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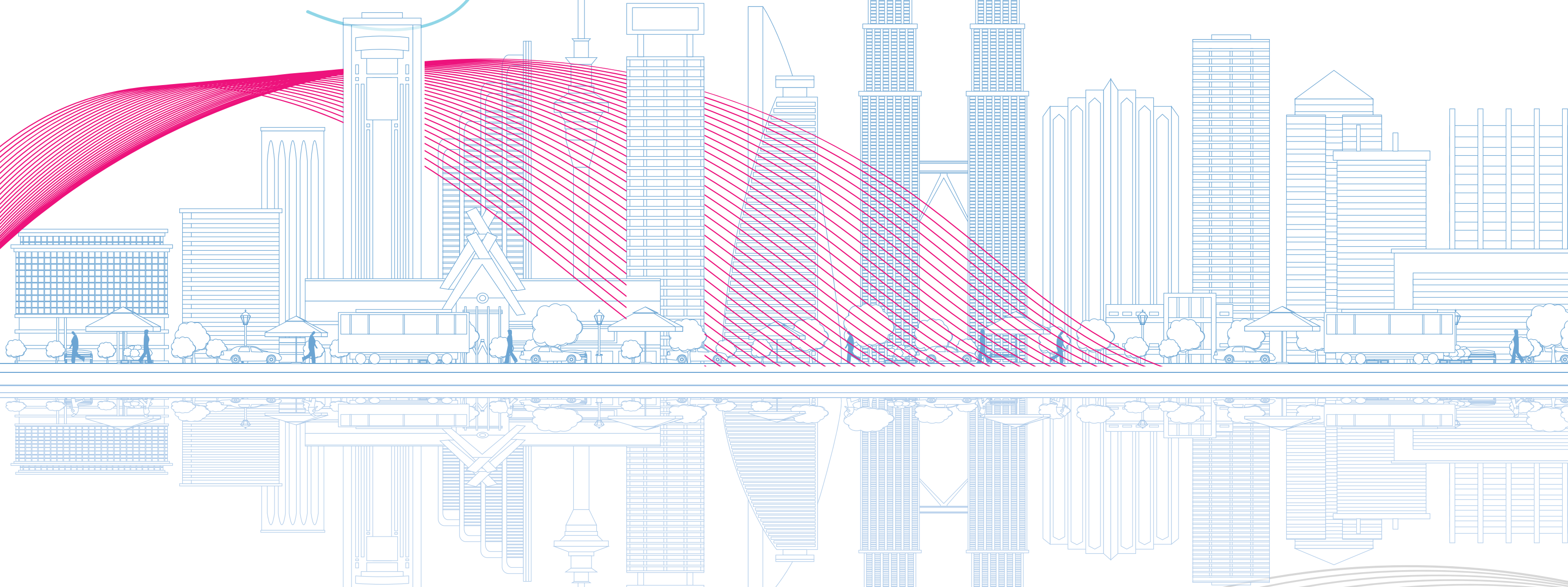
"Undergraduates' Digital Engagement Towards Global Ingenuity"

2nd Edition



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Co-organiser :

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DRAIN COVER OF STEEL FIBRE-REINFORCED CONCRETE VS. REBAR: WHICH IS BETTER?

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Abstract
The purpose of this study is to present empirical data that supports the feasibility of Steel Fibre-Reinforced Concrete (SFRC) as a long-lasting and effective drainage cover option. The compressive strength and split tensile strength of the material are significantly improved with the addition of 1% steel fibre. The research provides insightful information on the structural performance and viability of SFRC as an environmentally friendly substitute for traditional concrete drainage covers in urban infrastructure. The present study tackles the constraints associated with traditional materials and presents novel approaches in the fields of civil engineering and construction. For every specimen, the concrete mix was designed to have a 28-day strength of 30 MPa. Following BS EN 12390-6:2009 and BS EN 1433:2002 standards, testing included 600 mm x 300 mm x 70 mm drainage cover specimens for frame load testing, 100 mm x 100 mm x 100 mm cubes for compressive strength, and 100 mm diameter by 200 mm height cylinders for split tensile strength. The findings showed that each variety of cement has unique strengths. For both controlled and steel fibre specimens, LHC had the highest average compressive and split tensile strengths. For OPC, PLC, and LHC, the addition of 1% steel fibre increased compressive strength by 5.4%, 12.08%, and 1.84%, respectively. Frame load tests showed that traditional drainage covers with rebar fared better than SFRC covers. This is probably because rebar provides more consistent and strategic reinforcement than steel fibres, which are distributed unevenly.

Keywords: *drain cover, SFRC, rebar, OPC, PLC, LHC*

1. INTRODUCTION

Concrete drainage covers are essential components of urban infrastructure, as they guarantee safety and durability under varying loads and provide access to subsurface utilities. Yet conventional concrete coverings frequently experience problems such as cracking and limited capacity to carry loads. According to Mbereyaho et al. (2020), the durability and load-bearing capacity of drainage covers have been enhanced by fibres. Hence, this study investigates the efficacy of Steel Fibre-Reinforced Concrete (SFRC) in comparison to conventional rebar in drainage covers to address these issues. Specifically, it determines the effects of incorporating 1% steel fibre into concrete mixes using various varieties of cement, including Ordinary Portland Cement (OPC), Low Heat Cement (LHC), and Portland Limestone Cement (PLC). Furthermore, research has demonstrated that materials such as SFRC can enhance mechanical properties, including compressive and tensile strength (Shrikant, 2019; Sinha and Verma, 2017; Ojha et al., 2022). Other than that, research on various varieties of cement, such as PLC and LHC (Sandeep et al., 2020; Jadhav, 2021), emphasises their contribution to the modification of concrete properties and the reduction of environmental impact.

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2. MATERIALS AND METHODS

2.1 Materials

The main materials used in this study were cement, fine and coarse aggregate, water, admixtures, and steel fibres. Table 2.1 shows the types and specifications of materials used in this study.

Table 2.1. Types and Specifications of Materials.

Materials	**Type / Specifications**
Cement	Ordinary Portland Cement (MS EN 197-1 CEM I 52.5N) Portland-Limestone Cement (MS EN 197-1 CEM 11/B-L 32.5R) Low Heat Cement (MS EN 197-1:2014 CEM II/B-V42.5 N)
Coarse Aggregate	Passing 20mm sieve
Fine Aggregate	Passing 0.15mm to 4.75mm sieve
Steel Fibre	Hooked End 0.75/60 Dramix 3D 80/60 BG Conforms to ASTM A820
Reinforcement Bar	High Tensile Strength Steel (Y10)
Admixture	Superplasticiser Master Glenium Ace 8538

2.2 Methods

The desired 28-day strength of the concrete mix was 30 MPa for all specimens. The specimens consisted of 100 mm x 100 mm x 100 mm cubes (15 samples) for compressive strength, 100 mm diameter by 200 mm height cylinders (15 samples) for split tensile strength, and 600 mm x 300 mm x 70 mm frames (15 samples) for frame load testing. The Department of Irrigation and Drainage, Shah Alam City Council (MBSA), has recommended the size of the drainage cover. The mix proportions for the SFRC and conventional concrete are illustrated in Table 2.2.

Table 2.2. Mix Design Proportions.

Ingredients	Quantity in kg	Density	Volume in m3 without fibre	First trial	Volume in m3 with fibre	Interpolation (x w=1.009)*	Final weight in kg
Cement	375	3150	0.119	370	0.117	0.1185	373
Silica fume (5%)	-	2200	-	-	-	-	-
Fly ash (25%)	-	2100	-	-	-	-	-
Water	205	1000	0.205	204	0.204	0.2053	205
Fine Aggregate	685	2650	0.258	668	0.252	0.2543	674
Coarse Aggregate	1120	2650	0.423	1094	0.413	0.4165	1104
Fibre (1%)(steel) by volume		7800			0.01	0.0101	78.69
w/c	0.55	-					
w/b	-	-					
Cementitious/Total	-	-					
Cement/Total	0.21	-					
Fine Agg/Coarse Agg	0.61	-					
Air -content	1.00%	-	0.01	0.01	0.01	0.01	
Total Volume			1.015		1.006	1.0147	

3. RESULTS AND DISCUSSION

The experiment was conducted properly according to proper standards, and data was collected for further analysis.

3.1 Compressive Strength and Split Tensile Strength Tests

The results for the compressive and split tensile strength tests are tabulated in Table 3.1 and

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Table 3.2. The data shows two (2) measurements of the controlled specimen and three (3) measurements of steel fibre concrete specimens for each type of testing. Based on the results, all types of cement showed distinctive strength. The steel fibre concrete shows greater compressive and split tensile strength compared to the normal concrete. Figures 3.1 and 3.2 show that there was also an improvement in the strength of concrete with the inclusion of 1% steel fibres. Plus, the specimens using the LHC have the greatest reading of compressive strength compared to the others. The steel fibres in the concrete also improved the toughness and ductility of the concrete, making it more resilient to impact and fatigue.

Table 3.1. Compressive Strength Test Results.

Specimen	Compressive Strength Test Result					
	OPC		PLC		LHC	
	Max. Load (kN)	Max. Stress (kPa)	Max. Load (kN)	Max. Stress (kPa)	Max. Load (kN)	Max. Stress (kPa)
CC (Average)	383.15	38.32	274.60	27.46	454.05	45.41
CSF (Average)	405.03	40.50	312.33	31.23	462.56	46.26

Table 3.2. Split Tensile Strength Test Results.

Specimen	Split Tensile Strength Test Result					
	OPC		PLC		LHC	
	Max. Load (kN)	Max. Stress (kPa)	Max. Load (kN)	Max. Stress (kPa)	Max. Load (kN)	Max. Stress (kPa)
CC (Average)	60.28	7.68	55.47	7.06	68.88	8.77
CSF (Average)	100.49	12.80	103.78	13.21	124.64	15.87

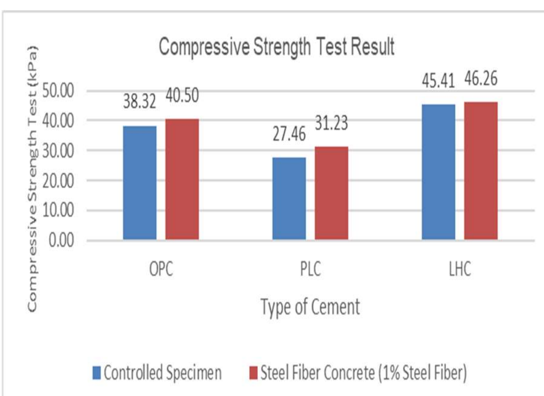

Figure 3.1. Compressive Strength Test Results

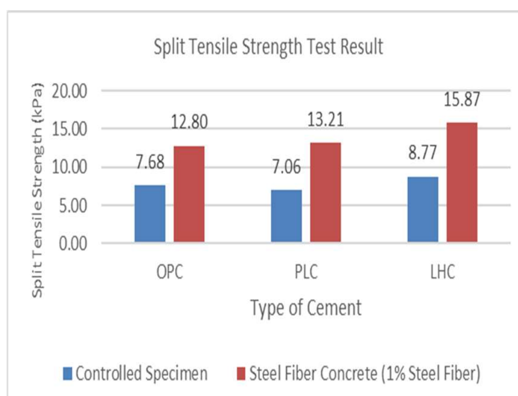

Figure 3.2. Split Tensile Strength Test Results.

3.2 Frame Load Test

The static strength of the drainage cover specimen was determined using the frame load test. The result of the test is represented in Table 3.3. The table shows that there was a difference in the strength of the specimen. The conventional and SFRC drainage covers made using the LHC catered to a maximum load of 47.57 kN and 12.52 kN, respectively.

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This type of specimen carried the biggest load compared to the other two types of specimens. Meanwhile, Figure 3.3 illustrates the differences between the maximum load catered by each type of specimen. The test shows that the conventional drainage cover was stronger compared to the SFRC because it can carry a greater load until it fails.

Table 3.3. Frame Load Test Results.

Specimen	Frame Load Test Result					
	OPC		PLC		LHC	
	Max. Load (kN)	Max. Stress (kPa)	Max. Load (kN)	Max. Stress (kPa)	Max. Load (kN)	Max. Stress (kPa)
Conventional DC (Average)	50.08	7030.66	40.06	5624.53	47.57	6679.13
SFRC DC(Average)	10.02	1406.13	10.18	1429.57	12.52	1757.67

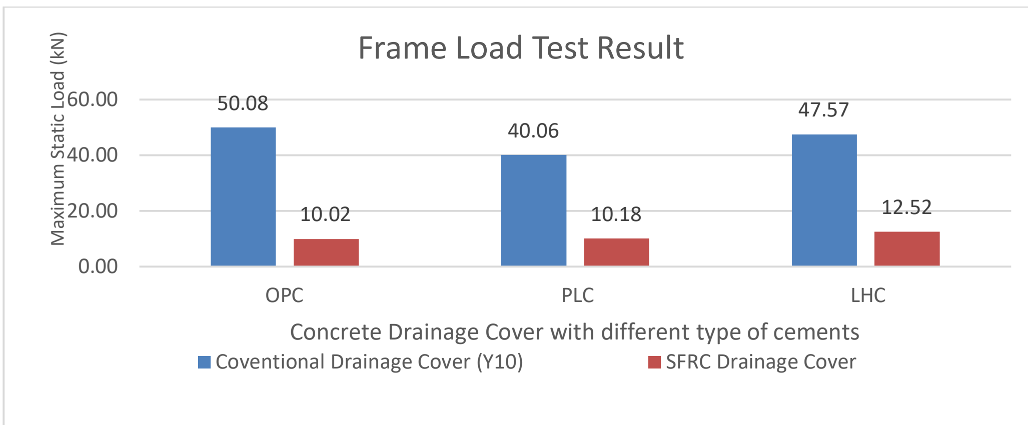

Figure 3.3. Frame Load Test Results.

3.3 Strength Comparison between the SFRC Drainage Cover and the Conventional Drainage Cover with Reinforcement Bar

When comparing the strength between the SFRC drainage cover and the conventional drainage cover with reinforcement bar, the result from the frame load test shows that the strength of the conventional drainage cover with reinforcement bar was stronger compared to the SFRC drainage cover. The reason for this result may be because the distribution of steel fibre in the concrete was not homogeneous. The steel fibre was supposed to be distributed evenly in the concrete mixture to improve the tensile strength of the concrete. Due to uneven distribution, the steel fibre failed to provide uniform reinforcement along the load paths, which caused it to fail at small, applied loads. Whereas the conventional drainage cover with rebar has strong steel reinforcement that was placed strategically in the concrete, providing a direct load-bearing capacity along specific directions and enhancing the overall structural strength of the drainage cover. Plus, the bonding and anchorage of the rebars in the concrete mix were stronger than the steel fibres because the rebars were mechanically anchored and bonded to the concrete mix through the high-tensile strength steel bars to ensure effective load transfer and distribution. Therefore, from the frame load test, it is concluded that the strength of the drainage cover with a conventional reinforcement bar is greater than the steel fibre-reinforcement drainage cover.

4. CONCLUSION

In summary, the study accomplished its objectives and offered insightful information about how the addition of 1% steel fibre affects the material qualities and structural integrity of different kinds of concrete. Concrete's compressive and split tensile strengths were greatly increased by the addition of 1% steel fibre; among the types of cement put to the test, Low Heat Cement (LHC) showed the greatest strength improvements. In comparison to their controlled counterparts, steel fibre concrete specimens have greater compressive strengths, indicating that steel fibres improve the material qualities of concrete. Conventional drainage covers with rebar reinforcement fared better than those with 1% steel fibre reinforcement in terms of strength, allowing for noticeably larger maximum loads. The reason for this discrepancy in performance is that rebar provides more consistent and targeted reinforcing, unlike the unequal dispersion of steel fibres within the concrete matrix. The study finds that although adding steel fibre to concrete increases its tensile and compressive strength, traditional rebar reinforcement is still the best option for situations needing a high load-bearing capability. Overall, the study finds that typical rebar reinforcement provides superior structural strength for load-bearing applications such as drainage covers, even though 1% steel fibre insertion enhances the material qualities of concrete. These results direct the choice of reinforcing techniques according to the particular needs of concrete constructions.

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