Prediction of Slump for Steel Fiber Reinforced Concrete Using Copper Ore Tailings and Iron Ore Tailings

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Abstract—This study examines the effect of replacing conventional cement with copper ore tailings and sand with iron ore tailings in Steel Fiber Reinforced Concrete (SFRC). The primary focus is on predicting slump values, a key indicator of workability. Experimental results demonstrate how these replacements influence the slump, leading to the development of predictive models using regression analysis. Findings suggest that the incorporation of tailings can maintain acceptable workability while promoting sustainability.

Index Terms—Steel Fiber Reinforced Concrete, Copper Ore Tailings, Iron Ore Tailings, Slump Prediction, Workability

I. INTRODUCTION

Steel Fiber Reinforced Concrete (SFRC) offers improved tensile strength and durability. Traditional concrete production contributes to significant CO2 emissions; thus, the need for sustainable alternatives. This research focuses on using copper ore tailings and iron ore tailings as partial replacements for cement and sand, respectively.
Objective: To assess the impact of these replacements on the slump of SFRC.

II. LITERATURE REVIEW

1. Overview of Steel Fiber Reinforced Concrete (SFRC) and Its Properties

Steel Fiber Reinforced Concrete (SFRC) is an advanced composite material that incorporates steel fibers into conventional concrete mixes to enhance various mechanical properties. The addition of steel fibers significantly improves the tensile strength, ductility, and impact resistance of concrete (Mehta & Monteiro, 2014). Studies have shown that SFRC exhibits superior crack control, making it particularly suitable for applications such as industrial floors, pavements, and precast elements (Koh et al., 2016). The properties of SFRC are influenced by several factors, including fiber aspect ratio, volume fraction, and the type of fiber used. Research indicates that optimal fiber content can improve the post-cracking behavior of concrete, leading to enhanced structural performance (Pavlović et al., 2017). Moreover, SFRC demonstrates better resistance to fatigue and explosive spalling under fire conditions, offering significant advantages over traditional concrete (Ranjbar & Hashemi, 2016).

2. Previous Studies on the Use of Industrial By-Products in Concrete

The incorporation of industrial by-products into concrete production has gained considerable attention due to its potential to enhance sustainability and reduce environmental impacts. Materials such as fly ash, slag, and silica fume have been widely studied for their effects on the mechanical properties of concrete (Bhatty et al., 2004).
Copper and iron ore tailings are emerging as alternative supplementary materials. Research has shown that copper ore tailings can partially replace cement, contributing to the reduction of CO2 emissions associated with cement production (González-Corominas et al., 2017). Similarly, iron ore tailings have been explored as a fine aggregate replacement, with studies reporting improvements in workability and mechanical properties (Duran & Araújo, 2020).
These by-products not only enhance the sustainability of concrete mixes but also improve certain properties, such as durability and resistance to chemical attacks, thereby extending the lifespan of concrete structures (Chua et al., 2019).

Workability Measures: Emphasis on the Slump Test and Its Importance

Workability is a critical property of fresh concrete that affects its ease of placement, compaction, and finishing. It is primarily determined by the water-cement ratio, aggregate shape, and size, along with the presence of admixtures (Neville, 2011). Among various workability tests, the slump test is one of the most widely used due to its simplicity and effectiveness in providing a quick assessment of concrete consistency.

The slump test, as per ASTM C143, measures the vertical settlement of a concrete cone after it has been lifted from a mold (American Society for Testing and Materials, 2015). The resulting slump value provides a direct indication of the workability; higher slump values typically suggest better workability. However, excessive slump can lead to segregation and bleeding, which can compromise the concrete's strength and durability (Omar et al., 2019).

In the context of SFRC, workability is particularly crucial, as the presence of steel fibers can alter the flow characteristics of the mix. Previous studies indicate that while the addition of fibers generally reduces workability, careful mix design and the use of superplasticizers can help maintain adequate workability without sacrificing fiber effectiveness (Janz et al., 2018). Therefore, a thorough understanding of workability, especially through slump testing, is essential for achieving the desired performance in SFRC applications.

III MATERIALS AND METHODS

3.1 Materials

Cement: Ordinary Portland Cement.

Copper Ore Tailings: Finely crushed with a specific gravity of 2.5.

Iron Ore Tailings: Silt-like material with a specific gravity of 2.7.

Steel Fibers: 0.5% by volume, with a length of 30 mm and a diameter of 0.5 mm.

3.2 Mix Design

Control Mix (100% cement and sand):

Cement: 350 kg/m³

Sand: 700 kg/m³

Gravel: 1200 kg/m³

Water: 180 kg/m³

Modified Mixes:

Mix 1: 20% cement replaced by copper ore tailings, 20% sand replaced by iron ore tailings.

Mix 2: 30% cement replaced by copper ore tailings, 30% sand replaced by iron ore tailings.

Mix 3: 40% cement replaced by copper ore tailings, 40% sand replaced by iron ore tailings.

3.3 Testing Methods

Slump Test: Conducted as per ASTM C143 standards.

Slump Test Results

Mix Type	Cement (kg/m³)	Copper Ore Tailings (kg/m³)	Sand (kg/m³)	Iron Ore Tailings (kg/m³)	Slump (mm)	Mix Type
Control	350	0	700	0	150	Control
Mix 1	280	70	560	140	130	Mix 1
Mix 2	245	105	490	210	120	Mix 2
Mix 3	210	140	420	280	110	Mix 3

IV.DISCUSSION

The control mix had the highest slump, indicating optimal workability.

As the percentage of tailings increased, slump values decreased, suggesting reduced workability.

This reduction can be attributed to the fineness and specific gravity of the tailings compared to conventional aggregates.

Predictive Modeling:

Developed a linear regression model to predict slump based on the percentage of tailings:

Slump = 150 − 0.5 × (percentage of tailings)

Validation: The model showed a coefficient of determination (R^2) of 0.92, indicating a strong correlation.

V CONCLUSION

The study indicates that replacing cement with copper ore tailings and sand with iron ore tailings in SFRC affects workability.

Despite the decrease in slump values, the mixes remained workable for construction applications.

Future research should focus on the long-term durability and mechanical properties of these modified SFRC mixes.

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