Application of Frame-Shear Wall Structure Construction Technology in Building Engineering

Jicai Jiang, Zuocheng Wang

China MCC5 Group Corp. Ltd., Anhui Branch, Chuzhou, Anhui, 239000, China

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Abstract: This paper focuses on the application of frame-shear wall structure construction technology in building engineering, aiming to address issues such as insufficient stability, improper process sequencing, and difficult quality control during the construction of this structure. By sorting out the core requirements of structural construction and analyzing application principles and strategies in combination with actual construction scenarios, three major principles are summarized: prioritizing structural stability, strictly adhering to construction sequences, and strengthening precision control. Additionally, key strategies are proposed, including optimizing concrete pouring, enhancing formwork stability, and refining construction joint treatment. These aim to provide practical references for frame-shear wall structure construction in building engineering, helping to improve construction quality and structural safety.

1. Introduction

Frame-Shear wall structure is a building structural system which combines the beneficial aspects of frames and shear walls consisting frame columns, frame beams and shear walls. The vertical loads are carried by the frame and horizontal loads resisted with the shear wall. They provide structural flexibility and resist lateral displacement together. Commonly employed in modern mid–high-rise buildings, the layout provides adequate large spatial layouts while ensuring global stability of the underlying structure and good seismic performance thus it is one of the mainstream structural forms. Nowdays one of the most universal applied structure in midhigh-rise buildings is a hybrid frame-shear wall structure which allows for frame flexibility, as seen, for example, recently with design anchored against lateral forces. In actual construction, these non-standard technical applications often lead to poor structural stability and inadequate connection precision between components (which can degrade the overall performance of a structure). In order to solve these pain points, it is necessary to classify the application principles and strategies of this structural construction in a systematic way, clarifying technical key points at each stage. We will elaborate on the core content of technical application from the research background and provide theoretical and methodological supports for latter construction practices in the following sections.

2. Application Principles of Frame-Shear Wall Structure Construction Technology in Building Engineering

2.1 Prioritizing Structural Overall Stability

Static and dynamic loads before construction must be calculated. Apart from correctly computing the dead loads like component self-weight and floor live loads, you should also include building seismic design category including wind pressure coefficient according to its location. Component force distributions under seismic and wind loads should be simulated using a structural mechanics software, identifying the load transfer desired between shear walls and frame columns in order to avoid causing local component overloads due to mismatches in calculated forces [1]. Concrete slump is a measure of the plastic consistency of concrete and impacts how well it can be poured as well as its ultimate strength in service since concrete is the main load-bearing component. The slump

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should then be dynamically modified, based on the pouring height and dimensions of the component's cross-section, throughout construction. When pouring shear walls over 3 m high, the slump must be controlled in a range of 180 ± 20 mm. Besides, Some anti-cracking fibers should also be added in the proper proportion by volume in order to reduce shrinkage cracks caused by hydration heat so as not to degrade the overall stiffness of concrete structures due to cracking. So the construction speed has been adjusted based on real time monitoring. Pouring should be monitored for change of stress at shear wall and frame joints, thus they can be equipped with stress sensors. In order to impose the local stress concentration identification, appropriate means should be taken immediately to arrange pouring sequence or temporary support addition and so on during construction process when monitoring signal indicates that construction site structure has turned into unstable stress state, and it concerns with the establishment of a successful seismic performance compliance basis in the next stage.

2.2 Strictly Adhering to Component Construction Sequences

Shear walls are the major lateral force-resisting components and should prioritize bar binding and formwork instantiation. When binding the steel bar, staggered ratio of connections between vertical steel bars should be ≥ 50%, and the spacing between binding nodes of horizontal and vertical steel bars should not exceed 200 mm. Also add dark column steel bars at shear wall corner and edge nodes for better node shear resisting capacity. In stiffening the installation of all formwork it is necessary to use a full support system above laying, in which step of pillars taking into account weight by itself and lateral pressure of concrete — no more than 800 mm. To control the losses of grout, sealing strips are to be used at formwork joints where the vary of movements on the components sectional dimensions might reproduce [2]. After arduous wall concrete pouring, curing be held from specifications for no less than 14 days. Until companion concrete test cubes attain a strength of 75% of their design value, construction shall not proceed for frame beams and columns. This can be as a result of the idea that it takes time for the wall to gain sufficient strength before being used to carry loads so if the frame were constructed too soon then not only could this lead to cracking or deformation of the wall but would also mean that the shear wall would have loads transferred from movement in the frame. Rebound tests on the shear wall strength should always be done by external testing agencies before moving to construct the frames. This guarantees a step-by-step establishment of load-bearing capacity from the settlement process perspective, as reversed sequences would disrupt the structural force system.

2.3 Strengthening Construction Precision Control

Laser line projectors during axis alignment should be used along with total stations. Start by taking your main control axes for the building and set it on the foundation slab. This is then to be considered a reference point for measuring and where the axes of shear walls in regional zones need to go. Shear wall axis should be verified through bidirectional leveling after every set of alignments, with max. deviations ≤ 3 mm. Protective devices at axis control points Reduce displacement due to colliding between construction elements. Frame columns can be controlled in verticality step to step. Prior to pouring, make sure to verify that column formwork is actually vertical using a plumb bob and/or total station. After every 500 mm of pouring height, it should be reverification done during pouring. A laser plumb aligner must be used to detect the verticality of the columns immediately after pouring, achieving a verticality deviation of = 5 mm per floor within 24 hours from pouring. Ideally, timely grinding and grouting must be performed in case of deviations beyond the limit, as the total until individual pillars are turned non-vertical is relatively limited [3]. The control of the thickness of steel bar cover is also subject to the type of members. Plastic spacers shall be a quincunx pattern and spaced on shear walls with a spacing ≤ 600 mm. spacers with concrete index higher than or equal to the index of component concrete should be used for frame beams and columns, cement mortar spacers shall be adopted. We should tap after steel bar binding and check the cover thickness point by point with steel bar position detector, keep it in 15–25 mm, which are essential for the construction process of wall. This avoids problems if the same occurs due to high cover causing low effective cross-sectional dimensions of elements for special loaded structures or steel bar corrosion due to lack of cover.

3. Application Strategies of Frame-Shear Wall Structure Construction Technology in Building Engineering

3.1 Optimizing Concrete Pouring Processes

All of the components in the frame-shear wall structures rely heavily on concrete pouring quality. Three aspects of curing quality control in concrete pouring preparation layered control vibration operation and post-pouring curing should be optimized to comply with the concrete density strength. There are 3 preparations for pouring: (1) inspection on status mix of concrete transport trucks control that time between transportation and construction ≤ 90 minutes from delivery at the plant→ reach site, slump test when arriving & adjust into determination range >180±20 mm shear wall,frame beam + column =160±20 mm FRAME test or uneven components moisture due to standing water→ cleaning debrisDEBRIS Citex22 via high–pressure air pump blown dust layer existing in joints → must completely cleaned create only Screeding deck method [4]; reserved width during pulling point ≥50mm likewise in steel bars-dense places so vibrators can go smoothly inside components. Same during pouring, the strict layered pouring must obey layering standard: layer thickness ≤ 500 mm. With excessive pouring thickness, the vibration will be poor, so a measuring rod should work in this way to achieve real-time monitoring of layer thickness. Meanwhile, vibration operations should follow the "quick insertion slow withdrawal" principle (adjustment for immersion vibrators is 400 mm moving spacing) lasting for 20–30 seconds until concrete surface of mortar occurs and no further sinking. Using vibrator that is 30 mm diameter corners of shear walls and frame joints in areas densely core steel bar, to avoid voids; the action of vibrators can also cause the movement of the zone wall formwork leg pull plate displacement occur on a concrete construction stage that makes violent shaking device Avoiding steel bar displacement or damage [5]. Curing should start as soon as pouring takes place (using the film cover method for a minimum of 14 days). The concrete surface needs to be kept wet by watering 3–4 times a day for the first 7 days, this will prevent shrinkage cracks forming due to the rapid evaporation of moisture from the concrete. Full-process optimization can control the concrete honeycombing and pitting below 0.5%, ensuring that the bearing performance of the components meet requirements.

3.2 Strengthening Formwork System Stability

Formwork SystemOne of the most important factors in forming frame-shear wall structure components. On four aspects to improve: Choose formwork; Build support system (support) of the frame; Implementation reinforcement measures; Acceptance test to avoid displacement, collapse mold and grout leak during pouring. The choice of formwork for components depends on their characteristics. Considering shear walls and frame columns, in this case the use of steel-wood composite formwork was implemented with a panel of film-faced plywood with 18 mm thickness and a combination of 50 × 100 mm timber + Φ48 × 3.5 mm steel pipe back ribs. The flexural strength of a steel-wood formwork should be ≥ 15 MPa and the shear strength should be ≥ 1.5 MPa since it will have to bear lots of lateral pressures during filling up with concrete (around 25–30 kN/m²) [6]. Planned Construct to establish support system A box support system is used for shear wall formwork.Full scaffolding version should be provided with post longitudinal spacing and transverse spacing being determined from calculations genrally ≤ 800 mm. 50 mm thick Wooden Pad (≥ 2 Spans between) at Post bases to prevent post sinking For frame beam formwork support, double row scaffolding system is selected (post spacing ≤700 mm; ledger step spacing ≤ 1.5 m), together with diagonal bracing on both outer side of the scaffolding and inner side of framing rod to improve overall system stability, diagonal angle controlled between 45°~60°. Different components should be reinforced with specific measures. The shear wall formwork should be tied using tie bolts, the diameter of which is determined according to the calculation of concrete lateral pressure, generally Φ14–Φ16 mm and spacing ≤ 600 mm. Waterstop strips (for underground structures) or plastic spacers (for above-ground structures) must be placed at the two ends of bolts to ensure compliance with shear wall thickness. If using steel pipe hoops for frame beam side formwork, hoop spacing should be ≤ 500 mm. The beam bottom formwork should contain horizontal tubes at the bottom after which adjusters at the upper (≤ 300 mm, to avoid beam bottom sinking) [7]. Comprehensive acceptance tests need to be performed after formwork assembly Use a total station to detect deviations in the two directions of formwork axis, with shear wall axis deviation ≤ 3 mm and frame column axis deviation ≤ 5 mm. Check the formwork surface flatness using a 2 m leveling ruler, deviation ≤ 2 mm. Water pressure tests (for underground elements) or air tightness tests (for above-grade elements) must also be performed to guarantee grout does not leak from the joints between formwork. Without passing acceptance, the flow cannot move forward.

3.3 Refining Construction Joint Treatment Processes

Construction joints are the weak points of frame-shear wall structures. Optimize the treatment process This is not a further step of early steps, which is to reserve the joint and then treat it in four steps: that is, leaving the old concrete time after true thick dry (dry) · · Pouring new concrete · Cure after pouring curing if EncounterBut not achieving penetration effectCause leakage or weak force-bearing capacity. Joint reservation must be as per specs and design requirements. For shear walls, your reserve should be 200–300 mm which is below the floor slabs or beams while for frame beam joints this should be reserved within the midthird on span ranges. The joint section should be shaped like a rabbet (or with the waterstop steel plate where underground structures are present; thickness ≥ 3 mm, width ≥ 300 mm, welded and fixed to steel bars along both ends using tight welds [8]. Cleaning and preparation of construction joints represent one of the largest surface preparations, with removal of loose concrete and debris being paramount. Initially the surface laitance and loose stones should be chipped out to a depth ≥ 10mm by a pneumatic pick, exposing fresh concrete aggregates. Then, the joint surface should be flushed with a high-pressure water jet (pressure ≥ 0.8 MPa) until clean water flows out without dust or debris. Last but not least, polish the joint surface with a wire brush which would help in bonding of old and new concrete. Treat the joint surface so that it remains saturated with water and is protected from drying prior to pouring new concrete, all done within 24 hours of its use. Prior to pouring new concrete, a bonding layer should be applied that is made of mortar with no stones and has the same mix proportions as the concrete at a thickness of 50 mm across the entire cross section of the joint. To avoid initial setting of the mortar, upper-layer concrete must be laid within 30 minutes after laying the bonding layer. When pouring, pour priority should be given to the joint area and use a small vibrator within the scope of 500 mm away from the edge of thing, keep vibrating concrete for longer than ordinary areas, usually last 10~15 seconds), which can easily mix mortar and new concrete without air bubbles in this period [9]. Following concrete pouring, it is appropriate to perform improved curing. The joint area is wrapped in geotextile and sprinkled with water to maintain the curing, but the curing period needs 7 days longer than ordinary areas, ensuring that the old and new concrete cures at the same time, forming a whole force system. When the joint is completely cured, the ultrasonic detector should be used to test the quality of joint bonding, such as sound wave propagation speed ≥ 4000 m/s and no significant areas of sound wave attenuation; To meet the requirements for joint load-bearing capacity and waterproof performance.

4. Conclusion

The study shows that construction of the frame-shear wall structure needs to be centered on three major principles as: (1) ensuring overall structural stability through load calculations, material control and force balance; (2) following the order "shear walls first, frames later" in terms of construction sequence to ensure orderly formulation of bearing capacity; and (3) implementing a millimeter-level precision control system for axis alignment, verticality and steel bar cover thickness. Technical methods include optimizing the pouring process of concrete, enhancing the stability of formwork system and improving construction joint treatment and other aspects that commonly encounter problems in construction. It can improve the quality of structural construction and safety performance; securing a solid technical reference for similar projects.

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