cost of the adjustable reinforcement device is higher than that of the traditional method, the adjustable device shows its economic advantages in long-term use, taking into account the long-term maintenance costs and anti-leakage measures. In addition, the device simplifies the process flow, improves the molding effect, and is recognized by the industry, promotes the improvement of the corporate image, and reflects the obvious social benefits. Through the experimental verification, the device in improving the stability of the structure and bearing capacity of the effect is remarkable, indicating that it can not only meet the different construction needs, but also significantly improve the seismic performance.

Keywords: Adjustable secondary structure formwork reinforcement device; Classification; Application cases; Work guidelines; Structure design; Material selection; Practical research

1 Introduction

In recent years, with the development of strengthening technology of engineering building formwork is becoming more and more mature, and the construction technology and method of new formwork strengthening device are constantly updated and changed[1]. The strengthening method of formwork under the traditional mode is affected by construction mode, and is prone to interference and restriction of various factors. Currently, in order to achieve high mechanical efficiency while limiting mass and volume, the concept of sandwich structure is introduced[2,3], such as using pull screws and tightening reinforcement. Although widely used in building construction, there are significant shortcomings in the complexity of operation, cost effectiveness, and long-term maintenance. In order to solve these problems, this study proposed an adjustable secondary structure formwork reinforcement device, the design innovation of the device is

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reflected in its flexibility and adaptability, which can be quickly adjusted according to the actual construction needs, reduce the dependence on labor in the construction process. And improve the stability of the reinforced structure, while reducing potential leakage problems, thus significantly improving the quality of construction. In addition, the device can also bring additional social benefits, such as enhancing the corporate image and enhancing the competitiveness of the industry.

2 A practical study of an adjustable secondary structure formwork reinforcement device

2.1 Design of Practice Scheme

For high-rise residential projects, it is necessary to determine the specific force of the formwork before installing it. Following the building construction code to ensure the accuracy of formwork installation and stress is a key step to ensure construction quality and structural safety[4]. In order to achieve this goal, the program carefully optimizes the secondary construction methods of conventional concrete door frames and structural columns, aiming to significantly improve the overall construction efficiency and structural quality through accurate construction planning and efficient implementation strategies. Through the introduction of advanced construction technology and materials to protect the filling wall from the influence of secondary structure reinforcement operations, the simple adjustable secondary structure formwork reinforcement device is mainly introduced based on the following four points.

1. High adaptability: The simple and adjustable design means that the device can be quickly adjusted to adapt to a variety of different sizes and shapes of the door frame and structural columns, to ensure the accuracy and efficiency of the reinforcement work.

2. Strong protection performance: In the secondary construction process, especially in the reinforced filling wall and other sensitive areas, the device can effectively prevent the damage that may be caused to the surrounding structure during construction.

3. Construction efficiency: By simplifying the reinforcement operation process, the device significantly reduces the construction time and labor demand, thereby improving the overall construction efficiency.

4. Safety guarantee: While strengthening construction safety, the use of the device also helps to improve the operating comfort and safety of the staff, and further reduces the risk of accidents during construction.

2.2 Practice the device and material

1. Device processing: We use discarded steel bars with a diameter of 16 ~ 20 (FIG. 1, FIG. 2) after screening, and use sleeves with adjustable bolts for processing. In order to ensure the strong structure, the connection between the rods is unified by welding, we pay special attention to the integrity of the weld, to ensure that the weld is fully

filled, and the height of the weld is maintained at least 6mm to meet the basic requirements of structural safety.

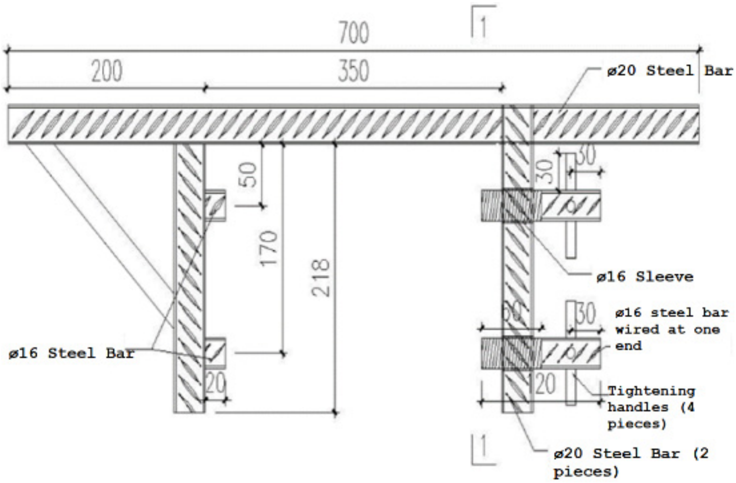

Fig. 1. Machining plan

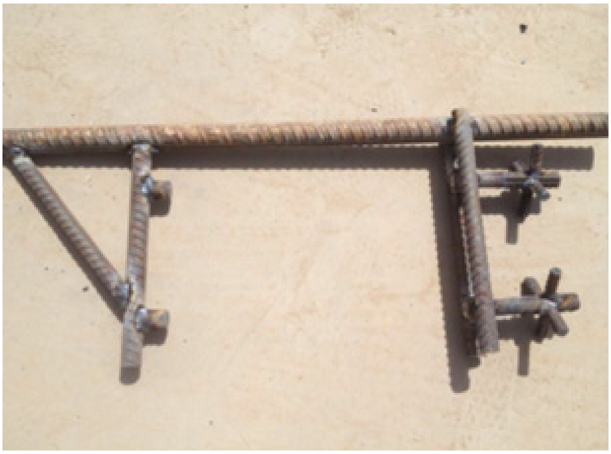

Fig. 2. Machining solid drawing

2. Structural reinforcement: After carefully considering the section size of the secondary structure, we appropriately adjusted the width and length of the reinforced members. The formwork must have sufficient bearing capacity to withstand the impact of concrete. At the same time, carefully check the rebar and rebar fixation to ensure that the rebar spacing meets the requirements[5]. Select steel bars with the same specifications as the horizontal brace, and weld vertical supports on both sides of the brace. Set a suitable sleeve between the two to enhance the structure's firmness. Also, keep the Angle between the strut and the horizontal strut exactly 90 degrees.

3. Sleeve and bolt processing: In the process of processing the sleeve, we first cut the Φ16 sleeve raw materials along the middle, and take half of the middle part of the vertical support for stable welding work. In order to make adjustable bolts, we choose the steel bar that matches the sleeve, and carry out sleeve processing through the "steel bar rolling machine" to ensure that the effective length of the steel wire head is at least 60 mm. At the other end of the bolt, we welded four fastening handles of about 30mm in length evenly vertically and symmetrically along both sides at about 30mm from the end head, providing ample holding points for installation.

4. Fixed adjustment: In the process of formwork installation, the pre-prepared formwork and wood should be temporarily positioned according to the control line marked on the ground or wall. Strictly control the spacing of the pull bolts to prevent cracks or crack expansion between the formwork and the wall during concrete construction due to pumping pressure, construction vibration and other reasons, resulting in concrete leakage[6]. When operating, grip the support frame with both hands and point its "concave" end towards the outside of the formwork to be reinforced. In the appropriate position of the template to be reinforced, adjust the cross brace so that it is snug against the outside of the template while the vertical brace clamps both sides of the template. Stabilize the bracing with one hand and adjust the tightening handle with the other so that the support points and adjustable bolts are symmetrical with respect to the formwork. If you have difficulty manually adjusting the tightening handle, stop immediately to check and correct the mounting quality of the support position and the verticality of the formwork. After confirmation, use the tailpipe to continue tightening operation. In the process of tightening the bolt, the torque should be checked with a torque wrench to ensure that the torque value generally reaches the standard of 45~60N·m.

5. Door frame reinforcement: Concrete door frame reinforcement, usually set at the bottom and top position of 200 ~ 300 mm or so reinforcement measures, in the middle of the door frame, should ensure that the reinforcement point spacing does not exceed 400mm.

6. Mold removal and cleaning: When the concrete construction is completed and the conditions for removing the template are met, the operation should be carried out in accordance with the process opposite to the aforementioned reinforcement operation. First, loosen the tightening handle, and then carefully remove the adjustable formwork bar. During the removal process, care should be taken to remove the residual concrete slurry and other impurities on the rebar in time, and ensure that the tool is clean and maintained for the next use. It is important to maintain the accuracy and rigor of the operation throughout the demolition process to avoid damaging the formwork and newly poured concrete members.

3 Benefits of adjustable secondary structure formwork reinforcement device

3.1 Economic benefit analysis

In order to measure the economic benefits, the traditional method of pulling screws and tightening reinforcement is compared with the adjustable reinforcement device. The specific comparative data and conclusions are detailed in Tables 1, 2, and 3.

Table 1. Cost list of reinforcement with countertension screw

Item	Materials	Amount used	Units	Unit price (yuan)	Total (yuan)	Comprehensive unit price (yuan)	Remarks
PVC pipe	DN15	1.1	m	1	1.1	101.495	
Counterpull screw	Φ12	1.7	m	6	10.2		
Pre-buried	Labor costs	0.04	Work day	250	10		
Installation and dismantling	Labor costs	0.2	Work day	300	60		
New purchase	Sponge strips	4.3	m	0.05	0.215		
Paste sponge strip	Labor costs	0.04	Work day	300	12		Clean up before plastering
Concrete defect repair	Material fee (cement mortar)	0.003	m3	260	0.78		
	Labor costs	0.04	Work day	180	7.2		

Table 2. Use "Step by step" reinforcement cost list

Item	Materials	Amount used	Units	Unit price (yuan)	Total (yuan)	Comprehensive unit price (yuan)	Remarks
New purchase	Step by step	6	number	4.5	27	110.515	
	Sponge strips	4.3	m	0.05	0.215		
Paste sponge strip	Labor costs	0.04	Work day	300	12		Clean up before plastering
Installation and dismantling	Labor costs	0.2	Work day	300	60		
Concrete defect repair	Material fee	0.004	m3	260	1.04		
	Labor costs	0.06	Work day	180	10.8		
Salvage value	Material fee	0.6	kg	0.9	0.54		Step by step

Table 3. Cost list of adjustable reinforcement device

Item	Materials	Amount used	Units	Unit price (yuan)	Total (yuan)	Comprehensive unit price (yuan)	Remarks
Rebar	Φ18~Φ20	12.8	kg	0.9	11.52	122.4	
Sleeve	Φ18	8	kg	0.6	4.8		
Processing and making		12.8	kg	4.5	57.6		
Installation and dismantling	Labor costs	0.2	Work day	300	60		
Salvage value	Material fee	12.8	kg	0.9	11.52		

According to comparative analysis data, in the strengthening work of single structure column, the cost of adjustable reinforcement device is higher than the cost of using wire drawing screws or step by step reinforcement, the difference is 20.905 yuan. However, the detailed cost analysis found that whether it is screw pulling or step by step reinforcement, it needs to spend an additional 7.98 yuan and 11.34 yuan of maintenance costs. In addition, the traditional reinforcement method requires anti-leakage measures such as pasting sponge strips, a process that includes cleaning and plastering before pasting, which will incur an additional cost of 12 yuan. In contrast, the adjustable reinforcement device eliminates these additional costs due to single molding, while ensuring higher construction quality.

3.2 Application effect evaluation

Table 4. Application effect evaluation

Evaluation content	Assessment method	Evaluation objectives
Reinforcement effect	Through the analysis and comparison of practical results	Strengthen the structural strength and im-prove the stability
Adjustble performance	By adjusting the parameters of the device (such as telescopic length and stiffness)	The ability to adapt to different structural requirements and working conditions
Economy and practicality	Through cost analysis and implementation difficulty assessment	The feasibility in the actual project
Service life and maintenance costs	Evaluate its viability and economic benefits for long term use	The feasibility and economic benefits of long term use
Safety	Pass structural strength, stability analysis and response ability test under different external loads	The performance of protecting structural safety
Impact on the structure and environment	Make sure the use will not cause damage or danger to other structural components	Do not negatively affect the structure and the environmen

According to the measures in Table 4, the series of data are collected through field operation, which reflect the performance of the adjustable secondary structure template reinforcement device. At first, we recorded in detail the reinforcement effect of the device after use, which includes the improvement of structural stability and the improvement of bearing capacity and other key indicators. At the same time, we also adjusted the adjustment parameters of the device to see how these variables affected the reinforcement effect.

Based on the data obtained from the field, we carried out a comprehensive analysis. First, we compared the bearing capacity and deformation degree of each sample before and after reinforcement treatment. The data comparison reveals that the adjustable secondary structure template strengthening device obviously enhances the load capacity of the structure and effectively reduces the deformation. In addition, we noticed that different configuration of adjustment parameters has a significant difference to the reinforcement effect, which prompted us to deeply analyze the best strategy of device parameter adjustment.

After analyzing the field test results, we came to the following conclusions. First of all, the reinforcement device can effectively enhance the bearing capacity and stability of the structure. Secondly, the selection of adjustment parameters has a not negligible impact on the reinforcement effect, and the appropriate configuration should be made according to the specific situation. Finally, we put forward some improvement strategies, such as further optimization of the structural design and material selection of the device, in order to improve the overall performance of the reinforcement device.

Through the comprehensive evaluation of the practical application effect of the adjustable secondary structure template reinforcement device, the performance of the device used in the field is deeply understood. This will provide a solid foundation for the subsequent improvement and application of the device.

The application of adjustable secondary structure formwork reinforcement device simplifies the process flow, improves the forming effect, and is widely recognized by the supervision and construction units, which is conducive to establishing a positive image of enterprises. On the whole, the device not only ensures the quality of concrete molding, improves the work efficiency, is conducive to reducing the project cost, and has significant social benefits.

4 Conclusion

After a series of design, experiment and analysis, the application potential of a new type of adjustable secondary structure template reinforcement device is evaluated. The results show that the device significantly improves the stability and bearing capacity of the structure through its unique adjustment mechanism, which confirms its effectiveness and practicability in the strengthening of building structures. However, while advancing the scientific development in this field, we are also aware of several limitations in the research process and potential directions for future work. Although the device demonstrated superior performance in several aspects, there were certain limitations in the setup of the experiment. First, the experimental conditions, though carefully designed, did not fully reflect the changeable construction environment and complex stress conditions of the real world. In addition, materials may face more complex environmental factors in practical applications, such as extreme climatic conditions and chemical erosion, which have not been fully considered in a laboratory environment.

To address these limitations and expand our research, future work may focus in the following directions:

1. Comprehensive environmental testing: Testing the device under more extreme and variable environmental conditions to assess its durability and performance stability in different climatic and chemical environments.

2. Long-term performance monitoring: Through long-term field follow-up studies, more in-depth investigation of the durability and maintenance needs of the unit.

3. Economic analysis: A more comprehensive analysis of the cost effectiveness of the device, including economic evaluation of manufacturing, transportation, installation and maintenance.

4. Technology iteration and innovation: research into more advanced materials and technologies, such as integrating smart sensors to achieve real-time monitoring of structural health, and the use of advanced manufacturing techniques to reduce costs and improve performance.

The contribution of this study lies in the innovative thinking it embodies and the substantial promotion to the field of building structural reinforcement. We not only provide a new structural reinforcement device, but also provide a solid framework for the evaluation and implementation of similar techniques. These results are of great significance and value in guiding future structural engineering and architectural practice, as well as stimulating further research.

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