Research on Cracks in Concrete Structures of Building Engineering

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Abstract: The appearance of cracks in concrete structures in construction projects not only affects the appearance of the structure, but also reduces the strength of structural concrete, affecting the safety and service life of structural components. This section analyses the causes of structural concrete cracks and studies preventive measures for concrete structural cracks from both structural design and construction perspectives.

1. Introduction

Concrete structures are widely used in modern construction engineering for crack control. The components in concrete structures can work with cracks within a reasonable range that meets the requirements of the specifications. Due to the long and complex process of construction engineering, there are many reasons and types of concrete cracks that occur. If left unchecked, it will create safety hazards. Both designers and construction personnel are gradually increasing their attention to concrete cracks in design and construction. Solve the problem in the early stage, start with design, strengthen measures and management during construction, and ensure the quality of the construction project.

2. The cause of cracks in concrete structures in construction projects

2.1 Shrinkage cracks

There are many reasons for the formation of cracks caused by shrinkage cracks, the most common being cracks caused by material shrinkage. According to the different causes of shrinkage cracks, they can be divided into plastic shrinkage, dehydration shrinkage and autogenous shrinkage. From the surface observation, the fracture surface of such cracks is relatively neat. The surface water of concrete loses quickly and the internal loss is slow, resulting in large surface shrinkage and small internal shrinkage. The surface shrinkage deformation is constrained by the internal concrete, causing the surface concrete to bear tensile force. When the tensile force of the surface concrete exceeds its tensile strength, shrinkage cracks occur. During the pouring period, the fluidity of the slurry exceeds the specified range, which is difficult to solve through technical means. After pouring, the slurry will experience significant shrinkage during the solidification process, ultimately leading to the generation of cracks. Most shrinkage cracks belong to surface cracks, with irregular shapes. Unreasonable proportion of raw materials and excessive reinforcement may cause shrinkage cracks.

2.2 Temperature cracks

Reinforced concrete components have the characteristics of thermal expansion and cold shrinkage. During the process of forming strength, a large amount of heat is generated inside the concrete, which is affected by external and internal temperature changes, causing deformation of the concrete. Deformation is constrained by steel bars, templates, and cohesive forces, which will generate stress within the structure. When this stress exceeds the tensile strength of concrete, temperature cracks will occur. Temperature cracks will expand or contract and close with temperature changes.

2.3 Cracks caused by load action

Concrete components may produce cracks under load, which exhibit different characteristics

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depending on the load. Load cracks are prone to occur in areas under tension, shear, or severe vibration. It is worth noting that the appearance of peeling or short cracks along the compression direction in the compression zone indicates that the structural components have reached their ultimate bearing capacity and is a precursor to structural failure. This is caused by excessive load or unreasonable design. [1]

2.4 Cracks caused by load action

The uneven vertical displacement of the building foundation, known as uneven settlement, causes additional stress in the structure, exceeding the tensile capacity of the concrete structure and leading to structural cracking. The situation that leads to uneven settlement of the foundation in construction projects is mainly divided into two aspects. On the one hand, it is due to the significant difference between the foundation condition and the geological survey report, and on the other hand, it is due to functional requirements, uneven distribution of building loads, and unreasonable structural design.

2.5 Cracks caused by steel corrosion

For reinforced concrete components, the concrete protective layer ensures that the steel bars are not oxidized and rusted. When there is a problem with the quality or thickness of concrete, or due to chloride intervention, the chloride ion content around the steel bars is high, it can cause the surface oxide film of the steel bars to be damaged, and the iron ions in the steel bars react with the oxygen and water invading the concrete to rust. The corroded steel bars generate iron hydroxide, which expands in volume, causing deformation and cracking of the concrete around the steel bars.[2] The bearing capacity of corroded steel bars decreases, leading to cracks in the structure of construction projects.

2.6 Cracks in concrete components caused by improper construction management

The substandard quality of the materials used in concrete may lead to cracks in the structure. During the pouring, formwork lifting, transportation, stacking, assembly, and hoisting process of concrete structures, if the construction process is unreasonable and the construction quality is poor, cracks are prone to occur. The location and width of cracks vary depending on the cause of their occurrence.

3. Measures to prevent concrete cracks from occurring

3.1 Strengthen the structural design work of building engineering

Structural cracks can be avoided through preventive measures, and the load-bearing capacity of the structure should be optimized during design. [3] When arranging structural components, try to avoid stress concentration caused by sudden changes in the structural cross-section and avoid eccentric stress. If it is not feasible due to the applicable functional requirements or design of the building, reinforcement measures should be fully considered. Handle the construction measures of components in constrained and unconstrained free deformation states, do not blindly improve the load-bearing capacity of components, and avoid the generation of cracks caused by excessive reinforcement. On the premise of meeting the usage requirements, measures such as arching can be taken to increase the deformation capacity of the components.

Necessary reinforcement measures should be taken for the parts of concrete components that must have holes and grooves left. The cast-in-place main beam needs to be equipped with additional hanging bars or stirrups when placing secondary beams. Pay attention to the application of structural steel bars. Especially for thin-walled components such as floors and wall panels, as well as large-span components, attention should be paid to the selection of the diameter and quantity of structural steel bars. According to the differences in load usage, anti-cracking steel bars are set up.

In basic design, to reduce the probability of uneven settlement. Avoid significant differences in structural stiffness, height, and load in the layout of building structural components. If set due to functional limitations. For example, the load difference between the main building and the podium, and the setting of local basements. Settlement joints or post pouring strips should be set up to appropriately strengthen the reinforcement of components near areas with significant load differences.

3.2 Strengthen quality control of concrete materials principle

The quality of concrete materials is an important factor determining the quality of concrete structures. Designers should consider comprehensively and choose reasonable concrete strength, mix proportion, and additives to save energy while meeting the safety and applicability of the structure. Strengthen the control of materials, select reputable and influential material suppliers for business cooperation, and strengthen the work management of construction material procurement personnel.

In terms of material selection, appropriate concrete strength grades and cement types and grades should be selected according to the structural requirements, and early strength cement should be avoided as much as possible. It is best to use cement with lower hydration heat, and it is strictly prohibited to use cement with unqualified safety. It is best to use rough and hard stone materials for coarse aggregates; Low porosity, good grading, and no alkaline reaction; the clay content and harmful substances shall not exceed the regulations. It is best to choose medium sand with smaller pores, coarser particles, and lower mud content for fine aggregates. Priority should be given to the use of water reducing agents and other admixtures to reduce water consumption, reduce shrinkage, and improve the workability of concrete. The expansion agent should fully consider the different expansion effects of different varieties and dosages. The optimal dosage of expansion agent should be determined through a large number of experiments. [4]

3.3 Strengthen construction process quality control

Strengthening construction organization design can provide more accurate construction basis for the engineering construction process. Accurate construction design data and construction standards can reduce the blindness of engineering construction, thereby improving the overall quality of engineering projects and improving the stability of concrete structures. Before carrying out relevant work, construction designers must conduct a thorough investigation and survey of the construction environment, strengthen the management of construction personnel, and ensure that the technical requirements of engineering construction can be effectively implemented.

To reduce concrete cracks caused by incomplete construction techniques, attention should be paid to the following aspects: when pouring and compacting, the vibrating rod should be inserted quickly and pulled out slowly. The vibrating time should be correctly controlled according to different concrete slumps to avoid excessive or missed vibration. It is recommended to use secondary vibration and secondary plastering techniques to eliminate moisture and bubbles inside the concrete. The maintenance of concrete is particularly important for the early maintenance of newly poured concrete in the prevention and control of concrete cracks, to ensure that the concrete produces as little shrinkage as possible in the early stages. The main task is to control the wet curing of components. For large volume concrete, it is advisable to use water storage or running water curing when conditions permit, with a curing time of 14-28 days.

4. Treatment measures for concrete cracks

4.1 Surface repair method

Surface repair methods include surface coating and surface patching. It is more suitable for repairing surface cracks, and the seam width is generally relatively small (less than 0.2mm) and relatively shallow.[5]If there are fewer small cracks in the building, surface coating is generally adopted; If there are large areas of honeycomb and pitted surfaces or micro deformation joints in the building, civil membrane or waterproof sheets are generally used for surface repair. In order to prevent the further development of concrete cracks while protecting them, measures such as pasting fiberglass cloth on the surface of the cracks can be taken to improve. This method also has significant drawbacks. Firstly, this method may conceal some unexplained cracks that cannot track the changes in the extended cracks; the second is that this treatment method cannot penetrate deep into the interior of the crack, which may leave hidden dangers. So when using this seemingly simple method, it also needs to be scientifically proven.

4.2 Grouting method

When the crack width is between 0.2 and 0.3mm, low-pressure grouting is usually used for remediation. Firstly, clean up the impurities in the cracks, then conduct leakage testing and prepare grouting fluid. Once the grouting fluid is successfully prepared, pressure grouting can be carried out. If the first grouting effect is not good, a second grouting can be carried out to remedy it, and finally, the surface can be cleaned up. When there are many cracks, first apply medical white adhesive tape to the crack location, and then use a narrow bristle brush to dip slurry back and forth along the crack to seal the crack. After about 10 minutes, remove the adhesive tape strip, expose the small crack, and tightly wrap the grouting nozzle with a key. After solidification, there may be cracks around the periphery, which must be repeatedly filled with grout to avoid grout leakage. [6]

4.3 Filling method

The filling method is suitable for cracks with a relatively large width (seam width greater than 0.5mm). It is necessary to chisel the cracks in the concrete into U-shaped or V-shaped grooves, clean the debris, and then use materials such as epoxy resin, polysulfide rubber, cement, sand, etc. to fill them. Finally, the surface should be cleaned. The specific method is as follows: mix the sand and cement that have been dried and sieved in proportion, and mix them evenly. Then, mix the epoxy resin and polysulfide rubber in proportion. Mix thoroughly and stir. Finally, dilute the mixed mortar with a small amount of acetone to a moderate consistency. Timely pour the mixed modified epoxy resin mortar into the cleaned and dried concrete trough. The entire construction process from mixing mortar to embedding it into concrete joints takes about 30 minutes to complete. After the mortar is embedded in the slot and treated, cover the mixed mortar with felt or hemp bags in a timely manner within two hours. After the initial setting is complete, start curing with water. This method has a wide range of applications, basically applicable to non-stress cracks, and the treatment effect is relatively good.

4.4 Structural reinforcement method

When concrete cracks are severe and affect structural safety, reinforcement methods should be adopted from the perspective of structural design to treat the concrete structure. This method is no longer simply eliminating the hidden danger of cracks, but through testing data and original design data, a new reinforcement design is carried out and a combined reinforcement plan is provided. The commonly used methods for structural reinforcement include increasing the cross-sectional area of concrete structures, wrapping steel at the corners of components, pasting steel plates for reinforcement, adding support points for reinforcement, and spraying concrete for reinforcement.

5. Conclusions

The prevention and treatment process of concrete cracks in building structures involves multiple factors and the construction process is complex. Here, a preliminary exploration has been conducted in theory and practice on the causes and control of concrete cracks. Although there are different academic opinions on the causes and calculation methods of concrete cracks, specific prevention and improvement measures and opinions are still unified according to experience and regulatory requirements. Through scientific and reasonable design ideas and construction measures, the generation of harmful cracks can be effectively reduced, ensuring the safety of buildings, fully utilizing the functions and functions of buildings, and solving problems in the project decision-making stage, design stage, construction organization and management stage, saving time and energy.

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