Discussion on Construction Technology of Masonry Structures in Building Engineering

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Abstract: This paper focuses on the construction technology of masonry structures in building engineering. Addressing current issues such as difficulty in quality control, high resource consumption, and insufficient crack prevention, it conducts research by sorting out the application process of masonry structure construction technology and exploring optimization strategies. The study systematically analyzes the key operational points of core stages including pre-construction material and site preparation, setting out and positioning, block masonry, and tie reinforcement installation. It also discusses the application methods of technologies such as high-strength mortar selection, ready-mixed mortar processes, block arrangement optimization, and crack prevention and control. The results aim to demonstrate that standardizing construction processes and rationally applying optimization technologies can effectively enhance the construction quality of masonry structures, reduce resource consumption, improve structural durability, and provide practical technical references for masonry structure construction.

1. Introduction

In the field of building engineering, masonry structures have long been widely used in residential buildings, office buildings, and other civil structures as well as industrial ancillary facilities due to advantages such as convenient material sourcing, low cost, and flexible construction. However, with the construction industry's increasing demands for project quality, construction efficiency, and environmental protection, problems exposed in traditional masonry structure construction—such as non-standard material inspection, insufficient setting out accuracy, high mortar waste, and susceptibility to wall cracking—have gradually become key factors restricting the improvement of engineering quality. If these problems are not effectively resolved, they will not only affect the safety and durability of the building structure but may also increase later maintenance costs and even cause engineering hazards. Therefore, in-depth discussion of the application process and optimization strategies of masonry structure construction technology, and sorting out the technical points of each link, is of great significance for promoting the technological upgrade of masonry structure construction and ensuring project quality.

2. Application Process of Masonry Structure Construction Technology

2.1 Pre-construction Material Inspection and Site Preparation

During the material inspection phase, blocks need to be inspected upon arrival by batch. Three sets of samples are randomly selected from each batch, with 10 blocks per set. Compressive strength and moisture content are tested according to relevant standards. The compressive strength of fired perforated bricks must reach MU15 or above, and the moisture content of autoclaved aerated concrete blocks should be stable between 4% and 6%. If the moisture content exceeds the standard, natural air drying is required until it falls within the qualified range to prevent dry shrinkage cracks after masonry[1]. Mortar raw materials need to be inspected separately, and mix proportions verified. Cement requires testing for 3-day and 28-day compressive strength. Sand requires sieve analysis to control the mud content to no more than 3%. Admixtures need testing for

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compatibility with cement. Ensure the 28-day compressive strength of the mortar meets the design grade; for M7.5 mixed mortar, the cement consumption per cubic meter should be maintained between 230–260 kg. During the site preparation stage, surface vegetation and soft soil layers in the construction area need to be cleared first. A vibratory roller is used for site compaction, with no less than 6 passes. The bearing capacity of the foundation after compaction must meet the design requirement of above 180 kPa. When dividing material storage areas, 200 mm high brick enclosures should be set up. The stacking height of blocks should not exceed 1.8 m. A rain shelter needs to be built in the mortar mixing area, equipped with electronic weighing devices to ensure the weighing accuracy error of raw materials does not exceed ±2%, laying a reliable foundation for subsequent construction.

2.2 Setting Out, Positioning, and Elevation Control Operations

Based on the axis coordinates in the construction drawings, high-precision total stations are used for primary control measurement. Four permanent control points are set around the site, forming a closed traverse network. The relative closure error of the traverse survey must be controlled within 1/5,000. After axis measurement, an electronic level is used for elevation transfer, transferring from the benchmark level point provided by the construction unit to the construction site, setting up more than 3 temporary level points. Temporary level points need regular rechecking, with a recheck cycle not exceeding 7 days. The elevation transfer error must be controlled within ±1 mm/m[2]. During setting out operations, a chalk line is first used to snap the wall center line and outer edge line. Additional 200 mm wide control lines are snapped at door and window opening positions for precise positioning during masonry. The story pole should be made of dry, undeformed squared timber. Besides conventional information, the positions of tie reinforcements and the bearing length of lintels must also be marked. When installing the story pole, a level must be used for point-by-point calibration, ensuring the elevation deviation of all story poles in the entire building does not exceed ±3 mm. Simultaneously, the axis and elevation should be double-checked before masonry of each wall to avoid accumulated errors affecting construction quality.

2.3 Block Masonry and Mortar Fullness Control

Blocks should be watered and moistened 24 hours before masonry. Spraying is used to ensure uniform water penetration. The surface moisture content of the blocks should be controlled between 10%–15%, avoiding direct soaking which reduces block strength. During masonry, the "2381" masonry process is adopted: spreading mortar length not exceeding 2 m, masonry height not exceeding 1.8 m, mortar joint thickness controlled between 8–12 mm, and pointing performed after each course of blocks is laid[3]. Mortar fullness inspection requires specialized tools. Horizontal joints are inspected with a feeler gauge, with inspection points spaced no more than 2 m apart. Three measurements are taken at each point, ensuring the average fullness of horizontal joints is not less than 90%. Vertical joints are inspected ultrasonically, with no less than 5 inspection points per wall. The fullness of vertical joints must reach above 80%.

2.4 Wall Tie Reinforcement Installation and Inspection

Before installing tie reinforcements, the concrete structure surface must be treated. Mechanical grinding is used to remove surface laitance, ensuring tight bonding between the tie reinforcement and concrete[4]. HRB400 grade reinforcement bars are used for ties. The diameter is determined based on wall thickness: φ6 bars for 120 mm thick walls, and 2 φ6 bars for 240 mm thick walls. The vertical spacing of the bars is set at 500 mm. The length of the tie reinforcement extending into the wall must meet seismic requirements, generally not less than 1,000 mm. The length embedded into the concrete structure should not be less than 20d (d is the bar diameter). After installation, concealed acceptance inspection is required. Inspection includes bar specification, quantity, spacing, anchorage length, and cover thickness. A rebar locator is used to detect the position deviation of tie reinforcements, which must be controlled within ±5 mm. Pull-out tests are used to check the anchorage force of the ties. Three samples are taken from each inspection lot, and the pull-out force value must be not less than 1.05 times the design value.

3. Optimization Strategies for Masonry Structure Construction Technology

3.1 Selecting High-Strength Special Masonry Mortar to Reduce Waste

During the performance customization stage, determine the mortar strength grade based on engineering load requirements. Prioritize using P.O 42.5R grade cement as the base material, combined with admixtures like modified starch ether and air-entraining agent, to stabilize the 28-day compressive strength of the mortar at M10 or above, simultaneously increasing the impermeability grade to P6 and maintaining water retention above 90%, ensuring the mortar is less prone to water loss and segregation during masonry[5]. Precise dosage control requires first calculating the theoretical usage based on block size and joint thickness. Taking a 300 mm × 200 mm × 240 mm block as an example, the theoretical mortar consumption per cubic meter of masonry is about 0.23 m^3. On-site, use fully automatic measuring and mixing equipment to control the measuring error of sand, cement, and admixtures within ±0.5%, avoiding mortar strength deficiency or waste due to mix deviation. The dynamic adaptation link requires real-time adjustment of mortar performance based on the construction environment. When the ambient temperature is below 5°C, add early-strength anti-freezing agents to make the critical freezing strength of the mortar reach above 70% of the design strength. When air humidity is below 40%, increase the dosage of water-retaining components to extend the mortar's workable time to over 3 hours.

3.2 Adopting Standardized Construction Process with Ready-Mixed Mortar

During the production phase, develop special mix ratios based on engineering design requirements. Use twin-shaft forced mixing equipment, control mixing time between 3–5 minutes, ensuring mortar homogeneity meets standards. Sample and test consistency and compressive strength once every 50 m^3 of mortar produced, with data uploaded in real-time to the quality supervision platform. For transportation, use dedicated tankers with GPS positioning and temperature monitoring functions. Install spiral mixing blades on the inner wall of the tank. Maintain low-speed stirring during transportation to prevent mortar sedimentation. Control the transportation radius within 50 km. If exceeding 30 km, add retarder to the tanker to ensure the on-site workable time is not less than 2 hours. On-site, set up mortar storage tanks with temperature control functions in the construction area. Control the storage tank temperature between 15–25°C. When outputting mortar from the storage tank, use variable frequency metering pumps for precise dosage control, calibrating measurement accuracy once per hour[6]. Masonry construction requires using specialized mortar spreaders and pointing tools, ensuring mortar joint thickness deviation does not exceed ±1 mm, and horizontal joint fullness reaches above 95%. Simultaneously, conduct daily sampling inspections of construction quality, with the pass rate needing to stay above 98%. Establish a full-process quality traceability system from production to construction, significantly improving the stability of masonry structure construction quality.

3.3 Optimizing Block Arrangement to Reduce Cutting Waste

Preliminary layout requires creating a 3D model based on the architectural construction drawings. Perform virtual arrangement according to standard block specifications, prioritizing the use of whole bricks. For wall lengths that are non-standard sizes, achieve whole brick splicing by finely adjusting joint thickness within the 8–12 mm range. If non-whole bricks cannot be avoided, control their size to above 1/3 brick length, and the proportion of non-whole bricks should not exceed 3%. After layout is complete, generate detailed block arrangement guidance drawings, marking the position, orientation, and specification of each block, and distribute them to the construction teams. Before on-site construction, recheck the actual wall dimensions. If the deviation from the drawings exceeds 8 mm, readjust the layout plan to avoid extensive cutting due to size deviations. Cutting operations must be performed in a dedicated cutting area using CNC cutting machines. Before cutting, use a laser line projector to mark the cutting line on the block surface, controlling the cutting error within ±2 mm[7]. Collect generated scraps by category. Scraps larger than 150 mm can be used for masonry wall waist lines, window sills, etc. Scraps between 50–150 mm can be crushed and used as aggregate mixed into masonry mortar. Scraps smaller than 50 mm are collected and recycled for making small concrete precast components. By establishing a block usage statistics and waste analysis mechanism, comparing actual usage with theoretical usage monthly, and continuously optimizing the layout plan, the block cutting waste rate can be reduced from 12% to below 3%.

3.4 Introducing Masonry Crack Prevention and Control Technical Measures

During material selection, ensure the physical properties of blocks and mortar match. Select autoclaved aerated concrete blocks with a drying shrinkage rate below 0.5 mm/m, paired with special anti-crack mortar. Control the difference in linear expansion coefficients between mortar and blocks within 1×10^{-6}/°C to avoid cracks caused by material shrinkage differences[8]. In terms of construction technology, a 20 mm thick cement mortar leveling layer must be laid on the top of the foundation before wall masonry. The flatness deviation of the leveling layer should not exceed 3 mm/2m, reducing uneven stress on the wall caused by an uneven foundation. Control the daily masonry height to no more than 1.4 m during masonry. After masonry is completed, let it stand for 6 days before performing the top closing course. Use wedge-shaped blocks for the top closing course, with an inclination angle of 65–70°. Fill tightly with micro-expansion mortar, controlling the expansion rate between 0.03%–0.05%, effectively filling the gap at the top of the wall. For walls longer than 5 m, set up structural columns in the middle of the wall. Install tie reinforcements at the connection between the structural column and the wall, with the tie reinforcement extending into the wall for not less than 1,000 mm and spaced at 400 mm. Late-stage maintenance requires covering the wall with geotextile and water curing after masonry is completed. The curing time should be no less than 10 days. During curing, the ambient temperature fluctuation should not exceed 8°C/day, and humidity should be maintained above 65%[9]. Paste 200 mm wide alkali-resistant glass fiber mesh cloth at corners of door and window openings, wall corners, and other crack-prone areas. The lap length of the mesh cloth should be not less than 100 mm. Through the above comprehensive measures, the incidence of masonry cracks can be reduced from 25% to below 4%, significantly improving the durability of the masonry structure.

4. Conclusion

The following conclusions are drawn from the systematic discussion above on the construction technology of masonry structures in building engineering: From pre-construction material inspection and site preparation, to setting out and positioning, block masonry, and then to wall tie reinforcement installation and inspection, each link must strictly follow technical requirements, ensuring material performance meets standards and operational accuracy is qualified, to lay a solid foundation for subsequent construction. Selecting high-strength special masonry mortar can reduce waste; adopting standardized ready-mixed mortar processes can improve construction stability; optimizing block arrangement can reduce resource waste; and introducing crack prevention and control technologies can enhance structural durability. The comprehensive application of these optimization measures can effectively solve many pain points in traditional construction. Collaborative management and control throughout the entire construction process are indispensable. Links such as material selection, process operation, and quality acceptance need to be closely connected to form a complete quality control system, thereby practically enhancing the overall construction level of masonry structures and meeting the quality and safety requirements of building engineering.

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