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CHARACTERISTICS OF STEEL FIBER REINFORCED CONCRETE WITH RECYCLED COARSE AGGREGATE

Mustaqqim Abdul Rahim[1], Omi Yanti Pohan[2], Mohd Badrul Hisyam Ab Manaf[3], Ahmad Nur Aizat Ahmad[4], Shahiron Shahidan[5], Zuhayr Md. Ghazaly[6], Nor Faizah Bawadi[7], Shamilah Anudai@Anuar[8], Zulkarnain Hassan[9], Zul-Atfi Ismail[10], Teoh Jun Hong[11]

[1,2,6,7,8,9,10] School of Environmental Engineering, Universiti Malaysia Perlis, 02600, Arau, Perlis, Malaysia.
[3,11]Faculty of Engineering Technology, University Malaysia Perlis,02100 Padang Besar, Perlis, Malaysia.
[4]Faculty of Technology Management and Business, Universiti Tun Hussein Onn, 86400, Batu Pahat, Johor, Malaysia.
[5]Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn, 86400, Batu Pahat, Johor, Malaysia.

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Corresponding author's email: mustaqqim@unimap.edu.my

Abstract **–**Steel is one of the fibers used in fiber reinforced concrete technology. Steel fibers in concrete help to improve flexural strength and crack resistance. Today, there are critical shortages of natural resources. In this research, waste concrete is being used to produce recycled aggregate. The Recycled Coarse Aggregate (RCA) is partially replaced with the natural coarse aggregate (NCA) in concrete to analyze the mechanical properties of steel fiber reinforced concrete (SFRC). Several tests were conducted, such as compression and flexural tests. Five batches (A, B, C, D and E) of concrete cube and prism samples with different proportions of RCA (0%, 25%, 50%, 75% & 100%) and 1.5% volume fraction of steel fiber were tested, together with one control sample which used 100% NCA and 0% volume fraction of steel fiber. As a result, the control sample achieved 27.32 MPa in compression strength and 0.90 MPa for flexural strength while batch A managed to achieve 48.60 MPa and 1.10 MPa respectively. The cube and prism samples of all batches (A, B, C, D, E) showed decreasing compressive and flexural strength with increasing proportion of RCA in the concrete. Four samples fully achieved more than 20 MPa of compression strength and optimum flexural strength.

Keywords**:** Recycled coarse aggregate, steel fiber reinforced concrete

1.0 INTRODUCTION

Concrete with aggregate from recycled materials, which enables saving sources of natural aggregate, is considered to have generally worse mechanical properties than common concrete. But the idea to add steel fibers to a concrete mixture with recycled aggregate may change material properties of such concrete, improve behaviour and bring about new types of applications. Steel fiber reinforced concrete with recycled coarse aggregate can be considered as optimal structural concrete for various applications [1]. Even though it is established that SFRC is superior to ordinary concrete in many applications, very little research has been carried out on utilizing recycled aggregates in the production of SFRC. Many waste materials have been proven to be successfully utilized in the manufacturing of normal concrete [2]. However, there are only a few attempts to utilize recycled aggregates in the production of SFRC due to the original defects of recycled aggregates. Nevertheless, the utilization of recycled aggregates for SFRC is still necessary, as SFRC is widely used nowadays.

2.0 MATERIALS AND METHODS

Concrete contains cement, water, fine aggregate, coarse aggregate (recycled and natural) with the control concrete; 0% (Batch A), 25% (Batch B), 50% (Batch C), 75% (Batch D) and 100% (Batch E) of the naturally coarse aggregate is replaced with the recycled coarse aggregates (RCA). Three cube and prism samples per batch were cast in 100 x 100 x 100 mm and 100 x 100 x 500 mm molds respectively. A 1:2:4 concrete mix with the proportion replacement of coarse aggregate with w/c ratio of 0.50 and addition of 1.5% volume fraction of steel fiber was also added to each sample. After about 24 hours the specimens were de-molded and water curing continued till the respective specimens were tested after 7, 14 and 28 days for compressive strength, and after 7 and 28 days for flexural strength.

3.0 RESULTS AND DISCUSSION

Compression Test

Table 1 and Figure 1 shows the relationship of compressive strength between normal concrete and the steel fiber reinforced concrete which contains 1.5% volume fraction of steel fibers. The idea of adding steel fiber in the normal concrete is acceptable as the compression strength of SFRC is higher than normal concrete after the samples are tested after curing periods of 7, 14, and 28 days. At 7 days, the compression strength of normal concrete is 23MPa and 39 MPa for SFRC, at 14 days it is 24 MPa for normal concrete and 41MPa for SFRC, and after 28 days it is 27 MPa for normal concrete and 48MPa for SFRC. Results show the compression strength of concrete increases nearly 80% when adding 1.5% volume fraction of steel fibers to the concrete.

Table 1 Relationship of compressive strength between normal concrete and 1.5% volume fraction of steel fiber reinforced concrete

Curing	Compressive Strength (MPa)	
(Days)	Normal Concrete	SFRC Concrete
7	23.35	39.17
14	24.74	41.58
28	27.32	48.6

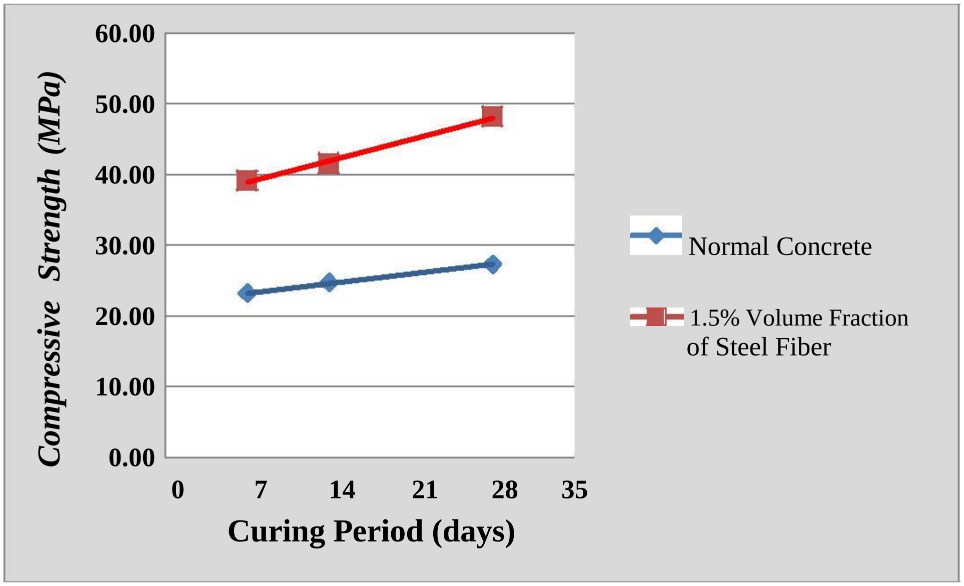

Figure 1 Relationship of compressive strength between normal concrete and 1.5% volume fraction of steel fiber reinforced concrete

Figure 2 shows that with the increase of replacement of RCA in NCA, there is a decrease in the compressive strength. However even 75% RCA replacement could develop a 20 MPa concrete easily with the addition of 1.5% volume fraction of steel fibers which acts as crack resistor in the concrete. The drop patterns of the compressive strength of all batches are not drastic, decreasing between 5-10 MPa only. The compressive strength for 0% RCA replacement in the concrete was 40.60 MPa compression strength which is considered a high strength of concrete. It dropped to 31MPa and 27 MPa with 25% and 50% RCA replacement of NCA in the concrete respectively. For 100% replacement of RCA, compression strength dropped to 11 MPa which is considered failure as the minimum strength of concrete in this study is 20MPa.

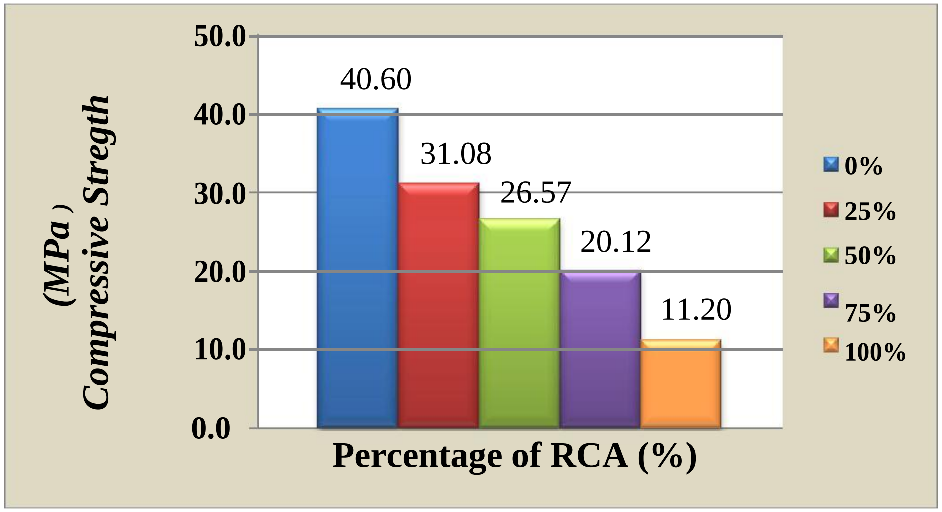

Figure 2 Compressive strength of SFRC with different percentages of RCA

Flexural Test

Table 2 and Figure 3 shows the relationship of flexural strength between normal concrete and the steel fiber reinforced concrete which contains 1.5% volume fraction of steel fibers. The idea of adding steel fiber to normal concrete is acceptable as the flexural strength of SFRC is higher than normal concrete after the samples were tested after 7 and 28 days. After 7 days of curing, the flexural strength of normal concrete is 0.6 MPa and 0.9 MPa for SFRC. After 28 days curing time, it is 0.9 MPa for normal concrete and 1.1 MPa for SFRC. Flexural strength of concrete is increased nearly 20% by adding a 1.5% volume fraction of steel fibers in the concrete after curing for 28 days.

Table 2 Relationship between flexural strength of normal concrete and 1.5% volume fraction of steel fiber reinforced concrete.

Curing	Flexural Strength (MPa)	
(Days)	Normal Concrete	SFRC Concrete
7	0.6	0.9
28	0.9	1.1

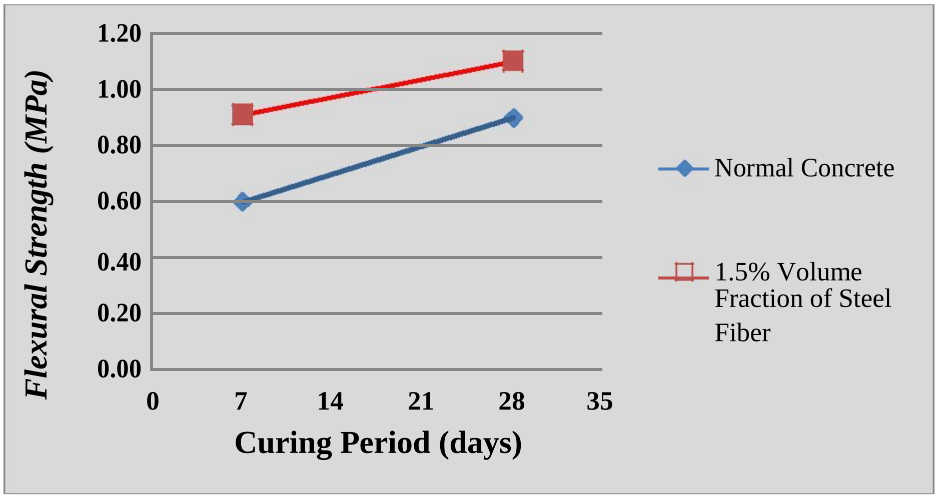

Figure 3 Relationship between flexural strength of normal concrete and1.5% volume fraction of steel fiber reinforced concrete.

Table 2 summarizes the flexural strength of SFRC with different percentages of RCA in the concrete. The increase in replacement of RCA in NCA leads to a decrease in the flexural strength of the SFRC. But the difference in flexural strength of all samples is small, ranging only between 0.02 MPa to 0.20 MPa. After 28 days, the flexural strength of 0% replacement of RCA in SFRC is 1.1 MPa, and 0.9MPa for 100% replacement. This decreasing result is obtained because porosity and amount of weak bond areas of RCA is higher than NCA. The greater number of weak bond areas in RCA is due to old mortar attached to RCA particles [3].

Table 2 Relationship between flexural strength and percentage of RCA

% of RCA	Flexural Strength (Mpa)
0	1.1
25	1.197
50	1.134
75	0.931
100	0.91

CONCLUSION

The main aim of this research project was to utilize recycled coarse aggregate (RCA) for the production of steel fiber reinforced concrete. It is essential to know whether the replacement of RCA in concrete is inappropriate or acceptable. Data analysis in comparison with the control concrete test results allowed the following several conclusions to be made:

a) The compression and flexural strength of a steel fiber reinforced concrete which contains 1.5% volume fractions of steel fibre is higher than a normal concrete.

b) Increasing RCA replacement in the concrete mixtures caused the compressive strength of SFRC concretes to decrease.

c) Increasing RCA replacement in the concrete mixtures caused the flexural strength of SFRC concretes to decrease.

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