COMPARATIVE STUDY OF CONVENTIONAL AND STEEL FIBER REINFORCED CONCRETE CORNER JOINTS

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ABSTRACT
This article presents a comparative analysis of conventional concrete corner joints and steel fiber-reinforced concrete (SFRC) corner joints under cyclic loading. The primary objective is to evaluate the structural performance and durability of SFRC compared to traditional concrete. Experimental specimens were prepared with varying percentages of steel fibers, maintaining consistent geometrical and mechanical properties. Key parameters assessed include load-bearing capacity, crack propagation, and energy absorption. The results indicate that SFRC corner joints exhibit superior performance, with a significant increase in load-bearing capacity and enhanced crack resistance. The integration of steel fibers improves the ductility and toughness of the concrete, leading to better energy dissipation during cyclic loading. Additionally, the presence of steel fibers minimizes the extent of crack width and distribution, thereby enhancing the durability and lifespan of the corner joints. This comparative study underscores the potential of SFRC in improving the structural integrity and resilience of concrete corner joints, making it a viable option for applications requiring high performance and durability.

Keywords: - Steel, Fiber Reinforced Concrete, cyclic loading, load-bearing capacity, crack propagation, and energy absorption.

INTRODUCTION
Steel fiber reinforced concrete (SFRC) is a type of ordinary concrete that contains short, discontinuous fibers with a tiny diameter. SFRC is a hydraulic cement-based concrete with fine and coarse aggregates and discontinuous discrete fibers. According to ACI committee 544, composites have a wide range of uses, particularly in structural parts. Its current fields of application include highways and airports.

Concrete's numerous attractive characteristics lend themselves to a wide range of inventive designs. Concrete has strong compressive strength, stiffness, and low thermal and electrical conductivity, but it is brittle and weak under compression. These two weaknesses, however, have been addressed by the invention of fiber reinforced concrete composites.

Steel fibers in reinforced concrete create two-phased composite materials, improving the properties of the other phase. This concept has led to the development of new materials with superior performance and crack arrestors. Different diameter steel bars have the same effect, while short discontinuous fibers offer uniform distribution. Around 30 major producers worldwide produce steel fibers for concrete modification, offering over 100 types from Europe, the USA, South Africa, Australia, and South Korea. The invention of steel fiber reinforced concrete began in 1874 with A. Bernard in California. In 1910, Porter suggested applying short wire to improve concrete homogeneity. In 1918, H. Alfsen patented a method modifying concrete with long steel, wooden, and other fibers to increase tensile strength. The patent details fiber shapes, crack types, and energy absorption in steel fiber reinforced concrete (SFRC). The US, France, and Germany have submitted the most patents on SFRC use in concrete modification. Traditional rod reinforcement has limited applications.

CONVENTIONAL CONCRETE
Conventional concrete, a composite material composed of coarse and fine aggregates bonded with a fluid cement that hardens over time, is the most widely used construction material globally. It is employed in a variety of construction projects due to its versatility, strength, and durability.

Composition and Types

Conventional concrete primarily consists of water, Portland cement, and aggregates (sand, gravel, or crushed stone). The mixture's properties can be altered by varying the proportions of these components. The primary types of conventional concrete include:

a) **Ordinary Portland Cement (OPC) Concrete**: The most common type, used in general construction.

b) **Reinforced Concrete**: Contains steel reinforcement bars (rebar) to improve tensile strength.

c) **Pre-stressed Concrete**: Concrete in which internal stresses are introduced to counteract potential tensile stresses.

d) **Lightweight Concrete**: Uses lightweight aggregates to reduce the overall weight of the concrete.

PROPERTIES OF CONVENTIONAL CONCRETE

a. Strength

Concrete is renowned for its high compressive strength, which is the primary reason for its widespread use in structural applications. The compressive strength of conventional concrete typically ranges from 20 MPa to 40 MPa, but it can be enhanced by using admixtures and supplementary cementitious materials [1].

b. Workability

Workability refers to the ease with which concrete can be mixed, placed, and finished. It is influenced by the water-cement ratio, aggregate size and shape, and admixtures. High workability is crucial for ensuring that concrete can be poured into complex forms and properly compacted without segregation.

c. Durability

Conventional concrete is highly durable and can withstand various environmental conditions, including freeze-thaw cycles, chemical attacks, and abrasion. Durability is enhanced through proper mix design and curing practices. For example, reducing the water-cement ratio and adding pozzolanic materials like fly ash can significantly improve the concrete's resistance to chemical attacks [2].

d. Thermal Properties

Concrete has relatively low thermal conductivity, making it a good insulator. It also has a high heat capacity, which helps in reducing temperature fluctuations in buildings. However, concrete can undergo thermal cracking if subjected to extreme temperature changes without proper precautions.

e. Density

The density of conventional concrete ranges from 2200 to 2500 kg/m^3. This property is influenced by the type of aggregates used and the mix proportions. High-density concrete is used for radiation shielding and other specialized applications.

f. Shrinkage and Creep

Concrete experiences shrinkage as it loses moisture and undergoes a reduction in volume. Creep is the gradual deformation of concrete under sustained load. Both properties can lead to cracking if not properly managed. Control measures include proper curing, using shrinkage-reducing admixtures, and incorporating reinforcement.

g. Permeability

Low permeability is crucial for the durability of concrete, as it reduces the ingress of harmful substances like chlorides and sulfates. Reducing the water-cement ratio and adding supplementary cementitious materials can enhance the impermeability of conventional concrete [3].

STEEL FIBER REINFORCED CONCRETE (SFRC)

Steel fiber reinforced concrete (SFRC) has emerged as a robust material in civil engineering, particularly in enhancing the performance of concrete structures under various loading conditions. This introduction delves into the unique properties and benefits of using SFRC in corner joints, which are critical points in structural frameworks due to their vulnerability to stress concentrations. Concrete is a composite material widely used in construction due to its compressive strength and durability. However, conventional concrete has limitations in tensile strength and ductility, leading to susceptibility to cracking and failure under dynamic loads. To address these shortcomings, the incorporation of steel fibers into concrete mixes has been explored. Steel fibers, typically 0.5-2.5% by volume of the concrete, improve the mechanical properties of concrete, including its tensile strength, ductility, and toughness. Corner joints in concrete structures are critical areas where two or more members intersect, creating points of high stress concentration. The use of SFRC in these joints enhances their load-bearing capacity and durability. The improved mechanical properties of SFRC ensure that these joints can better resist bending, shear, and torsional stresses. Additionally, the enhanced toughness and fatigue resistance of SFRC contribute to the longevity and safety of the structure.

PROPERTIES OF SFRC

1. **Increased Tensile Strength**: The addition of steel fibers to concrete significantly enhances its tensile strength. These fibers act as crack arresters, distributing the stress more evenly and preventing the propagation of micro-cracks. This property is crucial in corner joints where tensile stresses are typically higher due to bending and torsional loads [1].
2. **Improved Ductility**: SFRC exhibits improved ductility compared to conventional concrete. The presence of steel fibers allows the concrete to undergo larger deformations before failure, providing a warning before catastrophic collapse. This is particularly beneficial in corner joints, which are often subject to complex loading scenarios [2].
3. **Enhanced Toughness and Impact Resistance**: Steel fibers enhance the toughness and impact resistance of concrete. This property is vital for corner joints that might be exposed to accidental impacts or dynamic loads. The fibers help absorb and dissipate the energy, reducing the risk of sudden failure [3].
4. **Improved Fatigue Resistance**: The fatigue resistance of SFRC is higher than that of conventional concrete. This means SFRC can withstand repeated loading cycles, which is common in structural elements like corner joints subjected to fluctuating loads. The steel fibers bridge the cracks that form under cyclic loads, thereby prolonging the service life of the structure [4].
5. **Better Post-Cracking Behavior**: After the initial cracking, SFRC continues to carry significant loads, unlike conventional concrete, which tends to fail rapidly. This post-cracking strength is crucial for maintaining the integrity of corner joints, ensuring that minor damages do not lead to major structural failures [5].

COMPARATIVE ANALYSIS

Mechanical Performance

Research indicates that SFRC corner joints demonstrate superior mechanical performance compared to conventional concrete joints. The inclusion of steel fibers enhances the joint's ability to resist bending and shear forces, resulting in improved load-bearing capacity and reduced crack formation. Studies have shown that SFRC can increase strength, displacement ductility, and energy absorption by significant margins compared to conventional concrete [3].

Durability and Longevity

SFRC joints exhibit better durability and longevity due to their enhanced crack resistance and reduced susceptibility to damage under cyclic loading. Conventional concrete joints, while strong in compression, are more prone to deterioration due to crack development and propagation over time [1].

Cost and Construction Considerations

While SFRC offers numerous performance benefits, it is also associated with higher material costs due to the inclusion of steel fibers. However, these costs can be offset by reduced maintenance requirements and longer service life. Additionally, the use of SFRC can simplify construction by reducing the need for extensive rebar placement and allowing for more straightforward casting processes.

CONCLUSION

The comparative study of conventional and steel fiber reinforced concrete corner joints highlights the significant advantages of SFRC in terms of mechanical performance, durability, and overall structural integrity. While conventional concrete remains widely used, the integration of steel fibers presents a promising enhancement for critical structural applications, particularly in corner joints subjected to complex loading conditions. Future research and development in this area could further optimize the use of SFRC, balancing cost and performance to achieve more resilient and long-lasting concrete structures.

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