State of Art:The phenomenon of crack formation and the causes of its occurrence in reinforced Concrete structures.

Dr. Hossam Muhammad Ali
Abdul Rahman Hamza Hussein
*AL-Furat AL-Awsat Technical University – AL-Mussaib Techincal Collage – Building &Construction Department

Abstract

Two primary types of damage to a concrete structure are cracks and cavities. These damage types can lower the structure's tightness and load-bearing capability, which can result in structural failures and disasters. A structural element's ability to withstand corrosion and maintain the adhesion of its reinforcement may be weakened by excessive and uncontrollably cracking it. Furthermore, structural cracks detract from the building's appearance and, in severe circumstances, may make occupants uncomfortable. As a result, the accompanying essay offers a thorough analysis of the problems associated with the emergence and progression of damage and cracking in the concrete composites structure. It describes their fundamental categories and focuses on the factors that lead to crack initiation. A summary of the most Additionally provided are widely used techniques for identifying and evaluating the morphology of microcracks as well as assessing the path along which they propagate. Eight distinct criteria can be used to categorize the different sorts of cracks that appear in concrete composite materials. Microcracks in reinforced concrete elements are tied to their particular situation, while macrocracks in same elements are dependent on the kind of prevailing loads. The results of the analysis indicate that in tensioned elements, microcracks are often rectilinear in shape; in shear elements, wing microcracks with straight wings are present.

حالة فنية: ظاهرة تكون الشقوق والشروخ وأسباب حدوثها في المنشآت الخرسانية المسلحة

الباحث :عبد الرحمن حمزه حسين البروفيسور الدكتور حسام محمد علي.
ealgbur@gmail.com
hus@atu.edu.iq.com
جامعة الفرات الأوسط التقنية – الكلية التقنية المسيب – قسم البناء والتشييد

الملخص

هناك نوعان أساسيان من الأضرار التي تلحق بالهيكل الخرساني هما الشقوق والتجاويف. يمكن أن تؤدي أنواع الأضرار هذه إلى تقليل إحكام الهيكل وقدرته على التحمل، مما قد يؤدي إلى فشل هيكلي وكوارث. قد تضعف قدرة العنصر الهيكلي على مقاومة التآكل والحفاظ على التصاق تسليحه عن طريق تشققه المفرط وغير المتحكم فيه. علاوة على ذلك، فإن الشقوق الهيكلية تقلل من مظهر المبنى، وفي الظروف القاسية، قد تجعل شاغليه غير مرتاحين. ونتيجة لذلك، يقدم المقال المصاحب تحليلاً شاملاً للمشاكل المرتبطة بظهور وتطور الضرر والتشقق في هيكل المركبات الخرسانية. فهو يصف فئاتها الأساسية ويركز على العوامل التي

تؤدي إلى بدء التصدع. ملخص للتقنيات الأكثر استخدامًا بالإضافة إلى ذلك المستخدمة على نطاق واسع لتحديد وتقييم شكل الشقوق الصغيرة بالإضافة إلى تقييم المسار الذي تنتشر من خلاله. يمكن استخدام ثمانية معايير مختلفة لتصنيف الأنواع المختلفة من الشقوق التي تظهر في المواد المركبة الخرسانية. ترتبط الشقوق الصغيرة في عناصر الخرسانة المسلحة بوضعها الخاص، في حين تعتمد الشقوق الكبيرة في نفس العناصر على نوع الأحمال السائدة. تشير نتائج التحليل إلى أنه في العناصر المتوترة، غالبًا ما تكون الشقوق الصغيرة مستقيمة الشكل؛ في عناصر القص، توجد شقوق صغيرة في الأجنحة ذات أجنحة مستقيمة.

Introduction

The design and construction of buildings with the goal of achieving the highest level of structural safety at the lowest possible cost is one of the primary responsibilities of contemporary material engineering. Structural elements and the interactions between the material's micro- and macrostructure primarily affect the characteristics of concrete materials, especially their endurance Two primary types of damage to a concrete structure are cracks and voids, which can:

Reduce the structure's tightness and load-bearing capacity.

cause the structural piece to become less rigid and cease to function as a complete cross-section of reinforced concrete. cause building structures to malfunction and collapse

Due to total destruction (caused by damage and cracks) and the requirement to construct new structures using non-ecological and energy-consuming cement binder, concrete's carbon footprint and energy consumption will increase.

For these reasons, it is crucial to comprehend the events that lead to the development of fractures in reinforced concrete structures as well as to identify the locations where these cracks most frequently occur. concerning the emergence and progression of corrosion and cracking within the concrete composites' structure The primary focus lies in the factors that lead to the formation of cracks and the traits of their most common varieties. An overview of the most widely used techniques for identifying microcracks, evaluating their morphology, and determining their propagation trajectory is provided in the last section.

The production and spread of cracks in non-reinforced concrete elements and reinforced concrete structural elements reinforced using flaccid reinforcements are extensively reviewed in this article. Based on the carried out research, it has been concluded that the literature lacks a precise description of how cracks propagate in reinforced concrete elements in relation to different types of loads.

(A) Primary defects—caused by mistakes in design and execution, or by the inherent qualities of the material.

(B) Secondary defects—those that appear during use.

(a) The following factors are among the set of factors that lead to the development of primary defects:

1. Among the factors that contribute to the production of cracks in natural materials are:

2. The initial thermal stresses that arise in the initial hours following the creation of the concrete element;

3. Shrinkage in concrete brought on by the physico-chemical reactions of cement constituents;

4. Heterogeneity of materials.

(b)Among the following categories of applied reinforcement-related crack causes:

1- The state of the reinforcement's surface; 2- The reinforcement's adherence when applied;

3- Insert distribution method in the element's cross-section;

4-Dimensions of reinforcement.

5-Distance of inserts from the element's edge.

(c)In the group of causes of cracks as a result of design errors:

1-Faulty design assumptions for the working conditions of the structure;

2-Loads incorrectly assumed by designers, e.g., omission of temperature loads;

3-Improperly assumed conditions of construction execution;

4-The insufficient knowledge of the designers;

5-Calculation errors during project development;

6-Negligence of the authors of the project

. (d)Among the list of factors that can lead to cracks due to faults in technology and craftsmanship is:

1. Materials and products are not strong enough; 2. Assembly and structural connections are of low quality;

3-Prolonged technological pauses in the process of applying consecutive layers of concrete mix; 4-Inadequate concrete vibration and poor compaction when technological pauses occur;

5. An excessively thin and permeable concrete reinforcement layer;

6-Disturbances from the project when it is being implemented;

7. Inadequate training and expertise of contractors; 8. Inadequate oversight and collaboration with the designer; 9. Contractor neglect. (B)The subsequent set of factors that contribute to the development of secondary faults consists of the following:.

(a) Mistakes made when use the facility:

1. loads that are both excessive and insufficient given the design assumptions;

2. Modifications to the facility's purpose or static schematic;

3. Insufficient environmental protection for the structure; 4-Inadequate technical oversight of the operation;

5. Limited understand

(b) Errors in the design:

1- The building's foundation is incorrect.

2- There are not enough expansion joints.

3- Improperly constructed damp insulation.

4- Improperly designed terraces and roofing.

5- Improperly dimensioned structures of the users.

(c) Mistakes in job execution:

1. Using materials whose qualities are not as intended.

2. Incompetent work performance.

3. Not using the proper technology for the job; for example, choosing the wrong technology to operate at low temperatures.

(d) - The hostile influence of the outside world:

1. The effect of moisture

2. Concrete erosion and corrosion

Ground settlement, shocks and vibrations, snow deposition on roofs and the impact of biological variables, and horizontal wind pressure on walls and roofs are the next six examples.

(e)Exceptional loads include.

1-Excessive loads from wind and snow.

2-Gas explosions and malfunctions in technology;

3-Random damage and fire.

4-Seismic load.

5-Hurricanes.

Literature review

1-Poor construction practices: (Reference: ACI Committee 302. (2019)(1)

Inadequate Compaction: Insufficient compaction during the concrete pouring process can result in voids and air pockets within the concrete, weakening its structural integrity and making it more susceptible to cracking.

Improper Curing: Inadequate or improper curing practices can lead to premature drying of the concrete, which can result in shrinkage and cracking. Proper curing methods are crucial for maintaining the required moisture content and temperature for the concrete to develop its full strength.

Insufficient Concrete Cover for Reinforcement: Inadequate concrete cover over reinforcement can lead to corrosion of the steel, especially in aggressive environments. Corrosion can cause the steel to expand, leading to cracking and spalling of the concrete cover.

2-emperature changes: . (Reference: Neville, A. M. (2011) (2) Properties of concrete. Pearson Education Limited.).

It is true that temperature variations can cause thermal strains in concrete structures, which may result in cracking. Concrete expands or contracts in response to temperature variations, creating internal strains. Cracks may appear if these stresses are greater than the concrete's tensile strength. The longevity and structural integrity of the concrete components may be jeopardized by these fissures.

The degree of thermal stress and the likelihood of cracking are influenced by a number of variables, including the concrete's coefficient of thermal expansion, the rate at which temperatures fluctuate, and the structural constraints. Particularly vulnerable to these problems are concrete elements exposed to large temperature differences, such as those in areas with harsh climates or those experiencing abrupt temperature swings.

3-Chemical reactions(Reference: Malhotra, V. M., & Carino, N. J. (2004).(3) Handbook on Nondestructive Testing of Concrete. CRC Press.).

Exposure to aggressive chemicals or environmental factors can indeed lead to chemical reactions within concrete, resulting in various forms of deterioration, including cracking. Concrete is vulnerable to chemical attack from substances such as sulfates, chlorides, acids, and other aggressive agents. When these chemicals penetrate the concrete, they can react with its components, leading to the breakdown of the cementitious matrix and the reinforcement within.

The chemical reactions can cause the concrete to expand, crack, or even lose its structural integrity over time. This degradation can be particularly problematic in environments with high levels of pollutants, industrial sites, coastal areas exposed to saltwater, or regions where de-icing salts are commonly used.

To prevent or mitigate the effects of chemical reactions, engineers and construction professionals often employ various protective measures. These may include using high-performance or specialty concretes that are more resistant to chemical attack,

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applying surface coatings or sealants to protect the concrete from aggressive agents, and ensuring proper drainage to minimize the buildup of chemicals on the concrete surface.

4-are impacted by several elements such as temperature fluctuations, overload, corrosion in the reinforcement, and construction flaws.

5. Because crack growth is a multiscale, slow process, study is rather difficult.

There are a few typical technical issues that will be discussed.

Extraction of features from multimodal parameters

6-Bridge crack shape information, structural mechanics index information, and crack environment information are among the characterisation data pertaining to bridge cracks. The multimodal aspects of bridge cracks, such as their length, width, and depth, are included in the bridge crack shape information. The compressive strength, stress distribution, and dynamic and static elastic moduli are the components of the structural mechanics index information. Information on the crack environment include the load, temperature, humidity, and foundation settlement.

7-The knowledge and comprehension of the events that lead to the creation of cracks in reinforced concrete structures, as well as the identification of the locations where these cracks most frequently occur, are of considerable relevance in many ways (Wardach, M.; Krentowski, J.R.; Mackiewicz, 2022).

8- Zychowicz, J.; Stolarski, 2020; Basista, M.; Gross, D.; Szcześniak, A. Brittle Deformation and the Sliding Crack Model: An Internal Variable Approach. There are several typical sorts of fractures that can be identified based on how old they are, meaning that they can form before or after hardening. A description of the several types of cracks that can occur in cement composites, together with the causes of the formation and an estimated period of occurrence of each type of crack, are also included in Stress applied to brittle materials frequently causes cracks to form and spread. The concept that fractures may glide past one another or interact in a sophisticated way to affect the material's overall deformation behavior is probably incorporated into the sliding crack model.

9- Basista, M.; Gross, D.(1998) (9) The term "internal variable" suggests that there might be some internal property or parameter within the model that changes or evolves as deformation occurs. This internal variable could represent aspects like damage accumulation, crack density, or other parameters relevant to the material's

10- - Jacquot, P.; Rastogi, P.K. (1383) (10)The reference you've provided, "Jacquot, P.; Rastogi, P.K. Speckle Metrology and Holographic Interferometer Applied to the Study of Cracks Concrete," from the book "Fracture Mechanics of Concrete" edited by Whitman, F.H., published in 1983 by Elsevier Science Publishers, pertains to a specific study or chapter discussing the application of speckle metrology and holographic interferometry in analyzing cracks in concrete structures. Here's an overview based on the information available: 1. **Speckle Metrology**: This field involves using laser speckle patterns to measure microscopic surface deformations. It's applied in materials science to analyze surface changes, often in response to stress or strain. In the context of concrete, it might be used to detect and measure small movements or deformations related to crack initiation and propagation. 2. **Holographic Interferometry**

11 - Aggelis, D.G., Strantza, M., and Kordatos, E.Z. (2011) (11) Testing Without Damage (NDT): This process entails assessing constructions or materials without causing

harm. Non-destructive testing (NDT) methods are essential for evaluating the interior state of concrete without requiring invasive procedures.Characterization of Subsurface Cracks: The goal of the research is to comprehend and characterize the cracks that occur in concrete elements below the surface. Although these subsurface cracks might not be apparent from the outside, they can have a substantial impact on the concrete's structural integrity. Approach Synopsis: It is possible that the research describes a particular approach or procedure for identifying, measuring, and maybe assessing these subsurface fissures. This strategy might have made use of a variety of non-destructive testing (NDT) techniques, including infrared thermography, acoustic emission, ground-penetrating radar, and ultrasonic testing.Journal of Construction and Building Materials: The study's publication in this journal indicates that its goal was to provide professionals in the building sector with insightful information about the assessment and management of

12 -Słowik, M. The Role of Aggregate Granulation on Testing Fracture Properties of Concrete. Frat. Int. Strutt.(2021) (12)- Aggregate Granulation: In concrete, aggregates play a crucial role in determining its mechanical properties. Aggregate granulation refers to the size distribution and arrangement of the aggregates (like sand, gravel, (crushed stone) used in concrete mixtures. The size and distribution of aggregates can significantly impact the overall properties of the concrete.Testing

Fracture Properties of Concrete: Fracture properties encompass a range of mechanical characteristics related to the behavior of concrete under stress, including its toughness, resistance to crack propagation, and overall fracture mechanics.-Role of Aggregate Granulation: The article likely explores how different sizes or distributions of aggregates within the concrete mixture influence its fracture properties. This could include examining how variations in aggregate size impact the initiation, propagation, and behavior of cracks within the concrete matrix.

[13] - Feng, J.; Chen, Y. (2021) (13) Volume Fraction of Coarse Aggregate: Concrete is a composite material made of cement, water, and aggregates (fine and coarse). The coarse aggregates, which are usually bigger particles such as crushed stone or gravel, are a major factor in defining the characteristics of concrete. This study primarily looks at how fracture behavior is affected by varying the volume percentage, or the amount of coarse aggregates in the concrete mixture.Modes of Fracture Behavior, I and II: Materials' fracture behavior is frequently divided into several modes. Shearing or sliding along a plane parallel to the applied force is referred to as Mode II, whereas tensile opening or separation of the material along a plane perpendicular to the direction of the applied force is referred to as Mode I.Experimental Research: This project most likely entails

(14) S-Prakoor, M.; Khaji, Z. (2008) (14)train Energy Release Rate (SERR): This crucial metric measures the amount of energy needed for a crack in a material to spread. It's useful for comprehending the behavior of fractures, particularly in mixed-mode situations when shearing and tensile opening fractures are possible.Strengthening SERIS, or the Isotropic Solid Model: This seems to be a brand-new model or standard that Khaji and Fakoor have put out. It probably includes taking an isotropic solid model with reinforcement and integrating it with the idea of strain energy release rate. This implies a more sophisticated method that takes into account both mode I and mode II fractures when analyzing and forecasting fracture behavior in orthotropic materials.Materials that are orthotropic: Materials that are orthotropic have distinct properties along different axes. They display several mechanical actions, includingCompared to isotropic materials, they have varied directions of (such as stiffness or strength), which complicates the fracture analysis of these materials.Examination of Breakage Behavior The creation of a model or criterion (SERIS) that sheds light on the fracture behavior of orthotropic materials under mixed-mode I/II loading circumstances appears to be the primary objective of this work. This could be important for a number of technical applications requiring materials that behave orthotropically, such as composites or specific natural materials.This work probably presents a new method or standard for evaluating fracture behavior, particularly in orthotropic materials

where it is important to comprehend both mode I and mode II fractures. Research of this kind advances the field of fracture mechanics and helps to build more reliable and fracture-resistant materials and structures.Reaching the particularThe SERIS criterion, its theoretical underpinnings, mathematical formulations, experimental validations (if any), and its implications for comprehending the fracture behavior of orthotropic materials under mixed-mode loading situations are all covered in more detail in a paper or publication.

(15) -Khaji, Z.; Fakoor, M.(2008) (15) Prestressed Elastic Composites: Prestressed materials have internal forces or stresses intentionally induced to improve their performance. In composites, which are made of different materials combined to enhance specific properties, such as strength or flexibility, the behavior can become more complex due to the interaction between components.-Crack Propagation: Understanding how cracks propagate in materials is crucial for ensuring structural integrity and safety. Energy-based criteria often offer insights into the conditions under which cracks will propagate or arrest in a material.-E.M. Craciun's Work: This paper or study by E.M. Craciun likely introduces or investigates energy-based criteria specifically tailored for analyzing crack propagation within prestressed elastic composites. It might involve theoretical formulations, numerical simulations, or experimental validations to establish criteria for predicting crack growth in such materials.

Calculations

The flaws and damage in the initial juvenile structure and subsequently the mature concrete greatly influence the strength and longevity of palpable structural elements. This is because weaker areas inside the concrete composite concentrate pressure and make it easier for different external forces to seep in. Force diminishes in areas where microcracks are dispersed, destroying nearby objects and emergency situations. As a result, the topics covered in this article are crucial to the reliability and integrity of concrete structures. The peculiarity of armed concrete constructions and the properties of chemicals hiding inside the cement matrix cause the concrete to break down in structural elements, making analysis of these issues exceedingly challenging.

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3-Chemical reactions: Exposure to aggressive chemicals or environmental factors can lead to chemical reactions in concrete, causing cracking. (Reference: Malhotra, V. M., & Carino, N. J. (2004). Handbook on Nondestructive Testing of Concrete. CRC Press.)

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