Reinforcement Design and Construction Technology Research in Housing Architecture

Hantao Lu
School of Civil Engineering & Architecture, Zhejiang University of Science & Technology, Hangzhou, Zhejiang, China

Abstract: With the development of society and the improvement of people's living standards, the demand for the quality of housing structures and living comfort is increasing. Long-term exposure to external environments and factors such as loading will gradually reduce the durability of housing structure materials, eventually leading to adverse effects on living comfort and safety. To minimize these impacts, it is necessary to reinforce the housing structure by reasonably selecting reinforcement design and construction techniques according to the actual situation of the building, in order to enhance the safety quality and performance of the construction project. This article analyzes the key points of reinforcement design in housing architecture, discusses commonly used reinforcement design methods, and construction techniques for reinforced building structures for reference by industry professionals.

Keywords: Housing Architecture; Reinforcement Design; Construction Technology

1.Introduction

With the rapid development of the economy in our country, the urbanization process is accelerating continuously. The construction industry is also growing rapidly, and people's demands for the quality of their residential buildings are increasing. Buildings can suffer various damages due to the natural environment and other factors. The evident weathering of materials can lead to a decrease in the overall performance of the structures. It is essential to reinforce the building structures based on local conditions during the construction process to enhance the engineering quality, ensure the safety during use, and better serve the people. Strengthening the construction and design of building structures is a complex engineering task that needs to meet modern construction requirements while providing residents with a more comfortable living environment [1]. This requires strengthening the effective application of reinforcement construction technology based on the structural characteristics to ensure the safety of building construction.

2.Analysis of Key Points of Housing Structure Reinforcement Design

When designing structural reinforcement for buildings, it is essential to consider the actual conditions and usage requirements of the structure. Rational selection of reinforcement methods and corresponding construction techniques such as crack repair and anchoring technology is crucial. During the design phase, a comprehensive analysis of the external environment should be conducted based on the external forces that the building structure will endure. For example, reinforcement types include overall reinforcement, component reinforcement, structural measures, among others. Overall reinforcement can effectively improve the overall load-bearing capacity of the building, while component reinforcement enhances the mechanical performance of the reinforced components. Choosing structural measures wisely can increase the feasibility of the aforementioned reinforcement methods. Regardless of the chosen reinforcement method, it should be based on precise calculations and comprehensive analysis of the overall structure to ensure the desired outcome. When carrying out house building reinforcement in earthquake-prone areas in China, both the load-bearing capacity and earthquake resistance need to be considered to guarantee effective reinforcement results.

Furthermore, focusing on safety and reliability as the core, developing reinforcement design plans is essential. Comprehensive considerations should be made regarding stability, convenience, and feasibility during construction. This

necessitates designers to conduct on-site investigations, communicate thoroughly with construction personnel, and decide on the final reinforcement design plan based on the actual conditions of the building project. It is imperative that frontline workers strictly adhere to the plan during construction to avoid discrepancies between the design drawings and actual reinforcement needs, ensuring practicality during construction and minimizing adverse effects on the surrounding environment.

Moreover, the selection of materials is a key aspect of building structure reinforcement design. Ensuring that material quality, performance, and specifications align with industry standards and the original building reinforcement design requirements is crucial to achieving the desired reinforcement effect. For instance, if the original building used 32.5 ordinary Portland cement, the same grade of cement should be selected for the reinforcement design, and the steel reinforcement should match the original building's structure. Designers should make the most of the original structure's load-bearing capacity, combine it with appropriate reinforcement methods, and reduce any adverse effects that the reinforcement design may have on the original building structure. If the chosen reinforcement method requires modifications to certain structural components, a comprehensive evaluation should be conducted on the potential impacts on the overall structural stability.

3.Common Reinforcement Design Methods for Housing Structure

3.1Common Methods of Masonry Structure Houses

3.1.1Reinforced concrete section reinforcement method and reinforced mesh cement mortar surface layer reinforcement method

Reinforced concrete section reinforcement method belongs to the composite section reinforcement method, mainly used for strengthening masonry walls, columns under compression, shear, seismic resistance, etc. By using reinforced concrete on the side of the original masonry columns and walls for reinforcement, it can improve the compression and shear performance of the original columns and walls. This method is relatively simple in construction, widely applicable, and significantly enhances the load-bearing capacity and performance of the original structure after reinforcement. However, due to the long wet operation and curing time required, it causes a certain degree of loss in the original building's usable area, impacting normal production and daily life [2].

Steel mesh cement mortar surface reinforcement method can be used for strengthening masonry walls, columns under compression, shear, seismic resistance, crack resistance, and reinforcement of compression components. This method involves applying a layer of cement mortar with steel mesh on the side of columns and walls to form a composite wall with the original structure. During construction, it is essential to ensure that the original mortar strength of shear components is above M2.5. If it is brick masonry, the original mortar strength should be at least M1, and for low-rise buildings, it should be above M0.4. This method is cost-effective, simple to implement, has strong adaptability, and mature design and construction experience. After reinforcement, the overall load-carrying capacity of the building will be improved. However, similar to the reinforced concrete section reinforcement method, this approach will reduce the building's usable area, increase wet operation during construction, require maintenance time, and impact residents' production and daily life.

3.1.2External steel reinforcement method

The external steel reinforcement method is based on the original structure of the house, enhancing the compressive load-bearing capacity of masonry columns by wrapping angle steel, flat steel, and other steel frames on the original masonry columns. It is mainly used for compression and seismic reinforcement of masonry columns, especially suitable for situations where the original component volume cannot be increased but significant enhancement of structural load capacity is needed. This method is reliable in force transmission, simple in construction operation, with significantly less work and wet operation compared to the above two methods. However, due to the relatively high cost of steel, the reinforcement cost is higher, and additional costs are incurred for rust and fire prevention treatment of structural steel.

3.1.3 Paste fiber composite material reinforcement method

The fiber composite reinforcement method generally involves using structural adhesive to bond fiber composite materials to the surface of a wall, enabling them to bear loads together with

the wall, aiming to enhance the overall load-bearing capacity. This method is commonly used for shear and seismic reinforcement within flat brick walls. In comparison to other methods, this approach requires higher surface integrity and strength levels of the wall. The wall to be reinforced should not have cracks, corrosion, or aging, and the measured strength levels of the brick and mortar should be at least MU7.5 and M2.5 respectively. This method is simple to operate and does not alter the structural weight or appearance during reinforcement construction. However, due to the poor durability and fire resistance of organic adhesives, improper protection may lead to fire or intentional damage.

3.1.4 Additional masonry columns, ring beams and structural columns reinforcement method

The method of adding support pillars involves increasing the load-bearing performance by adding masonry pillars on the side of a wall to form a unified whole. This method is generally suitable for reinforcing masonry walls in areas with seismic fortification intensity not exceeding 6 degrees. It is simple to construct and cost-effective but requires a long maintenance period and may reduce indoor space. In cases where there are structural defects in the building's overall structure, compensating by adding ring beams and structural columns can enhance the overall seismic performance. This method plays a beneficial role in improving the overall structure and enhancing seismic performance but has challenges such as wet operations and extended maintenance periods [3].

3.2 Common Methods of Reinforced Concrete Structure Houses

3.2.1 Increasing section reinforcement method

Increasing section reinforcement method mainly involves increasing the original component's cross-sectional area and adding reinforcement to improve the stiffness and bearing capacity of components like beams, slabs, columns, and walls. This alters their natural frequency, enhancing overall stability, making it suitable for cases requiring enlarging component dimensions while reducing axial compression ratios. It is relatively simple to implement and versatile, with abundant application experience in building reinforcement in China. However, this method involves wet operations, has a lengthy construction period, and may affect the performance of original or other components.

3.2.2 Bonding steel plate and external bonding steel reinforcement method

Steel plate bonding and external bonding steel reinforcement method involve attaching thin steel plates to the surface of concrete structures using high-performance epoxy adhesives to create a unified structure, enhancing the load-bearing capacity and stiffness through the tensile strength of the steel plates. This method is suitable for bending, shear on oblique sections, tension, and eccentric compression components, but not for plain concrete elements. Use of this method does not alter the appearance of the reinforced component, nor increase its weight or affect interior space in buildings. It offers quick construction, short timeframe, high steel utilization efficiency, and minimal usage. To ensure construction efficacy, the quality of the selected adhesive material must be guaranteed, bonding surfaces should be dry and clean, and steel plates should undergo rust and fire prevention treatments. When reinforcing concrete beams, columns, walls, framework nodes, etc., external bonding steel reinforcement can be adopted, where the components are enclosed with welded steel, flat steel, and injected structural adhesive to function together. The advantages and considerations of this method are similar to steel plate bonding reinforcement.

3.2.3 Carbon fiber reinforcement method

Carbon fiber reinforcement method involves using composite materials including carbon fibers, aramid fibers, glass fibers, etc., bonded onto the main stress points of concrete components with structural adhesive to form a unified composite section, improving overall structural load-bearing capacity and ductility. The materials used in this method are lightweight, strong, easy to work with, suitable for irregular or curved structures, highly corrosion-resistant, without increasing original component cross-sectional area or affecting indoor space usage. It presents significant advantages in building reinforcement. However, like other adhesive-requiring methods, these materials have poor durability, limited resistance to high temperatures, and are somewhat restricted by environmental conditions requiring specific fire protection treatments.

3.2.4 Structural system reinforcement method

For buildings with originally deficient or improper structural designs, the structural

system reinforcement method can be employed by adding shear walls, lateral supports, or components to compensate for existing flaws, enhancing overall structural load capacity, stiffness, and ductility, making the original structural system more robust and compliant with current standards. This method effectively enhances structural integrity and seismic resistance but may lead to differential settlement at junctions between old and new structures, affecting the performance of added components.

4. Common Building Structure Reinforcement Construction Techniques

4.1 Fiber Composite Reinforcement Construction Technology

Fiber composite materials reinforcement construction techniques typically utilize high-strength and high-toughness fiber composite materials such as carbon fiber, glass fiber, aramid fiber, etc., combined with resin adhesives to be closely integrated with concrete structures through pasting or wrapping. The use of fiber composite materials not only significantly enhances the bending and shear resistance of building structures but also effectively improves the seismic performance and durability of buildings. Additionally, the lightweight properties of fiber composite materials result in minimal increase in the self-weight of buildings during reinforcement, leading to a quick and clean construction process with minimal impact on the original building structure and daily use. Furthermore, fiber composite materials can be custom-designed according to the specific structural shape and loading characteristics of buildings, exhibiting good adaptability to maximize the reinforcement effects.

4.2 Bonded Steel Reinforcement Construction Technology

Steel bonding reinforcement construction can effectively enhance the load-bearing capacity of structural components. By adhering steel plates to the surface of components, steel bonding reinforcement construction techniques can improve the overall strength and stability of the structure. The main advantages of steel bonding reinforcement construction lie in the ease of obtaining materials, the minimal maintenance required after completion, immediate usability post-construction, and no adverse impacts on the surrounding environment. This technique is suitable for reinforcing flexural, highly eccentric compression, or tensioned reinforced concrete components, but not for concrete components with strength grades lower than C15 or insufficient steel reinforcement rates below 0.2%. Steel bonding reinforcement construction is convenient to operate with minimal impact on daily use. It is worth mentioning that to prevent chemical corrosion issues during steel bonding reinforcement operations, the construction team should maintain the construction environment temperature below 60°C.

4.3 Pre-Stressing Reinforcement Construction Technology

When applying prestressed reinforcement construction techniques, the construction team can pre-set rebars and steel cable channels at appropriate positions in the building structure according to its characteristics and reinforcement needs. Subsequently, feed the rebars and steel cables into the preset channels, use specialized tensioning equipment for pre-tensioning, and ensure that the applied prestress meets design requirements. Through anchoring systems, the construction team can transmit prestress to the structure, effectively enhancing the overall performance of the structure and improving its bending and shear resistance. The advantages of prestressed reinforcement construction techniques include the ability to increase the load-bearing capacity of structures without significantly increasing their self-weight, with minimal disturbance to existing structures. These techniques are suitable for various types of buildings, especially for the reinforcement and renovation construction of large buildings such as bridges, high-rises, and warehouses. It is important to note that prestressed reinforcement construction techniques require a high level of expertise and should be operated by experienced professional teams to ensure construction safety and reinforcement effects.

4.4 Outer Wrapped Steel Reinforcement Construction Technology

The external steel reinforcement construction technique involves using steel sections to externally wrap and reinforce building components, thereby enhancing the overall structural strength. The construction team should select steel sections of appropriate size and

shape based on the load requirements and structural characteristics of the components to be reinforced. Prior to reinforcement construction, the team must clean and prepare the surfaces of the building components to be reinforced, then securely attach the steel sections to the component surfaces using welding or bolt connections. To protect the steel from corrosion, after fixing the steel sections, the construction team typically applies anti-corrosion coatings or other surface treatments to the outer surface. A notable feature of the external steel reinforcement construction technique is its faster construction speed compared to other reinforcement methods, allowing for quick completion of reinforcement work, especially suitable for buildings requiring rapid restoration of use, such as reinforcing load-bearing components like beams and columns. Furthermore, this technique can effectively control building deformation, enhance overall stability, and play a crucial role in seismic reinforcement. However, there are limitations to the external steel reinforcement construction technique [4]. The use of steel sections increases the structural dead load, requiring the construction team to comprehensively assess the load-bearing capacity of the original structure before reinforcement. The connection method of the steel sections to the original structure and the handling of reinforcement details significantly impact the effectiveness of the reinforcement, necessitating precise design and a professional construction team for the external steel reinforcement construction. Considering that the use of steel sections may affect the appearance and usable space of the building, the design unit should fully consider these factors during the design phase to achieve a balance between structural reinforcement, aesthetics, and practicality.

4.5 Steel Wire Mesh Mortar Reinforcement Construction Technology

The basic principle of wire mesh mortar reinforcement construction technique involves using wire mesh as a reinforcement material combined with mortar to reinforce existing building structures. In the specific operation process, the construction team should first clean the surface of the structure to be reinforced, removing loose or damaged parts to ensure good adhesion of the wire mesh and mortar to the structure surface. After cleaning, the team should cut out appropriately sized wire mesh based on the specific dimensions and shape of the structure. Wire mesh typically consists of lightweight welded mesh or woven mesh with a certain elasticity and strength. The construction team can secure the wire mesh to the structure surface using nails or specialized bonding materials, then apply cement mortar or special reinforcement mortar on the wire mesh to fill the voids in the grid. The wire mesh mortar reinforcement technique is suitable for various types of buildings, particularly for the reinforcement and renovation of old buildings and cultural heritage structures. Additionally, due to the relatively low material costs of wire mesh and mortar and the simplicity of construction, the application cost of wire mesh mortar reinforcement construction technique is low, making it particularly suitable for reinforcement projects with limited budgets [5].

5. Coclusion

With the rapid advancement of urbanization, people have raised higher demands for the safety and stability of building structures. Currently, building structure reinforcement technology has been widely applied in various construction projects, demonstrating practicality. To ensure the safety and stability of building structures, construction units should base their practices on the specific requirements of the engineering projects, continuously innovate building structure reinforcement technologies, develop scientifically sound reinforcement plans, maximize the effectiveness of reinforcement technologies, and guarantee the quality and safety of building structures.

References

[1] Du Jikun. Analysis of key points of Building Structure Strengthening Technology and Construction Technology [J]. Housing and Real Estate, 2021(34): 176-177.

[2] Luo Liqun. Building Structure Reinforcement Design and Application of Construction Technology [J]. Decoration World, 2020(9):238.

[3] Yin Ting. Discussion on Strengthening design of building structure and application of strengthening construction technology [J]. Chinese Building Metal structures, 2021(5): 114-115.

[4] Cui Jiankun. Analysis on the Design and Application of building structure

Reinforcement Technology [J]. Jiangxi Building Materials, 2021(6):47-48.
[5] Zhang Xiaojun. The effective application of Structural strengthening Technology in building construction [J]. Windows and Doors, 2019(16): 27-28.

