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Analysis of Concrete Crack Treatment Technologies in Buildings

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Abstract: With the continuous development of civil engineering, concrete crack treatment technology has become an important research field. This paper proposes treatment techniques for different types of cracks, including the prevention and repair of surface cracks, the reinforcement and grouting of structural cracks, and the design and construction of controlled cracks through the analysis of the causes and classification of concrete cracks. The methods and suggestions proposed in this paper are practical and can improve the quality and safety of buildings.

Keywords: Civil engineering; Concrete cracks; Construction treatment technology; Structural damage; Safety hazards

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1. Introduction

It is crucial to treat concrete cracks in order to ensure the quality and safety of buildings. Therefore, this paper aims to comprehensively analyze the causes and classification of concrete cracks and the treatment techniques for different types of cracks. Through comprehensive research and case studies, effective treatment methods and suggestions are proposed to help solve problems related to concrete cracks. A deep understanding and application of these technologies will help improve the reliability and durability of buildings.

2. Causes and classification of concrete cracks

2.1. Causes of concrete cracks

There are causes of concrete cracks can be divided into two categories: internal and external. Internal factors include concrete shrinkage, temperature changes, material inhomogeneity, internal stress, etc., which cause stress concentration during curing and use, which leads to the formation of cracks. External factors include earthquakes, foundation settlement, load action, moisture infiltration, etc., in which the pressure and deformation exerted on the concrete structure by these external forces lead to the formation of cracks [1].

2.2. Classification and characteristics

Concrete cracks can be divided into several types depending on the nature and morphology of cracks. Common types include shrinkage cracks, temperature cracks, fractures, spalling cracks, and structural cracks. Shrinkage cracks are caused by the shrinkage of concrete during the drying and curing process, and they are usually presented as fine surface cracks. Temperature cracks are caused by thermal expansion and contraction of concrete under temperature changes, and the cracks appear as long linear cracks. Fractures are network cracks formed on the surface of concrete, mainly due to insufficient fracture toughness or stress concentration of concrete (**Figure 1**). Spalling cracks are cracks formed by spalling of the concrete surface, usually caused by prolonged usage, chemical reaction, or freeze-thaw cycles. Structural cracks are major cracks in concrete structures and can be caused by loading, deformation, or improper structural design [2-4].

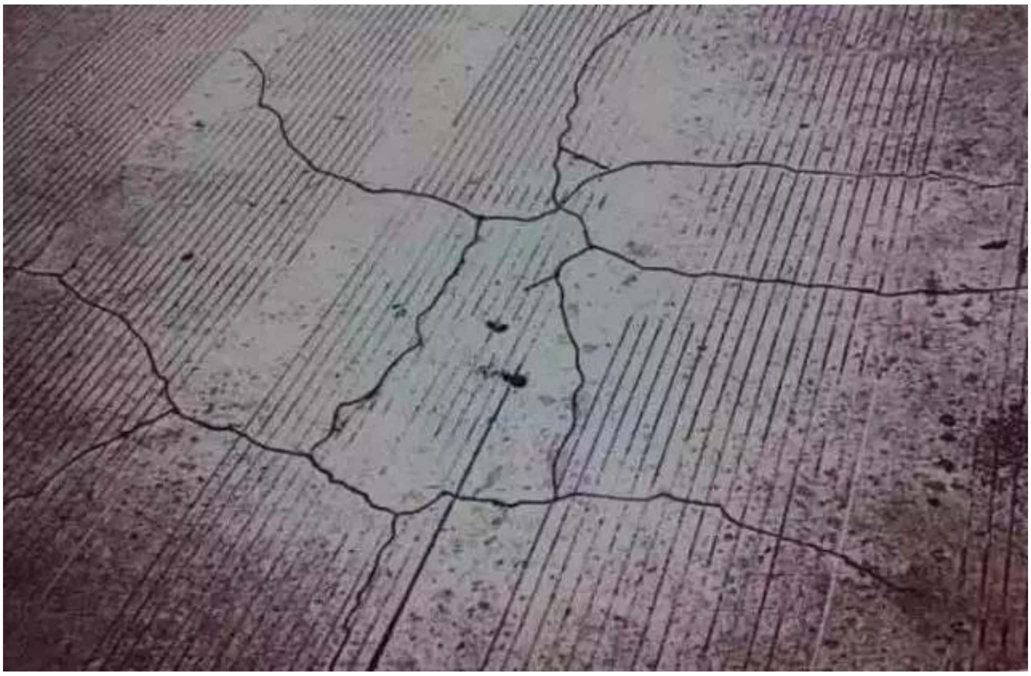

Figure 1. Cracking type of concrete crack

3. The construction treatment technology of surface cracks

3.1. Precautions

During the construction process, taking precautionary measures can effectively reduce the occurrence of surface cracks. Firstly, it is important to control the water-cement ratio of the concrete so that the concrete will not be too dry or too wet. Secondly, the crack resistance and durability of concrete can be improved by using appropriate concrete crack resistance materials and reinforcements [5-8]. In addition, the humidity and temperature of the construction environment should be well-controlled to prevent quick drying or excessive temperature changes. There are several techniques to treat surface cracks. Firstly, a layer of sealer or coating can be applied onto the surface of the concrete to increase its crack resistance and durability. Secondly, small cracks can be treated by filling the cracks with polymer repair materials, and the surface can be flattened by polishing and leveling to ensure a proper finish. At the same time, waterproofing techniques like waterproof coatings or permeable waterproofing agents can be applied to protect the concrete from moisture erosion and reduce the possibility of cracks.

3.2. Surface treatment technology

Common surface treatment techniques include coating, sealing, and polishing. Coating provides an additional protective layer to the concrete surface. The coatings used can be polymer coatings, epoxy coatings, or other special coatings that provide excellent crack resistance and durability [9-12]. The coating forms a protective film that prevents moisture and harmful substances from penetrating into the concrete, thus preventing the formation of cracks. Sealers are applied onto the surface of concrete to fill fine cracks and improve the impermeability and crack resistance of concrete. Commonly used sealers include polymer sealers, silicate sealers, etc. The sealer fills cracks and penetrates into the concrete, creating a protective film that provides additional durability and crack resistance. Polishing flattens and smoothens the concrete surface and gives a glossy finish. Polishing can not only repair fine cracks, but also improve the hardness and wear resistance of the concrete surface. The polished surface is not only aesthetically pleasing, but also easier to clean and maintain.

3.3. Filling and patching techniques

Filling and patching are commonly used to treat cracks on the surface of concrete, which can repair the existing fine cracks and restore the flatness and beauty of the concrete surface. Some commonly used fillers include polymers, epoxy resins, cementitious fillers, etc. These materials have good adhesion and filling and are able to fill small cracks and form strong bonds with concrete surfaces. The procedure of concrete filling is as follows: First, the area of the cracks are cleaned, and debris and loose concrete particles are removed; then, a suitable filler is used to fill the cracks depending on the width and depth of the crack [12-15]. Filling can be done by hand or by injected using an injection device to ensure that the repair material fills the cracks completely and bonds well with the concrete; lastly, the repaired area is flattened and smoothened. The advantage of filling and repair technology is that it can effectively repair small cracks and improve the flatness and aesthetics of concrete surfaces. In addition, the selection of fillers and filling method should also be reasonably evaluated and decided according to the nature of cracks and the environment to ensure the best effect of the repair.

3.4. Waterproof treatment technology

Waterproof treatment technology plays an important role in the treatment of concrete cracks by preventing moisture penetration and erosion, and prevents the formation and expansion of cracks. Some commonly used waterproofing techniques are waterproof coatings and permeable waterproofing agents. Waterproof coating is a coating applied to the surface of concrete with waterproof properties. These coatings can form a waterproof membrane that prevents moisture from penetrating into the interior of the concrete. Waterproof coatings can be divided into two categories: rigid coatings and elastic coatings. Rigid coatings are suitable for flat concrete surfaces such as floors and walls. Elastomeric coatings are suitable for concrete structures that require high elasticity and durability, such as basements and bridges. Permeable waterproofing agents are chemicals that penetrate into the interior of concrete and fill in fine pores. These waterproofing agents are able to react with the cement components in the concrete to form a water-resistant gel that prevents moisture from penetrating. Permeable waterproofing agents do not change the appearance or surface texture of concrete and have good durability.

4. Treatment technology for structural cracks

4.1. Structural reinforcement and strengthening

The purpose of treatment of structural cracks is to restore the strength and stability of the concrete. A commonly used treatment technique structural reinforcement and strengthening. Structural reinforcement treats cracks by increasing the bearing capacity of concrete structures. A commonly used reinforcement is rebar. This involves drilling holes around the cracks and injecting epoxy binder, then inserting rebar into the holes to form a rebar reinforcement band. This increases the strength and stiffness of the structure and prevents the spread of cracks. In addition, high-strength materials such as fiber-reinforced composites (FRP) can also be used for reinforcement, which provides additional strength and stiffness by attaching them to the surface of the structure. Structural strengthening technology is used to improve the stress performance of the structure and prevent the formation of cracks [16-17]. A common approach is to add shear walls, reinforcement beams or reinforcement columns to concrete structures, etc. This can change the force transfer path of the structure, reduce the stress concentration at the crack, and improve the seismic performance and stability of the structure as a whole. When selecting and applying structural reinforcement and strengthening technology, it is necessary to comprehensively consider factors such as the type of structure, stress state, and the nature and degree of cracks. Besides, the treatment should be performed in strict accordance with relevant specifications and requirements to ensure the effectiveness and safety of reinforcement and strengthening measures. Through reasonable structural reinforcement and strengthening technology, the crack resistance and overall stability of concrete structures can be improved, and their service life can be extended [18-19].

4.2. Grouting

Grouting is a commonly used structural crack treatment method where the crack is injected with a slurry to reinforce and repair concrete structures. This technology effectively restores the integrity and strength of the structure and prevents further expansion of cracks.

Some commonly used slurry in grouting include polymer, cement, epoxy resin, etc. These slurries have good flow rate and adhesion, and they can fill cracks and form a strong bond with the surrounding concrete.

The procedure of grouting is as follows: Firstly, the crack surface is cleaned, and loose concrete particles and debris are removed; then, holes are drilled in the crack and the appropriate grouting equipment is selected according to the width and depth of the crack; when grouting, it is important to control of grouting pressure and grouting speed to ensure that the slurry fully fills the cracks and bonds well with the concrete; lastly, the slurry material is left to solidify, and the repair and reinforcement process is completed. Cracks in concrete structures can be effectively filled and repaired by grouting, thus improving their strength and stability. However, it is necessary to select the appropriate slurry material and grouting method according to the situation. Besides, it is also important to strictly abide by the relevant specifications and requirements to ensure the treatment effect and the safety and reliability of the structure.

4.3. Prestressing

Prestressing is an advanced method for treating structural cracks that enhances the strength and stability of concrete structures by applying pre-applied tensile forces. The technology is suitable for structures that need to withstand large loads, such as long-span bridges, high-rise buildings, and other major projects. The main steps of prestressing technology are as follows: First, prestressed steel bundles are buried in the concrete structure, and these steel bundles will apply tension during the prestressing process; then, tensile force is applied through the tensioning equipment to prestress the steel beam; once the required degree of prestress is reached, the steel bundle is fixed to the anchor; lastly, the concrete will be compressed by the tensile force of the prestressed steel bundles, improving the strength and stability of the structure. The advantage of prestressing is that it can effectively control the cracks of the structure and reduce the width and propagation of cracks. Through prestressing, the tension in the structure can be offset or reduced, thereby reducing the stress on the concrete. This reduces the stress concentration of the concrete and reduces the formation and propagation of cracks. In addition, prestressing can improve the overall stiffness and seismic performance of the structure.

4.4. Structural modification and reconstruction

Structural modification and reconstruction are a comprehensive approach in dealing with structural cracks for severely damaged or loss-of-load-bearing concrete structures. Structural modification and reconstruction are performed to repair and rebuild structures so that they are in a secure and safe state. Structural modification involves adjusting and repairing existing structural components to increase their load-bearing capacity and stability. This may involve replacing damaged components, adding reinforcement, adjusting how members are connected, etc. Through these adjustments, the damaged parts of the structure can be repaired, and its overall strength and stability can be improved. Structural reconstruction refers to the complete demolition and reconstruction of severely damaged or failed parts of a structure, which may include removing damaged concrete elements and rebuilding new structural components. The reconstruction process requires detailed design and calculations to ensure the accuracy and stability of the new components. Structural modification and reconstruction should be designed and performed by experienced engineers to ensure the safety and stability of the structure. Before modifications and reconstructions, a comprehensive structural assessment and analysis is required to identify the parts that need to be adjusted or rebuilt. At the same time, it is also important to adhere to relevant building codes and requirements to ensure the compliance and sustainability of the structure [20].

5. Crack treatment technologies

5.1. Design and construction of control joints

The design and construction of control joints is important in preventing and controlling cracks in concrete structures. Control joints guides and controls the formation and propagation of cracks by placing specific gaps in the concrete structure. When designing control joints, factors such as the type, size, stress state and expected deformation of the structure need to be considered. The construction of control joints usually involves creating slab gaps or cutting the concrete. Through reasonable design and construction of control joints, the width and number of cracks can be reduced, and the durability and overall performance of the structure can be improved.

5.2. Treatment of temperature and shrinkage cracks

Temperature and shrinkage are common causes of cracks in concrete structures. During temperature changes and shrinkage of concrete, internal stresses are generated, which trigger the formation of cracks. Methods for dealing with temperature and shrinkage cracks include controlling the temperature and humidity of the concrete, using bulking agents or additives to reduce concrete shrinkage, and considering the elasticity of the structure during the design and construction stages. Through effective temperature and shrinkage control, the incidence and degree of cracks can be reduced, and the integrity and stability of the structure can be maintained.

5.3. Prestressing and post-tensioning

Prestressing and post-tensioning are methods of controlling cracks in concrete structures by applying prestress or post-tension. Stresses and deformations in the structure can be reduced by applying tensile forces, thereby reducing the formation and propagation of cracks. Prestressing and post-tensioning are commonly used in large bridges, beam-and-column structures, and underground structures that are subject to large loads. Through reasonable prestressing and post-tensioning, the number and width of cracks can be effectively reduced, and the stability and crack resistance of the structure can be improved.

5.4. Reasonable construction process and sequence

Reasonable construction process and construction sequence play a key role in controlling cracks in concrete structures. During the construction process, appropriate measures need to be taken to reduce the stress concentration and deformation of the structure. This includes suitable pouring methods, adequate moist curing, and appropriate curing time. In addition, a reasonable sequence of construction is also a key factor, especially for large structures and complex shapes. Through reasonable construction process and sequence, stress and deformation in the structure can be reduced, thus preventing the formation and expansion of cracks.

In short, the design and construction of control joints, the treatment of temperature and shrinkage cracks, the process of prestressing and post-tensioning, and the reasonable construction process and construction sequence are crucial to prevent cracks in concrete structures. They work together to effectively prevent and control the occurrence of cracks, improving the durability and overall performance of the structure. Besides the specific situation of the project should be considered, and relevant design specifications and construction requirements should be to ensure the construction quality and structural safety.

6. Conclusion

In conclusion, concrete crack treatment technology is of great significance in civil engineering. Through an in-depth analysis of the causes and classification of concrete cracks, as well as the treatment techniques for different types of cracks, cracks can be effectively prevented, controlled, and repaired. As a result, the stability and durability of concrete structures can be improved. However, in order to achieve good treatment results, it is necessary to comprehensively consider many factors such as the selection of materials, the rationality of design, and the utilization of construction technology. Future research should be carried out to better understand concrete cracks, promote technological innovation, and continuously improve the quality and sustainable development of civil engineering.

Disclosure statement

The author declares no conflict of interest.

References

[1] Han C, 2023, Research on the Cause and Prevention of Concrete Cracks in Civil Engineering. China Building Decoration and Decoration, 2023(07): 110–112.

[2] Wang Y, 2023, Analysis of Cracks Related to Concrete Floor Slab in Construction Civil Engineering. Development Orientation of Building Materials, 21(04): 60–62.

[3] Ji H, Luo N, 2023, Causes and Quality Control Analysis of Concrete Cracks in High-Rise Buildings. Urban Construction Theory Research (Electronic Edition), 2023(02): 131–133.

[4] Zhao J, 2022, Discussion on Key Technologies of Concrete Structure Construction in Civil Engineering Buildings. Engineering Technology Research, 7(16): 80–82.

[5] Zang P, 2021, Discussion on the Construction Treatment Technology of Concrete Cracks in Civil Engineering Buildings. Jushe, 2021(16): 33–34 + 86.

[6] Tang H, 2021, Exploration of Architectural Planning and Design Concept of Hefei Xinzhuang Primary School. Anhui Architecture, 28(8): 21–22.

[7] Liu Y, Ji M, 2021, Spatial Scale Thinking in the Planning and Layout of New Large-Scale Campus: A Case Study of the Planning and Architectural Design of the New Campus of Hebei Union University. Contemporary Architecture, 2021(8): 29–32.

[8] Qin Z, 2020, Research on Building Energy-Saving Campus Construction Based on Life Cycle Cost Theory. Industrial Innovation Research, 2020(8): 184–185

[9] Zhang Y, 2020, Research on Campus Planning and Architectural Design of Primary and Secondary Schools: A Case Study of Nanjing Foreign Language School Fangshan Branch. Urban Architecture, 2020(8): 52–57.

[10] Geng Y, 2020, Strategies for Improving Residential Planning and Design and Living Environment Under the New Situation. Housing & Real Estate, 2020(21): 46

[11] Sun H, 2020, Research on the Blended Learning Mode of University English in the Era of "Internet+". Science Teaching Journal, 2020(7): 27–28.

[12] Ge M, Cui W, Tang H, et al., 2020, Campus Model, Space Type, and Architectural Construction: A Seminar on Shenzhen Campus Planning and Design of Chinese University of Hong Kong. Architectural Journal, 2020(3): 99–111.

[13] Sun Y, 2020, Exploration and Thinking on Primary and Secondary School Campus Planning and Architectural Design. Housing & Real Estate, 2020(9): 82–83.

[14] Zhang L, Chen J, 2020, A Brief Analysis of the Modern Interpretation of Regional Culture in Campus Architectural Design: A Case Study of Campus Planning and Design of Guangxi University for Nationalities. Architecture and Culture, 2020(3): 90–91.

[15] He T, 2022, Analysis of the Characteristics and Sense of the Times of School Buildings: A Case Study of Zengcheng District Experimental Middle School of Guangzhou. Urban Architecture, 2022(24)

[16] Yue L, 2023, Discussion on Campus Architecture Design Based on humanized Design Concept. China Architectural Decoration, 2023(5): 109–111.

[17] Huang X, 2022, Strengthening Design of Building Structure in Renovation of Old Residential Area. China Housing Facilities, 2022(7): 34–36.

[18] Li J, 2021, Strategies to Improve Building Safety in Building Structure Design. Commodity and Quality, 2021(19): 121.

[19] Zhang H, Lan Q, Niu B, 2022, Application of Wood Structure in Canadian School Architecture. New Construction, 2020(06): 110–113.

[20] Wang Y, 2010, Design Concept of School Building. Basic Education Curriculum, 2010(04): 78.