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Variations in Mechanical Properties of Concrete with Recycled Aggregates and Jute Fiber: A Review

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A B S T R A C T

This paper aims to review the changes in mechanical properties of various concrete composites made from recycled aggregates and reinforced with jute fibers. Various testing methods were used to investigate these composites. The mechanism of mechanical testing, using state-of-the-art equipment to simplify apparatus developed by various researchers on prototypes and at full scale, is presented. A brief overview of the parameters used in these methods is also provided. The properties of jute fibers and their performance in enhancing the mechanical strength of concrete are highlighted, and conclusions are drawn to gain a better understanding of the effectiveness of these modifications against loadings. The results of these methods are in terms of predicting the actual behavior of jute fiber concrete for real-world applications.

K E Y W O R D S: Mechanical Properties; Concrete Strength; Recycle aggregates; Jute Fibers; Review.

1. Introduction

Construction demolition waste obtained from old infrastructure not properly disposed of has become the major concern and point of concentration in the way of sustainable development, the efficient use of recycled aggregates is to reuse them again in concrete composites effectively this will not only helps in disposing of the material but also saves the natural resources extracted by detreating mountains, the strength properties of recycling aggregates compared with virgin aggregates are low so as a result, it decreases the strength of concrete, the incorporation of organic and natural fibers in concrete to enhance the concrete properties and, to build low-cost, long-lasting fiber reinforced cement concrete. Steel, carbon, plastics, glass, and natural fibers are among the fibers now in use in the way of sustainable development.

According to the findings, promoting the use of recycled aggregates wasn't limited to the technique of removing old mortar to enhance their performance. However, assessing the performance of recycled concrete may be improved to fulfill the requirements of concrete quality by using certain straightforward and affordable approaches, such as managing the water-cement ratio, modifying the aggregate moisture content, and using a different mixing process. 3 components of the performance.[1] The strength of recycled concrete decreases with an increasing water-cement ratio. However, due to the water absorption of the recycled aggregate, it has a certain inhibitory effect on strength reduction. As the replacement rate of recycled aggregates increases, the optimal sand ratio decreases. The sand ratio is controlled between 32% and 38%, which is ideal for recycled concrete. [2] When the water-cement ratio is the same, the apparent density of recycled aggregate concrete decreases continuously with the increase of recycled aggregate replacement, As the replacement rate of recycled aggregates continues to increase, the apparent density of concrete continues to decrease. [2] The creep of RAC is higher compared to conventional concrete. And the creep of RAC increases with the increase of the RCA replacement. [3] The modulus of elasticity for RAC generally reduces as the RCA content increases; however, the strain at peak stress is larger than that of conventional concrete.[3]

The structural behavior of RAC elements/members is generally slightly weaker in comparison to that of elements made with natural aggregates.[3]

Natural fibers have received a lot of attention recently since they are inexpensive, readily available, and ecologically benign. Jute fibers are among the most affordable natural fibers and are common in tropical nations. Long, silky, and glossy, jute is a type of vegetable fiber that may be spun into strong, coarse threads. It is made from plants of the Corchorus genus, which was once included in the Tiliaceae family or, more recently, in the Malvaceae family. [4]

Natural jute fiber can be an effective material to reinforce concrete strength which will not only explore a way to improve the properties of concrete, it will also explore the use of jute and restrict the utilization of polymer which is environmentally detrimental.[5] The large cut length and higher content of reinforcing materials (jute fiber) result in the unfortunate tendency of balling formation and high porosity of composites followed by the degrading of mechanical properties of JFRCC about plain concrete. But in the incorporation of short and low fiber content, an intact structure develops which enhances the mechanical properties of the same composite. It was also noted that all the remarkable increment values were found mostly in the presence of higher cement content.[5] The mechanical behavior of fiber-cement composite, which accounts for the bond between the fiber and surrounding concrete, largely depends on many factors like the physical characteristics of the fibers such as geometry, type and surface characteristics, fiber orientation, fiber volume ratio and fiber distribution, the chemical composition of the fiber, and so on.[5]

2. Mechanical Properties of Recycle Aggregates in Concrete

Concrete made with recycled aggregates (20%, 50%, and 100% replacement) from old masonry or old concrete can have the same fresh workability and can achieve the same compressive strength as concrete made by natural aggregates in the range of 20–40 MPa at 28 days [6]. Using unwashed recycled aggregate in concrete will affect its strength. The effect will be more obvious at lower water/cement ratios. At a water/cement ratio of 0.38, the compressive strength of recycled concrete remains only 60% of that of normal concrete. However, the strength ratio can be increased to more than 75% when the water/cement ratio is greater than 0.60.[7] Under the same mixture proportions, the mechanical properties of recycled concrete were worse than that of normal concrete. When the recycled aggregate was washed, these negative effects were greatly improved. This is especially true for the flexural strength of recycled concrete [7]

2.1 Compressive Strength

Compressive strength test results from the recycled and normal concrete made from the same mortar and the same water/ cement ratio are illustrated in Fig. 1 below. The figure shows that the compressive strength of normal concrete is higher than that of recycled concrete, especially at lower water/cement ratios.[7]

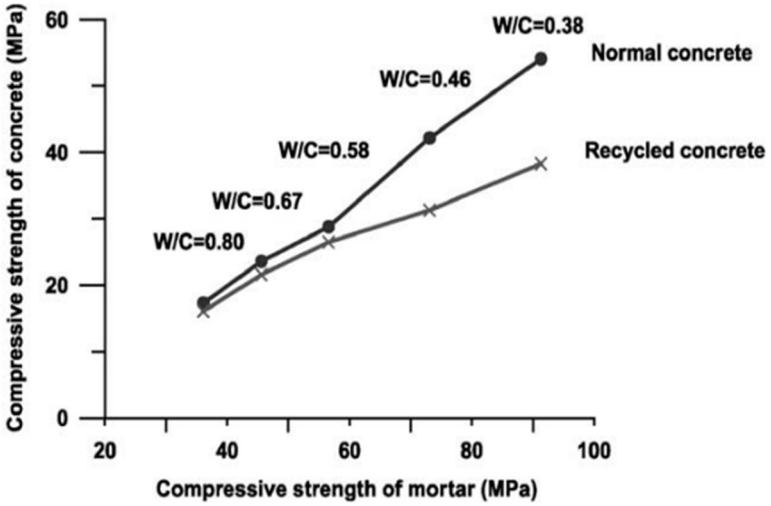

Fig. 1 compressive strength at different w/c ratios

The compressive strength of recycled aggregate concrete is somewhat lower (in some cases up to 20% lower, but usually less) compared with the strength of control mixes of conventional concrete.[8]

The incorporation of course and fine RA cuts the average compressive strength by between 8 and 60%, relative to the strength of the original mixes made with natural aggregates. [9]

2.2 Flexural Strength

(Zhou et al.) investigated the RAC slabs with the same cross-section but different RCA replacement ratios (5%, 10%, and 15%), and found that with the increasing of the RCA replacement percentage, the cracking load and the ultimate load of the RAC slab decreased, and the ultimate load deceased much obviously [10-19]

(Xiao et al.) investigated the longitudinal shearing properties of steel deck RAC composite slabs with different RCA replacement ratios (0%, 30%, and 100%) and found that, when the RCA replacement percentage was greater than 30%, the shear capacity began to decrease. [10-20]

(Deng and Yu, Bai and Wang, Liu and Yan et al) all reported that the RAC beam had elastic, cracking, yield, and ultimate stage. The average strain measured on the cross-section obliged the plane section assumption. Under the same conditions, the cracking and ultimate moment of the RAC beam are similar to those of a conventional concrete beam. Before the crack appeared in the RAC beam, the deflections were increased with the content of RCA [10]

2.3 Split Tensile Strength

The determination of the splitting tensile strength of cylindrical concrete samples such as moulded cylinders and drilled cores is outlined in this procedure. A diametral compressive load will be applied along the length of the sample at a continuous rate until failure occurs. This loading induces tensile stresses on the plane containing the applied load, causing tensile failure of the sample. The splitting tensile strength will be determined by dividing the maximum applied load by the appropriate geometrical factors. ASTM C496 formed the basis for the development of this procedure (Xiao et al 2012).

(Cheng, Shi, et al. and Zhou et al.) [10] investigated the influence of RCA on the splitting tensile strength of RAC. In their tests, cube specimens were used. The test results are presented and compared in Fig.2

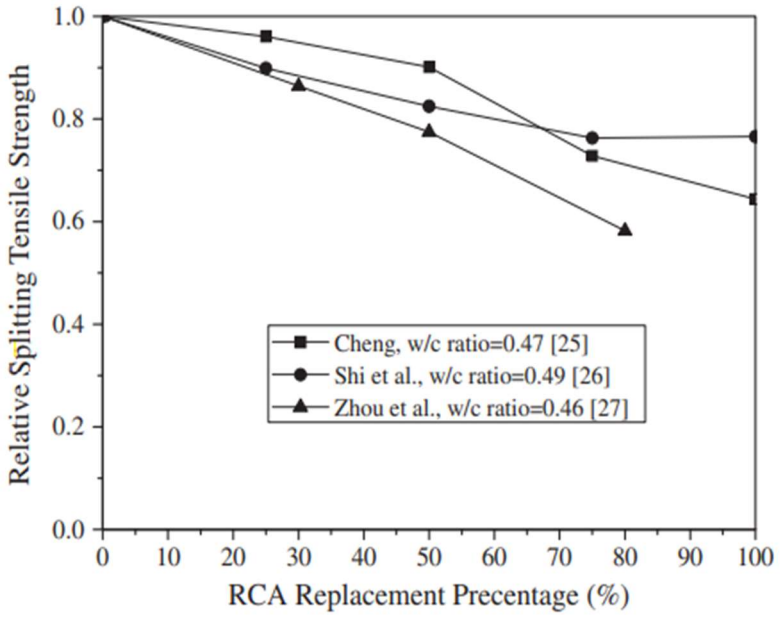

Fig. 2 Split Tensile at different Percentages of RCA

From figure 2, it is evident that the splitting tensile strength reduces as the RCA content increases. Researchers from other countries such as (Ravindra raja et al.) reported that the splitting tensile strength of RAC was consistently 10% lower than that of conventional concrete. (Tabsh and Abdelfatah) reported that about a 25–30% drop in tensile strength was observed in concrete made with RCA. It may be concluded that in most cases there is somewhat of a difference in tensile strength between RAC and conventional concrete. Xiao et al. [17] revealed that the splitting failure of RAC was initiated not only from the interfaces between the RCA and new cement paste but also from some of the RCA itself.

3. Mechanical Properties of Jute fiber in Concrete

On the contrary, natural fibers which are biodegradable, inexpensive, environmentally friendly, and easily available are produced from naturally available resources, for instance, coconut tree, banana tree, cotton, and jute (Sagoe-Crentsil et al 2001). Researchers have conducted numerous studies on the effect of natural fibers on the mechanical and physical behavior of concrete to investigate the extent of improvement. In recent years, unrelenting efforts have been observed for using natural fibers in FRCC for improving energy efficiency, economy, and eco-friendliness flavor. Hence, the demand to utilize natural fibers for making good-quality and low-cost sustainable FRCC for housing and other necessities is increasing. Additionally, the other potential application of natural fiber-reinforced cement composites is limited to that area where energy is to be absorbed or the areas prone to impact damage (poon et al 2004).

With the incorporation of short and low fiber content and percentages as shown in Table 2, an intact structure develops which enhances the mechanical properties of the same composite. It was also noted that all the remarkable increment values were found mostly in the presence of higher cement content. So, it can be concluded that the presence of Jute fiber with more cement content strengthens the concrete to a greater extent.[7]

Table 1. Chemical composition of jute

Element	Jute fiber (%)	Jute stick (%)	Element	Jute fiber (%)
Cellulose	58-63	34.18-45.20	Water Soluble	0.6-1.2
Lignin	12-14	22.21-23.50	Polyuronide	4.8-5.2
Wax(Oil Materials)	0.4-0.8	7.18-7.25	Acetyl Value	2.8-3.5
Ash Content	-	0.37-0.4	Nitrogenous matter	1.56-1.87
Oxalic acid	-	13.3-22.3	Material Substances	0.5-0.79
Hemi-cellulose	20-23	-	-	-

3.1 Compressive Strength

The remarkable enrichment of compressive strength is observed when compared with plain concrete only for 10 and 15-mmm fiber cut with 0.10 % volumetric content; however, the 25-mm fiber length causes the maximum strength loss of concrete composites. For 15-mm fiber length, a 15 % increment of compressive strength is observed with 0.10 % dosing in a 1:1.5:3 mix ratio whereas, for another mix ratio, 10 % enhancement is visualized with the same fiber length and

content.[7-14]

The highest compressive strength was observed at 0.1% fiber content for jute fibers both 10mm and 15mm in length. Compared to normal concrete, 64.34% and70.9% enhanced the compression strength of 28 days of 10 and 15mm lengths respectively[15]

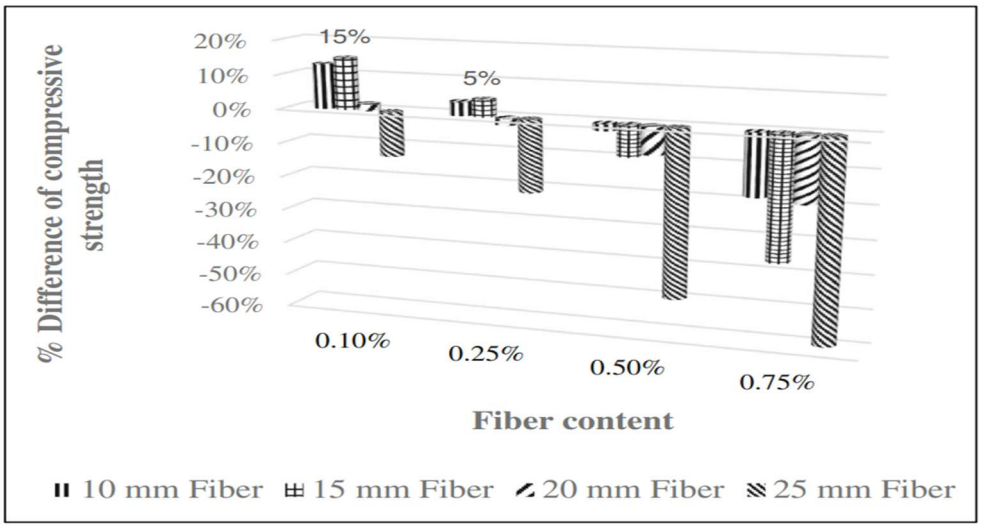

Fig. 3 compressive strength enhancement comparison at different lengths and volumes

3.2 flexure Strength

The highest strength augmentation up to 22 and 14 % was achieved for 15-mm fiber of 0.10 % dozing with a mix ratio of 1:1.5:3 and 1:2:4, respectively. Mixing of concrete low cut length's jute fiber can move easily and causes the even spreading of fiber and create better reinforcement on composites. However, the higher porosity and uneven distribution of reinforcing material causes the heavy reduction of bending strength due to >15-mm fiber length and >0.25 % volumetric dozing; the maximum drop was found to be 69 % lower than that of the plain concrete. Moreover, the inclusion of more jute of larger length results in the discontinuity of concrete mixing and improper arrangement of the concrete constituents that highly affect the strength against bending of a prism specimen[7-14-15]

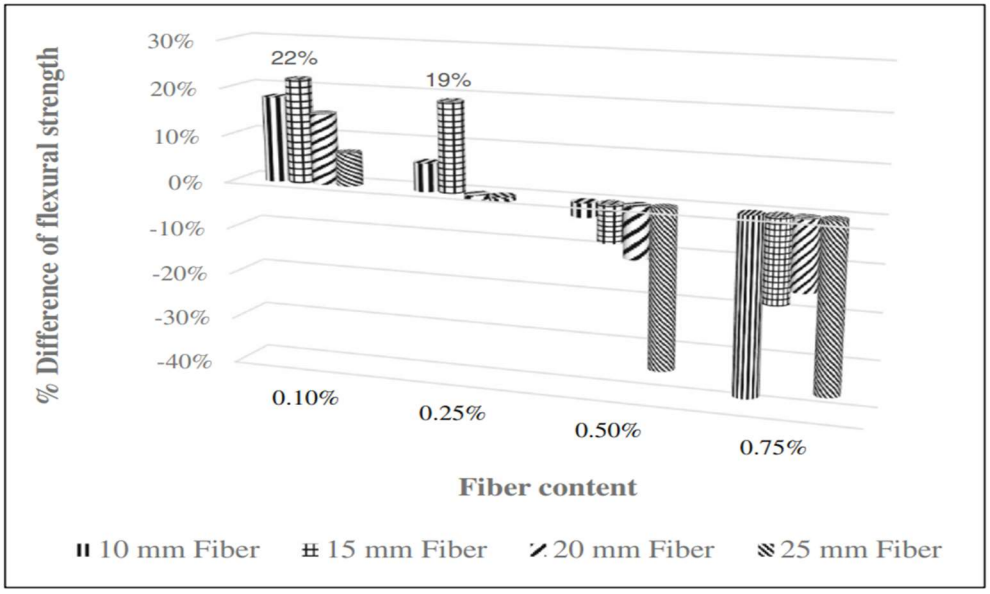

Fig. 4 flexural strength enhancement comparison at different lengths and volumes

3.3 split tensile Strength

the shorter jute with lower content is more promising than the longer fiber with more amount for concrete reinforcement. The maximum enhancement was achieved at 35 % for 15-mm fiber with 0.10 % volumetric dozing about plain concrete in the case of a 1:1.5:3 mix ratio.[14-18]

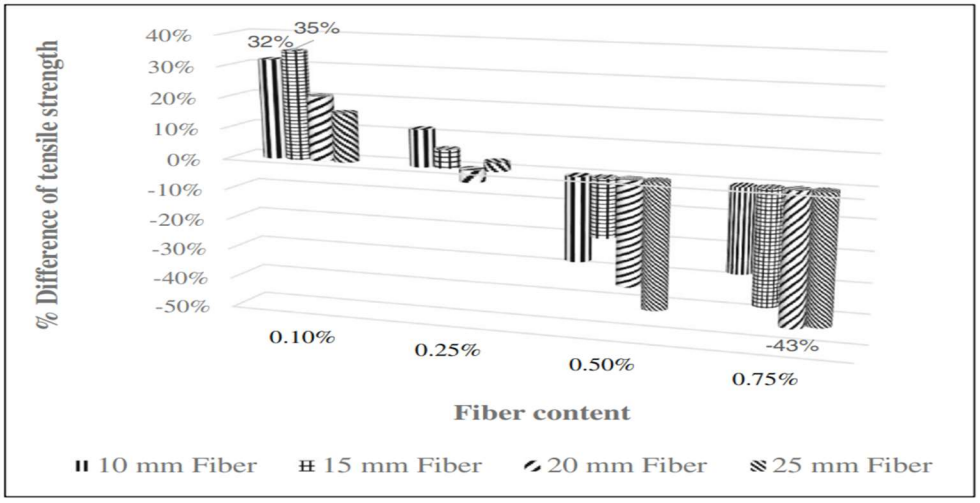

Fig. 5. split Tensile Strength enhancement comparison at different lengths and volume

4. Summary

Table. 2. Summary of results reviewed at different percentages of the jute fiber content

Jute fiber (JTF)	Slump	Optimum	Results
0%, 0.25%, 0.50%, 0.75%, and 1.00%	Decreased	0.5%	Compressive, flexure, and tensile strength improved
0%, 1%, 2%, 3%, and 4%	-	-	Compressive and tensile strength improved
0%, 0.5%, 1.0%, and 1.5%	-	1%	Compressive, flexure, and tensile strength improved
1.5, 3.0, and 4.5	-	3%	Compressive and tensile strength improved
0%, 0.5%, 1.0%, and 1.5%	Decreased	-	Compressive, flexure, and tensile strength improved
0%, 0.5%, 1.0%, and 1.5%	Decreased	-	Compressive and tensile strength improved
0%, 0.1%, 0.3%, and 0.5%	-	-	Flexure and tensile strength improved
0%, 0.2%, 0.4%, 0.6%, 0.8%, 1.0%, 1.2%, 1.4%, and 1.6%	-	1.4%	Compressive strength improved
0%, 10%, 20%, 25%, and 35%	-	-	Flexure strength improved
0%, 0.5%, 1%, and 1.5%	-	1%	Compressive strength improved
0%, 0.10%, 0.25%, and 0.50%	-	0.10%	Compressive, flexure, and tensile strength improved
0%, 0.25%, 0.50%, 0.75%, and 1.0%	Decreased	0.25%	Compressive, flexure, and tensile strength improved
0%, 2%, 4%, 6%, 8%, and 10%	-	6%	Flexure and tensile strength improved
5%, 10%, 15%, 20%, and 25%	-	20%	Compressive strength improved

5. Conclusion and Recommendations

Literature supports the inclusion of Jute fibers in improving the mechanical properties of concrete. The use of natural fibers in optimum percentage can play a vital role in the enhancement of strength in concrete.

6. Acknowledgment

Wealthiest thanks to Allah Almighty for a tremendous measure of vitality, power, and the miraculous pushes occurring in a sweetly coordinated manner, only a few to [1]mention which drive our lives. we need to express sincere thanks to our supervisor for his continuous support throughout our writing and research idea.

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