Exploration of Anti-leakage Construction Technology for Concrete Structures in Building Engineering

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Abstract: In recent years, with the continuous increase in the number of building engineering projects, leakage problems in concrete structures have become increasingly common, gradually emerging as a topic of public concern and discussion. This paper focuses on the leakage issues of concrete structures in building engineering. It first analyzes the common leakage locations and their hazards, then examines the causes of leakage, such as design flaws, non-standard construction practices, ineffective material management, and structural deterioration. Subsequently, key technical points for anti-leakage measures, including waterproof concrete and critical joint treatments, are provided. Finally, quality control and management measures for all participating parties during various construction stages are clarified, aiming to offer reference for the practical work of relevant personnel.

1. Introduction

Among construction projects, if any real method of anti-leakage design and construction is not effectively executed, there can be an inability in green building demonstration waterproofing. Core indication tests for leakage will not pass during the latter phases of quality inspection. The scientific engineering application of anti-leakage technology is particularly important for engineering construction. By combining a responsible process build out with rigorous control of process parameters leakage can be prevented thereby reducing the financial waste associated with leakage and limiting the complexity of maintenance and overall financial burden over the life-span of the building.

2. Common Locations and Hazards of Leakage in Concrete Structures of Building Engineering

2.1 Common Leakage Locations in Concrete Structures of Building Engineering

The roof is a critical node, and first. The junctions between the roof parapet wall and the slab, around of land based drains and roots of vent pipes could be cracks because stress concentration in concrete. Other factors that are common include imperfect overlaps or even local damage during waterproofing layer construction that allow rain water to enter the structure through gaps [1].

Secondly, exterior walls are vulnerable areas. If concrete pouring around window and door openings, sealed scaffold holes, or junctions of exterior wall decorative lines is not dense, if sealing is improper, or if temperature deformation later causes sealing materials to age, rainwater can infiltrate the wall interior through gaps.

Special structural points in basements also need to be serviced. Basement post-poured strips, construction joints and the connections between the base slab and leading walls are all areas with high performance specifications. Poorly vibrated concrete, poorly cured strips after pouring, or misaligned waterstops can let ground water push through these weak points.

2.2 Hazards of Leakage in Concrete Structures of Building Engineering

Firstly, it can pose a threat to structural safety due to leakage. The long-term water erosion leads to the internal corrosion of rigidity. In soil conditions causing corrosion, the presence of water

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causes it to be absorbed by concrete structure (due to the solvent action); so during intense dry season when pores in structures becomes so small that there is no or little moisture available, localized drying occurs; rust occupies a size much bigger than iron covered with oxide layer and steel covered with carbonized layer + free copper ions enclosed between cement paste and metallic surfaces. In extreme cases, it could cause deformation in beams, slabs and columns which would then endanger the general stability of the structure [2].

Secondly, leakage affects functionality. In public buildings, leakage in exterior walls can lead to wall mold and even peeling off of the decoration layer in indoor areas affecting aesthetics and user experience. Leakage of basement causes moisture in the equipment room and storage space, which damages mechanical and electrical devices or stored items, but also affects normal use of building.

Finally, leakage increases economic losses and shortens lifespan. Leakage necessitates frequent repairs, generating additional maintenance costs and potentially affecting project schedules due to repair-related downtime. The long-term action of water accelerates concrete carbonation, damaging the integrity of the concrete structure and shortening the overall service life of the building.

3. Causes of Leakage in Concrete Structures

3.1 Systematic Defects in Design Scheme

Leakage risks stem from oversights in the design phase. Others, the contruction drawings are also not perfecting that the types and performance indicators of waterproofing materials are seldom indicated sufficiently, which leads to a lack of accurate basis for selection In addition, the unreasonable node design is common [3]. Examples are: roof flashing not being high enough, and no over-slope for parapet copings allowing water to follow the wall at the gaps between copings. Another example could be defects in drainage system design. Bad slope plan, such as on balcony and cantilevered slab areas, inappropriate roof slopes -for both thickness of insulation layer and structure level- will have local waters that collect there during the rain (ponding) reach of this area will be increased resulting in aging or even damage waterproofing layer quickly. In addition, inadequate design exploration work regarding site geological and hydrological conditions, as well as basement roof waterproofing structure that is not customizable according to overburden height leads to actual waterproofing capacity levels being lower than utilization demands causing channels for groundwater infiltration.

3.2 Non-standard Implementation of Construction Techniques

In some construction projects, during the construct phase, a poor Quality Control (QC) leads to leakage. There are also projects with special anti-leakage plans that are not targeted, and the leakage treatment measures at key leak points of important buildings do not meet the standards. Lack of technical skill of operators is a major contributing factor [4]. Such as uneven waterproof coating application and local insufficient thickness, not making standard rounded transitions at the internal corners of bay windows, etc. Because these factors will make the waterproofing effect not reach the ideal state. Moreover, complementary works are sometimes poorly coordinated, resulting in somesecundary damage. The second cause is that the concrete construction element needs to be protected after waterproofing layers are in place. Acceptance procedures become pro forma, with photograph templates failing to be filled for sign-off acceptance and no records kept for waterproofing-material-thickness testing; in effect allowing quality deficiencies to go undetected and uncorrected.

3.3 Failure in Whole-cycle Material Management

Quality control of the waterproofing material extends across all stages with regard to procurement, storage and construction. In part of the project, the incoming material test is not strict enough. The basis for testing parameters does not make a distinction according to specific standards; other waterproofing materials are used for more than one year without identification documents. The wrong storage environments affect material performance directly as well.

Performance of water based waterproof coatings can be damaged if they freeze or if a freeze thaw cycle occurs; sheet membrane materials will age and break down over time, if stored past their shelf life. Moreover, there is an insufficient material compatibility during construction phase [5]. An example : inconsistent material size between window sub-frames and structural openings lead to poor sealing efficiency, result in leakage path. Because substandard materials with poor anti-seepage performance are often purposely purchased in many projects due to insufficient personnel standards, which will lead to cracking and leakage after a little application.

3.4 Structural Deterioration Effects

Such leaks can appear due to an inherent defect in the concrete structure, its subsequent deformation. Honeycombs and surface voids created by insufficient vibration during construction provide conduits for water infiltration. Conversely, thermal stress is another prevalent reason for surface cracks. Too low compaction before final setting of concrete, or if the surface water evaporates too quick during curing and shrinkage cracks appear as a result; special nodes like post-poured strips and construction joints are therefore susceptible to gaps caused by the concrete shrinkage itself, e.g. due to misalignment of waterstop positions or insufficient curing periods, they can turn into leak paths easily. Furthermore, over long periods of time, chronic differential movement and thermal/hygrometric differences lead to progressive widening of initial very small cracks until they penetrate into the waterproof layer so that it no longer serves as a barrier against water infiltrating the environment.

4. Key Points of Anti-leakage Construction Technology for Concrete Structures in Building Engineering

4.1 Holistic Control of Waterproof Concrete Construction

As the basic support of anti-leakage, waterproof concrete needs raw material synergy and process optimization to realize structural self-waterproof. Material Selection Must Prioritize Compatibility The extreme nature of many cleanroom environments needs an attention to detail and a careful approach when it comes to material selection. Cement shall be of low heat of hydration and very impermeable type. Aggregates Should Have Continuous Grading to minimize Internal Pores. Admixtures must be rationally selected depending on impermeability requirements: water reducers tend to improve workability and reduce the amount of used water, while expansion agents may establish precompressive stress by compensating for shrinkage, avoiding cracking in the source [6]. At the same time, layered operation should be emphasized during pouring because it can have a uniform transmission of vibration energy to avoid pores which channel will be formed by insufficient vibration. The curing period should supply moisture continuously to maintain a normal hydration environment; otherwise, the surface water will evaporate quickly causing internal stress imbalance and eventually affecting the impermeability of concrete.

4.2 Key Points for Sealing and Protection of Critical Joints

Construction joints, expansion joints and post-pored strips as structural weak points need sealing protection through optimized structural design and precise execution. Designing the location of construction joints to stay clear of locations with high stress concentration naturally leads to an optimization in their shape which can seal off leakage paths at the concrete interface better between old and new concrete. You are advised to remove all surface laitance and other contaminants before construction, then increase bond strength via an interface bonding layer in order to eliminate any gaps at the interface [7]. In addition, to protect expansion joints two sealings should be applying. There is a need to ensure the waterstop selected will respond in concert with the joint according to its displacement characteristics. The multi-dimensional barrier produced by a combination of embedded and external waterstop. The fillers require not only elasticity but also sealing, so that they can effectively prevent the water penetration paths by the alternating deformation of structure. Strip construction after pouring requires tightly controlling when to pour the structural elements, it needs adding the construction time extensively according to at least what has been settled or thermally deformed. Use shrinkage compensation capable concrete, producing the closing of gaps through enhanced strength and impermeability.

4.3 Special Protection System for Pipelines and Embedded Parts

Establish a special protection system for leakage prevention of penetrating pipes and embedded parts (i.e., interface sealing and structural reinforcement). For penetrating pipes, it is necessary to have isolation protection using waterproof sleeves. Because of this, sleeves also avoid direct contact between a pipe and the structural wall, leading to that most waterstop rings present will enhance impermeability at that interface as well. Fill the gap between pipe and sleeve with layered sealing material to create a graded anti-seepage structure, blocking water from seeping along the gap. At the same time, embedded components should focus on surface treatment and structural strengthening. Corrosion removal ensures that they bond well with concrete before being installed. Embedded parts create a seepage barricade, thus waterstop structures are formed. Thereby, during the pouring process, have to prevent voids that in turn form leakage paths around embedded parts thus fundamentally hindering water from entering through the area between the embedded part and concrete.

4.4 Targeted Protection for Roof and Exterior Wall Nodes

For roof and exterior wall nodes, characteristic adaptation and process intensification through the schemes design to prevent the leakage based on different nodes with specific leakage risks. It is the combination of these two, drainage and waterproofing layer that serves the purpose of protecting sloped surfaces. This means that, in addition to making sure the drainage paths are smooth, preventing to prevent long-term water erosion of waterproof material. Concurrently, node design should avert high stress concentration in the waterproofing layer. For instance, a transitional fillet at the bottom of an existing parapet can decrease vulnerability to waterproofing layer damage. In addition, fixing and sealing of waterproofing layer must be provided continuously to form a closed loop along the edges to prevent the access of water. Furthermore, protection of the exterior wall must find a compromise between compactness and sealing at interfaces. The closure of scaffold holes should be layered to ensure density, and uneven pouring will easily cause pores in the tissue during the process; External window openings isolation should establish a hierarchical sealing system, and rely on fillers, sealants and waterproof mortar three effective components to jointly form the anti-seepage protection between filling building materials (waterproofing material or cement-based) and water permeable filling layers.

5. Quality Control and Management of Anti-leakage Construction

All issues you have detected need to be reported into the design unit quickly. The project department also needs to carry out special briefings for construction teams on key technologies, fully introduces technical parameters, quality control points and risk warnings for the anti-leakage works so that construction personnel accurately master the quality requirements [8]. In addition, in the inspection of raw materials and components, the construction unit needs to work with the supervision unit to carry out relevant sampling inspection methods for cement, aggregates, waterproofing membranes, water-stopping boards and other materials according to national standards or industry standards. In this way, unqualified products will never enter into the construction process.

The second is that the supervision unit should carry out whole-process standing supervision in all stages such as concrete mixing, transportation, pouring, vibration and curing during the construction process, and supervise whether there are unqualified construction techniques or not. At the same time, supervision unit must carry out monitoring work with respect to essential parts as well as processes such as construction joints, expansion joints and post-poured strips, emphasizing on confirmatory observation of how waterstop implementation works and self-inspection records. In addition, every process is qualified and self-inspection is required by the construction unit. Only after completing self-inspection will they be accepted for reporting to the supervision unit. But the next step could only begin after have been accepted by the supervision unit.

Finally, in the acceptance of the project, according to the technical specification and design documents, the client unit should organize the supervision and construction units to carry out water-proof performance test on concrete. Water ponding or water spray testing methods can be used for this. On the spot acceptance If non-conformities exist and quality of qualified products, as a rectification responsible party construction unit should designate to implement specific rectification plan responsible units and person within a time limit. After rectification work is completed, that is, when the supervision unit approves the rectification report, it should be led by the client unit for final review and confirmation.

6. Conclusion

In building engineering, anti-leakage measures for concrete structures play a key role as they are directly related to the structural safety, functionality and service life of projects. From the source prevention of design flaws, standardization of construction methods, and enhancement of whole-process material management to full-process quality supervision, it involves collaboration among clients, designers, contractors, and supervisors by absorbing technical levers and management requirements throughout. Only by using systematic thinking to establish a complete anti-leakage defense system, in order to accurately reduce risk at all stages, can we really reduce the possibility and extent of leakage hazards and truly improve the foundation quality and durability of the project.

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