EFFECT OF COCONUT FIBER AND MARBLE WASTE ON CONCRETE STRENGTH

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ABSTRACT

A large amount of marble waste (MW) is being produced by marble industry every year, while coconut fibers (CF) are abundantly available in tropical regions. These two raw materials can be used as a partial cement replacement in concrete. In this research, a combination of CF and marble dust (MD) has been investigated. Cubes were formed for compressive strength and beams were formed for flexure strength tests using different percentages of cement, CF and MD. It has been found that the combination affects the strength of concrete. It was observed that a total of 5% replacement of cement with CF and MD produced an increase in strength. More replacement results in a decrease in strength. Results showed that CF and MD can act as partial cement replacement, when used in specific proportions.

Keywords: *Marble waste powder, coconut fibers, compressive strength, tensile strength*

INTRODUCTION

In recent years green concrete has drawn attention of researchers, in which waste materials are used to replace cement and aggregates in concrete production. This not only reduces burden on natural resources but also minimize their negative impact on environment. Coconut fibers (CFs) and marble waste (MW) are among the wastes abundantly produced all over the world.

CFs are obtained from outermost coconut shell. 500,000 tons of CF is annually produced[1] out of which half is in raw fiber form. The two types of fibers being produced are brown and white fiber. Thick, strong and high abrasion resistant brown fibers are mostly used in engineering applications. CF is a ductile material and can absorb energy[2].

Mechanical properties of coir reinforced concrete are quite important in determining its suitability for construction purposes. Das Gupta et al.[3] investigated the coir reinforced cement pastes composites using different lengths and volume fractions of CFs. Tests revealed that the 38 mm length and 4% volume fraction gives maximum strength of cement paste composite. Mortar quality can also be enhanced by using coir fiber. Reis[4] studied the fracture and flexural behavior of natural fiber reinforced concrete. Four different fibers were used. It has been found that fracture toughness of CFs was greater than other fibers. Also CFs has demonstrated increase in flexural strength. Li et al.[5] did a research on flexural characteristics of cementations composites reinforced with coir fiber. Two lengths, 20 mm and 40 mm of untreated and alkalized CFs were used as reinforcement material using a ratio of cement 1, sand 3, water/cement ratio 0.43 and super plasticizer 0.01 by weight. A ductile, energy absorbing mortar with higher flexural strength and lighter weight was found. Baruah and Talukdar[6] compared the mechanical properties of fibers from different origins. Concrete with 2% fibers showed better results and increased the strengths up to 32.7% respectively. CFs can be used as a composite in cement paste. Ali et al.[7] investigated the mechanical and dynamic properties of reinforced CF concrete. Tests were performed using different percentages of fiber contents and fiber lengths. It was found that CF reinforced concrete with 5 cm fiber length has shown better properties, compressive strength increased by 4% and modulus of rupture by 2%.

Coir fiber also finds its use in the production of corrugated slabs. Paramasivam et al.[8], investigated the feasibility of corrugated slabs reinforced with coir fibers. It was observed that 2.5 cm long fibers and 3% volume with a casting pressure of 0.15 MPa produced better results.

Many countries such as USA, Sweden, France, Egypt, Spain, Italy, Greece, Brazil, Belgium and Portugal have many marble reserves. During processing a lot of marble aggregates, dust and slurry are produced as by products[9]. About 70% of marble gets wasted during different stages[10]. Tons of this waste produced every year which makes it an environmental pollutant. It can also spoil the natural fertility of soil.

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MW can be used as a cement replacement in concrete. Shirulea et al.[11] investigated mechanical properties of concrete partially replaced with marble dust (MD). They concluded that 10% of the cement replacement with MD increases the mechanical properties. This increase in strength was 17.7% in case of compressive strength at 28 days and 11.5% in case of split tensile strength at 28 days. According to Soliman[12] using 5% marble powder in concrete mixes results in 25% increase in compressive strength, increased stiffness and decreased deflection in R.C. slabs.

MW can be used as an aggregate replacement in concrete. Hameed and Sekar[13] studied the use of marble sludge and rock dust as fine aggregates, and concluded that the strength of concrete is not affected if these materials are used as fine aggregates up to with 50%. However, it increases concrete workability and satisfies self-compacting concrete performance. Bahar[14] investigated the use of MD as fine aggregates and concluded that with increasing percentage of MD, compressive strength increases and porosity of concrete decreases. Omar et al.[15] studied the concrete behavior by partial replacement of sand with limestone waste and MD. Tests showed that presence of marble powder (15%) and lime stone waste (50%) increases 7% compressive strength, 17% indirect tensile strength and 8% flexural strength.

The above literature review shows that research efforts has been done on use of MD and CF separately in concrete technology. But the combined effect of these two wastes needs further research. Therefore this research aims to determine the effect of MD and CF, taken simultaneously, on the compressive and flexure strength of concrete.

EXPERIMENTAL PROGRAM

Ordinary Portland cement (OPC) is used in all concrete mixes. Coarse aggregates used in the concrete mixes were obtained from Margalla Quarry. As a fine aggregate, sand was used. CFs used in the present research were soaked in water for 30 minutes. After soaking these were kept in oven for drying for 10-12 hours, keeping temperature at 30 degree centigrade. After oven drying CFs were cooled at room temperature. Then fibers were cut according to required length of 5.0 cm for use in concrete mixes. The MD chosen for the experiments was white colored. It was directly obtained from deposits of marble factories during shaping.

A mix design ratio of 1:2:4 was used with w/c ratio of 0.5. Different percentages of MD and CF were used as replacement of cement in concrete. Table 1 represents the different percentage of MD and CF used for investigation of compressive strength whereas Table 2 represents the different percentages used for flexure tests. Seven different ratios were investigated for concrete compressive strength. Based on the compressive strength results, three different ratios were investigated for flexure strength. For each ratio, three specimens were casted. Cubes of size 6″x6″x6″ were casted for compressive strength test. Likewise unreinforced beams of size 4″x4″x20″ were casted for flexure strength test.

For preparation of concrete mix a pan type concrete mixer was used. Except water, all materials were put to pan mixer and rotated for three minutes. After batching, 3/4th of water was added. After rotating the mixer for two minutes, the remaining 1/4th water was added. The mix was again rotated for two minutes. Same amount of water was added in all the samples with respect to w/c ratio of 0.5 for plain concrete. The mixture so formed was poured into cubes molds in three equal layers with compaction using tamping rod. Electric vibrator was used for removing air voids. The process was repeated for all specimens with different percentages of MD and CF. Specimens so formed were cured for 14 days and 28 days before testing.

Compressive strength test was performed on cubes and flexure test on beams using compression testing machine. A sand layer was spread on the lower jaw of machine and also on the upper surface of cube for uniform pressure application. Load was applied at a uniform rate and the ultimate load at which cube failed was noted. In case of flexure strength test, third point loading was applied each at a distance of 1/3rd from each support and load at which beam failed was noted.

RESULTS AND DISCUSSIONS

Compressive strength is an important parameter in the investigation of concrete properties. Compressive strength for cubes against 14 days and 28 days curing are reported in Table 3 and Table 4 respectively. Same

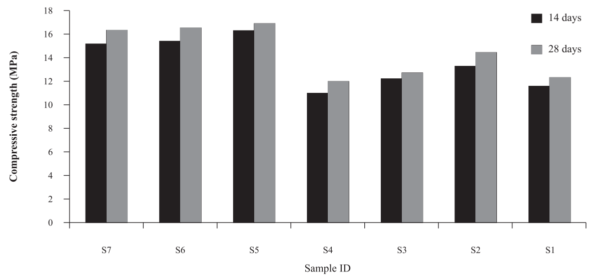

Figure 1: Compressive strength for all mixes at different ages

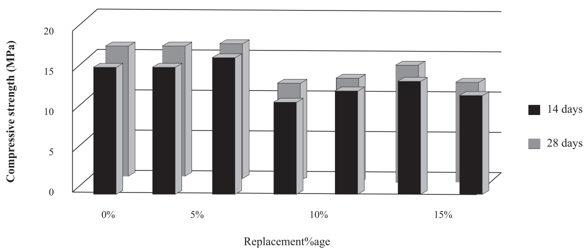

Figure 2: Compressive strength of specimens versus %age replacement

results are presented in graphical form in Figure 1 and Figure 2.

It can be clearly seen from the results that addition of waste affects the compressive strength of cubes. Increased waste addition results in more strength loss. For controlled specimen S7 (no waste addition) compressive strength is 15.27 MPa and 16.45 MPa for 14

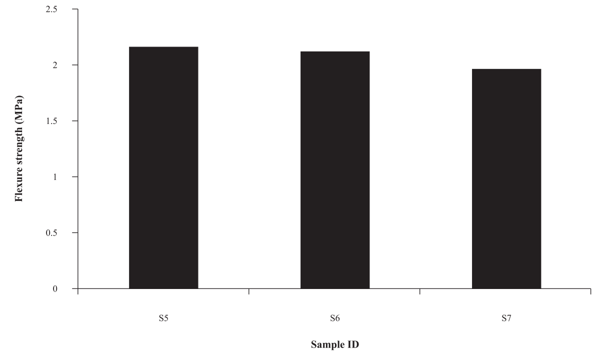

Figure 3: Flexure strength for three specimens

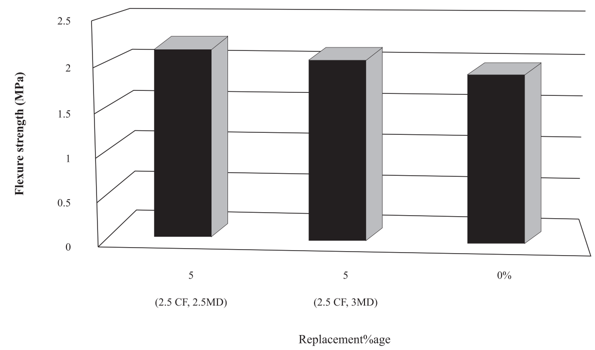

Figure 4: Flexure strength with different replacement percentages

and 28 days respectively. For lower cement replacement (S6 and S5), an increase in concrete strength is observed whereas with further increase of the waste (S1 to S4), compressive strength recorded was lesser

Table 1: Different percentages of MD and CF used in formation of cubes for compressive strength test

Sample ID	OPC (%)	CF (%)	MD (%)
S1	**85**	**3**	**12**
S2	85	3.5	11.5
S3	90	4	6
S4	90	4.5	5.5
S5	95	2.5	2.5
S6	95	2	3
S7	100	0	0

Table 2: Different percentages of MD and CF used in formation of beams in flexure strength

Sample ID	OPC (%)	CF (%)	MD (%)
S5	95	2	3
S6	95	2.5	2.5
S7	100	0	0

Table 3: Compressive strength of concrete after 14 days curing

Sample ID	OPC (%)	CF (%)	MD (%)	Compressive strength (MPa)
S1	85	3	12	11.63
S2	85	3.5	11.5	13.34
S3	90	4	6	12.27
S4	90	4.5	5.5	10.98
S5	95	2.5	2.5	16.36
S6	95	2	3	15.45
S7	100	0	0	15.27

Table 4: Compressive strength of concrete after 28 days curing

Sample ID	OPC (%)	CF (%)	MD (%)	Compressive strength (MPa)
S1	85	3	12	12.36
S2	85	3.5	11.5	14.47
S3	90	4	6	12.78
S4	90	4.5	5.5	12.10
S5	95	2.5	2.5	16.96
S6	95	2	3	16.60
S7	100	0	0	16.45

Table 5: Flexure strength of concrete after 28 days

Sample ID	OPC (%)	CF (%)	MD (%)	Tensile strength (MPa)
S5	95	2.5	2.5	2.15
S6	95	2	3	2.11
S7	100	0	0	1.95

than the controlled specimen. The best combination was proved to be S5 in which 2.5% MD and CF was added. Increase in strength recoded was 7.14% with respect to 14 days control specimen and 3.1% for 28 days. This shows that comparative increase in strength of cubes will be lesser as the age increases. Also the two specimens i.e. S6 and S5 both represent a net replacement of 5% of OPC. However, S5 has resulted in more strength as compared to S6 which advocates that the percentage in which the two materials mix is also critical.

The graph of compressive strength versus the cumulative waste percent is given in Figure 2. It can be seen that the strength first increases up to 5% replacement and then decreases. This implies that compressive strength decreases with the increase in percentage of cumulative wastes beyond 5%.

Flexure strength of concrete was also investigated based on compressive strength results for three specimens only. 28 days tensile strengths of the three specimens S5, S6 and S7 are given in Table 5. Figure 3 and Figure 4 represents the graphical format of the flexure test results. It can be noted that flexure strength increases with the replacement of cement. In case of S5 (2.5% CF and 2.5% MD) strength increase is 10.25% while for S6 (2% CF and 3% MD), strength increase is 8.20% as compared to control specimen S7. This implies that tensile strength increases with proper percentage of CF and MD, which may be attributed to increase in fibrous content of CF.

CONCLUSION

This research focus on the combination of the two wastes CF and MD in concrete, results being produced are summarized below:

i. MD and CF can be used as cement replacement in concrete up to a certain limit.

ii. It was seen that MD can increase the compressive strength of concrete up to net cement replacement of 5%. However, percentage in which the two materials (CF and MD) replaced also affects the strength.

iii. In experiments, different percentages of MD and CF were used and it was observed that compressive strength increase (up to 3.1%) when the replacement of 2.5% CF and 2.5% MD are considered. It can be concluded that compressive strength not only depends on percentage of cumulative wastes replacement but also on the individual percentage of each waste.

iv. It was observed that tensile strength increases (up to 10.2%) with the replacement of 5% in proportion of 2.5% CF and 2.5% MD.

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