Effects of Coconut Fiber and Marble waste on properties of Concrete

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ABSTRACT: This project presents the versatility of coconut fibers with mixture of marble waste and its applications in civil engineering as construction materials. In this project not only the physical, chemical and mechanical properties of coconut fibers and marble waste are described; but also properties of composites (cement pastes, mortar and/or concrete etc), in which coconut fibers and marble wastes are used as admixture, are discussed with proper practical aspects. It carries out on the basis of conclusions drawn by different researchers in last few decades. Marble can increase the compressive strength of concrete that is discussed with the help of experiments and coconut fiber maintains the internal temperature of concrete so it prevents from weathering effects. The aim of this project is to spread awareness of coconut fibers and marble waste as a construction material in civil engineering.

Keywords: Marble waste powder, Blending, Performance of concrete, Coconut fiber, Fiber pretreatment, Compressive Strength, Tensile Strength

Literature Review

Coconut fiber is extracted from the outer shell of a Coconut. The common name, scientific name and plant family of coconut fiber is Coir, Cocosnucifera and Arecaceae (Palm), respectively. There are two types of coconut fibres, brown fiber extracted from matured coconuts and white fibres extracted from immature coconuts. Brown fibres are thick, strong and have high abrasion resistance. White fibres are smoother and finer, but also weaker. Coconut fibres are commercial available in three forms, namely bristle (long fibers), mattress (relatively short) and decorticated (mixed fibers). These different types of fibres have different uses depending upon the requirement. In engineering, brown fibres are mostly used.

Nowadays, the ecological trend aims at limiting the use of natural raw materials in the field of building materials and hence there is an increased interest in the use of alternative materials (waste) from industrial activities, which presents significant advantages in economic, energetic and environmental terms. The main concern of using pozzolanic wastes was not only the cost effectiveness but also to improve the properties of concrete, especially durability. The advancement of concrete technology can reduce the consumption of natural resources and energy sources which in turn further lessen the burden of pollutants on the environment. Presently, large amount of marble dust are generated in natural stone processing plants with an important impact on the environment and humans. Leaving the waste materials to the environment directly can cause environmental problem so by using this waste as a construction material will be a beneficial to Environment.

Cement paste

The mechanical properties of cement paste composites for different lengths and volume fractions of coconut fibers were studied. It was concluded that the tensile strength and modulus of rupture of cement paste increased up to a certain length and volume fraction; and further increase in length or volume fraction decreased the strength of composite.

Table 1 shows the tensile strength and modulus of rupture of cement paste composite reinforced with different volume fractions of 38 mm long coconut fibers ranging from 2 % to 6 %. It can be easily observed that 4 % volume fraction of coconut fibers gives the highest mechanical properties amongst all tested volume fractions. With 4 % volume fraction, the reported tensile strengths were 2.3, 2.8 and 2.7 MPa with lengths of 25, 38 and 50 mm, respectively. Thus coconut fibers with a length of 38 mm and a volume fraction of 4% gave maximum strength of cement paste composite.

Aziz et al. (1981) cited the work of Das Gupta et al. (1978 and 1979)

Table 1: Mechanical Properties of Coconut Fiber Reinforced Cement Paste Composites

Fiber Volume Fraction (%)	**Tensile Strength (MPa)**	**Modulus of Rupture (MPa)**
2	1.9	3.6
3	2.5	4.9
4	2.8	5.45
5	2.2	5.4
6	1.5	4.6

The Mechanical properties of cement paste and concrete mixtures containing marble dusts and limestone dusts are studied. The test results exhibit that there is obvious increment in the compressive strength, abrasion resistance and sodium sulfate resistance with the increasing amount of marble dust. Furthermore, the use of marble waste for the production of concrete is investigated and proved that they can be used to improve the mechanical properties, workability and chemical resistance of the conventional concrete mixtures. **Binici H. *et al* (2007)**

Mortar

The mechanical properties of coir fiber reinforced cement sand mortar are investigated. Two different designs mixes (cement sand ratio by weight), first is 1:2.75 with water cement ratio of 0.54 and second is 1:4 with water cement ratio of 0.82 are tested. Fibers content is kept 0.08, 0.16 and 0.32% by total weight of cement, sand and water. The mortars for both design mixes without any fibers are also tested as reference. Cylinders having size of 50mm diameter and 100mm height and beams having size of 50mm width, 50mm depth and 200mm length are tested for compressive and flexural strength. The curing is done for 8 days only. It is found that all strengths are increased in case of fiber reinforced mortar as compared to that of plain mortar for both mix design with all fiber contents. However, a decrease in strength of mortar is also observed with an increase in fiber content. **Slate (1976)**

Untreated and alkalized coconut fibers with two lengths of 20 mm and 40 mm in cementitious composites as reinforcement materials are studied. Mortar is mixed in a laboratory mixer at a constant speed of 30 rpm, with cement: sand: water: super plasticizer ratio of 1: 3: 0.43: 0.01 by weight and fibers are slowly put into the running mixer. The resulting mortar has better flexural strength, higher energy absorbing ability and ductility, and lighter than the conventional mortar. Good results are achieved with the addition of a low percentage of coconut fibers and chemical agents in cementitious matrix.
Li et al. (2006)

The marble powder proved to be very effective in assuring very good cohesiveness of mortar and concrete, even in the presence of a super plasticizing admixture, provided that water to cement ratio is adequately low. On the basis of the low thixotropy values obtained, it seems that the use of marble powder would not be accompanied by an evident tendency to energy loss during concrete placing, as it is usual for other ultra- fine mineral additions (such as silica fume) that are able to confer high cohesiveness to the concrete mixture. In terms of mechanical performance, 10% substitution of sand by the marble powder in the presence of a super plasticizing admixture provided maximum compressive strength at the same workability level, comparable to that of the reference mixture after 28 days of curing. Moreover, an even more positive effect of marble powder is evident at early ages, due to its filler ability. **V. Corinaldesi et al. (2004)**

Concrete

The mechanical characterization (flexural strength, fracture toughness and fracture energy) of epoxy polymer concrete reinforced with natural fibers (coconut, sugarcane bagasse and banana fibers) are investigated. Fracture toughness and fracture energy of coconut fiber reinforced polymer concrete are higher than that of other fibers reinforced polymer concrete and flexural strength is increased up to 25 % with coconut fiber only. **Reis (2006)**

The static properties of plain concrete (PC) and fiber reinforced concrete (FRC) with different fiber volume fractions ranging from 0.5% to 2% are investigated. Fibers used are steel, artificial and natural fibers (jute and coir fibers only). Here, discussion is limited only to PC and the coir fibers reinforced concrete (CFRC). The mix design (cement: sand: aggregates) for plain concrete is 1: 1.67: 3.64 with water cement ratio of 0.535. Per cubic meter of concrete mix is cement = 350 kg, fine aggregates = 568.40 kg, Coarse aggregate = 1239.40 kg and water = 182 kg. The maximum size of aggregates is 20mm. Coir fibers having length of 4cm and diameter of 0.4mm with volume fraction of 0.5, 1, 1.5 and 2% are added to prepare CFRC. The sizes of specimens are:

(1) 150 mm diameter and 300mm height for cylinders
(2) 150 mm width, 150 mm depth and 700 mm length for beams
(3) 150mm cubes having a cut of 90 mm X 60 mm in cross-section and 150 mm high for L-shaped shear test specimens. All specimens were cured for 28 days. The compressive strength, splitting tensile strength, modulus of rupture and shear strength of coir fiber reinforced concrete with 2% fibers' by volume fraction were increased up to 13.7, 22.9, 28.0 and 32.7 %, respectively as compared to those of plain concrete. It is also noted from their research that all these properties were also improved for CFRC with all other tested volume fractions of fibers' 0.5, 1 and 1.5 %. **Baruah and Talukdar (2007)**

Table 2: Properties of Coconut Fiber Concrete

Fiber volume fraction (%)	Compressive Strength (MPa)	Split Tensile Strength (MPa)	Modulus of Rupture (MPa)	Shear Strength (MPa)	Toughness Index, I_5	Toughness Index , I_{10}
-	21.42	2.88	3.25	6.18	1.934	1.934
0.5	21.70	3.02	3.38	6.47	2.165	2.270
1.0	22.74	3.18	3.68	6.81	2.109	2.773
1.5	25.10	3.37	4.07	8.18	2.706	4.274
2.0	24.35	3.54	4.16	8.21	2.345	3.452

The refining of some fresh and hardened properties of concrete is successfully and economically achieved by utilizing and using some admixture materials such as mineral additions such as fly ash, silica fume, and marble powder. The influence of using fly ash and silica fume on the properties of normal concrete, high strength concrete and self-compact concrete is also studied. The influence of mineral additions on the rheology of self-compacting concrete is also overviewed.
V. Corinaldesi and G. Moriconi (2003)

Plaster

The coir fiber reinforced low alkaline cement taken from the internal and external walls of a 12 year old house is studied. The panel of the house is produced using 1:1.5:0.504 (binder: sand: water, by mass) mortar reinforced with 2% of coconut fibers by volume. Fibers removed from the old samples are reported to be undamaged. No significant difference is found in the lignin content of fibers' removed from external and those removed from internal walls. **John et al. (2005)**

Roofing material

The use of randomly distributed coir fiber reinforced cement composites is reported as low cost materials for roofing. The studied parameters are fiber lengths (2.5 cm, 3.75 cm and 6.35 cm), fiber volumes (2.5, 5, 7.5, 10 and 15%) and casting pressure (from 1 to 2 MPa with an increment of 0.33 MPa). Different properties like bending, impact, shrinkage, water absorption, permeability and fire resistance are investigated. **Cook et al. (1978)**

Coir and sisal fibers are studied as replacement for asbestos in roofing tiles. Coir fibers were more suitable among studied fibers. **Agopyan et al. (2005**)

Slabs

Conducted a feasibility study of making coir fiber reinforced corrugated slabs for use in low cost housing particularly for developing countries. They gave recommendations for the production of coconut fiber reinforced corrugated slabs along with casting technique. Tests for flexural strength, thermal and acoustic properties were performed. For producing required slabs having a flexural strength of 22 MPa, a volume fraction of 3 %, a fiber length of 2.5 cm and a casting pressure of 0.15 MPa (1.5 atmosphere) were recommended. The thermal conductivity and sound absorption coefficient for low frequency were comparable with those of locally available asbestos boards. **Paramasivam et al. (1984)**

Ramakrishna and sandarjan performed the experimental investigations of the resistance to impact loading were carried out on cement sand mortar (1:3) slabs. The slab specimens (300 mm x 300 mm x 20 mm) were reinforced with natural fibers (coconut, sisal, jute and hibiscus cannabinus fibers) having four different fiber contents (0.5, 1.0, 1.5 and 2.5% by weight of cement) and three fiber lengths (20, 30 and 40 mm). A fiber content of 2% and a fiber length of 40mm of coconut fibers showed best performance by absorbing 253.5J impact energy among all tested fibers. All fibers, except coconut fibers, showed fiber fracture, at ultimate failure where as coconut fiber showed fiber pull out failure.
Ramakrishna and Sandararajan (2005)

Noha M.soleman Worked on R.C slabs made with concrete mixed with marble waste and showed that Using 5% marble powder replacement of cement decreased the deflection of the R.C Slabs compared to the control slabs. And also Using 5% marble powder replacement of cement increased and the stiffness of the concrete slabs. **Noha M.soleman (2013)**

Wall paneling system

Wall panels made of gypsum and cement as binder and coconut fiber as the reinforcement were tested. Bending strength, compressive strength, moisture content, density, and absorption were investigated.

Coconut fibers did not contribute to bending strength of the tested wall panels. Compressive strength increased with the addition of coconut fibers, but the compressive strength decreased with an increase in water content and density was increased. There was no significant change of moisture content with coconut fibers. However, moisture content increased with time. There was also no significant effect to water absorption on increasing coconut fiber content.

Mohammad Hisbany Bin Mohammad Hashim (2005)

House construction

Coconut Fibre can replace construction materials such as tiles, bricks, plywood, and asbestos and cement hollow blocks. It is used for internal and exterior walls, partitions and ceiling. It can also be used as a component in the fabrication of furniture, cabinets, boxes and vases, among others.

Luisito J Penamora, Neil J Melencion and Rolendion Palomar (2005)

Objectives

- ✓ To study the influence of coconut fiber and marble waste mix on the compressive strength of concrete.
- ✓ Experimental investigations on bond strength between coconut fiber, marble waste and concrete.
- ✓ Strength and durability of coconut-fiber and marble waste mix concrete in aggressive Environments.
- ✓ Mechanical and dynamic properties of coconut fiber and marble mix concrete.

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Material and Methods:

Physical and Chemical Properties of coconut fiber:

First of all soak coconut fiber in water for 30 minutes. And after soaking kept this in oven for dry and keep temperature 30 degree centigrade. Time of oven-dry will be 10-12 hours. After oven dry keep this in open air for further dry. After that cut the fiber according to required length with guillotine then mixing of materials will be done. Pan type mixture will be used.

Table 3: physical and mechanical properties of coconut fibers

Material properties	Values
Density	1.2 g/cm3
Porosity	96%
Elongation at break	30%
Modulus Young	4 - 6 GPa
Material pH	5.5 - 6.5
Material Strength	175 MPa
Water Absorption	130-180 %

Coconut fibers contain cellulose, hemi-cellulose and lignin as major composition. These Compositions affect the different properties of coconut fibers. The pre-treatment of fibers changes the composition and ultimately changes not only its properties but also the properties of composites. Some-times it improves the behavior of fibers but sometimes its effect is not favorable.
The chemical composition of coconut fibers is presented in Table 4.

Table 4: Chemical properties of coconut fibers

Sr. No.	Fiber	Hemi-cellulose (%)	Cellulose (%)	Lignin (%)
1	Coir	31.1[a]	33.2[a]	20.5[a]
		15-28[b]	35-60[b]	20-48[b]
		16.8	68.9	32.1
		-	43	45
		0.15-0.25	36-43	41-45

[a] The compositions are % by weight of dry and powdered fiber sample

[b] Chemical compositions are % by mass and author took other researchers data

Physical and Chemical Properties of Marble Waste:

The Marble Dust chosen for these experiments was white colored. It is directly obtained from deposits of marble factories during shaping. Marble Dust was sieved using 0.25mm sieve.

Table: 5 physical properties of marble waste

Color	white
form	powder
Odor	odorless
Moisture content	1.59%

Table 6: chemical properties of marble waste

Chemical	Marble (%)	``Limestone (%)
Lime(CaO)	28-32	38-42
Silica	3-30	15-18
MgO	20-25	0.5-3
Alumina(Al2O3)	3-5	2-5
FeO+Fe2O3	1-3	1-1.5
LOI	20-45	30-32

Different Percentages of Marble waste and Coconut fiber Used for Experiment:

Table 7: Different Percentages of marble waste and coconut fiber used in formation of cubes for compressive strength test

Sample	OPC (%)	Coconut Fiber (%)	Marble Waste (%)
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 8: Different Percentages of marble waste and coconut fiber used in formation of Beams in split tensile strength

Sample	OPC (%)	Coconut Fiber (%)	Marble Waste (%)
S8	80	5	15
S9	75	5	20

Experimental Work

Mix Design:

Mix design ratio for cement, sand and aggregate will be (1:2:4) and water cement ratio will be 0.5. By knowing this information and different percentages of marble waste and coconut fiber used in concrete extracted the required quantity of cement, sand, aggregate used for experiment and also extracted the require quantity of marble waste and coconut fiber for different percentages used in formation of concrete.

Casting Procedure:

A pan type concrete mixer was used in preparing plain concrete. All materials were put in the mixer pan along with the water, and the mixer was rotated for three minutes. The slump test was 50 mm. For

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preparing Cubes, a layer of coconut fibers was spread in the pan, followed by spreading of Marble waste aggregates, sand and cement. The first layer of fibers was hidden under the dry concrete materials with the help of a spade. Then, another layer of coconut fibers followed by layer of Marble waste, aggregates, sand and cement was spread. This process is repeated until the rest materials were put into the mixer pan. Approximately, three quarters of the water (according to a water cement ratio of 0.5 which was the same as that of plain concrete) was added, and the mixer was rotated for 2 min. Then the remaining water was added and the mixer was again rotated for 2 min. After that Concrete with different percentages of marble waste and coconut fiber was poured into the moulds and the moulds were lifted up to a height of approximately 200–300 mm and then dropped to the floor for self compaction of the concrete and to remove air voids. All specimens were cured for 14 days and 28 days before testing.

Specimens:

Cubes having dimensions 6”X6”x6” were casted. And total number of samples were casted 14 in which 12 cubes have different percentages of Marble waste and coconut fiber as replacement of cement were used. And remaining two cubes will be caste simply without mixing coconut fiber and marble waste and these cubes were tested to perform the Compressive strength test. After that casted two beams of size 20x4x4 having different percentages of coconut fiber and marble waste for Split Tensile Strength test. So, there were total 16 specimens for testing.

Specimen Testing:

Compressive strength test Perform on cubes and Split tensile Strength test perform on beams.

Results:

Table 9: Compressive strength of concrete; curing strength for 14 days

Sample no.	OPC (%)	C.F (%)	M.W (%)	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	11.19
S7	100	0	0	15.27

Table 10: Compressive strength of concrete; curing strength for 28 days

Sample no.	OPC (%)	C.F (%)	M.W (%)	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	11.97
S7	100	0	0	16.45

Table 11: Tensile strength of concrete; curing strength for 28 days

Sample no.	OPC (%)	C.F (%)	M.W (%)	Tensile strength (Mpa)
S7	75	5	20	2.2
S8	80	5	15	2.4

Graphical Representation:

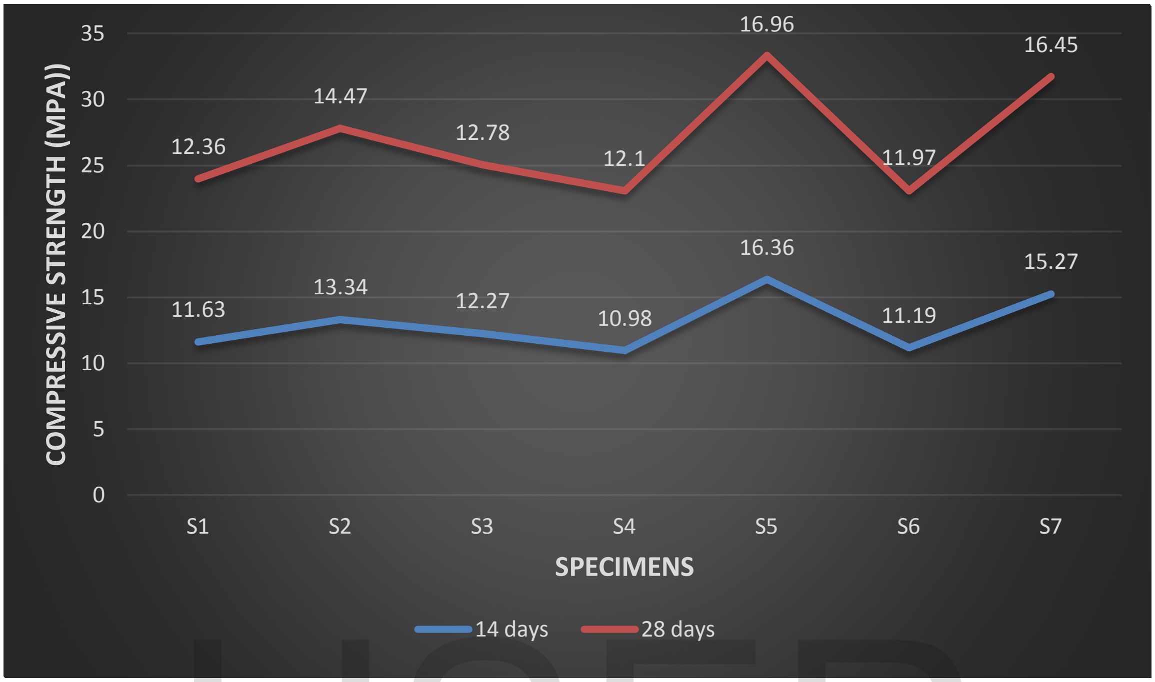

Fig 1: Compressive strength for all mixes at different age

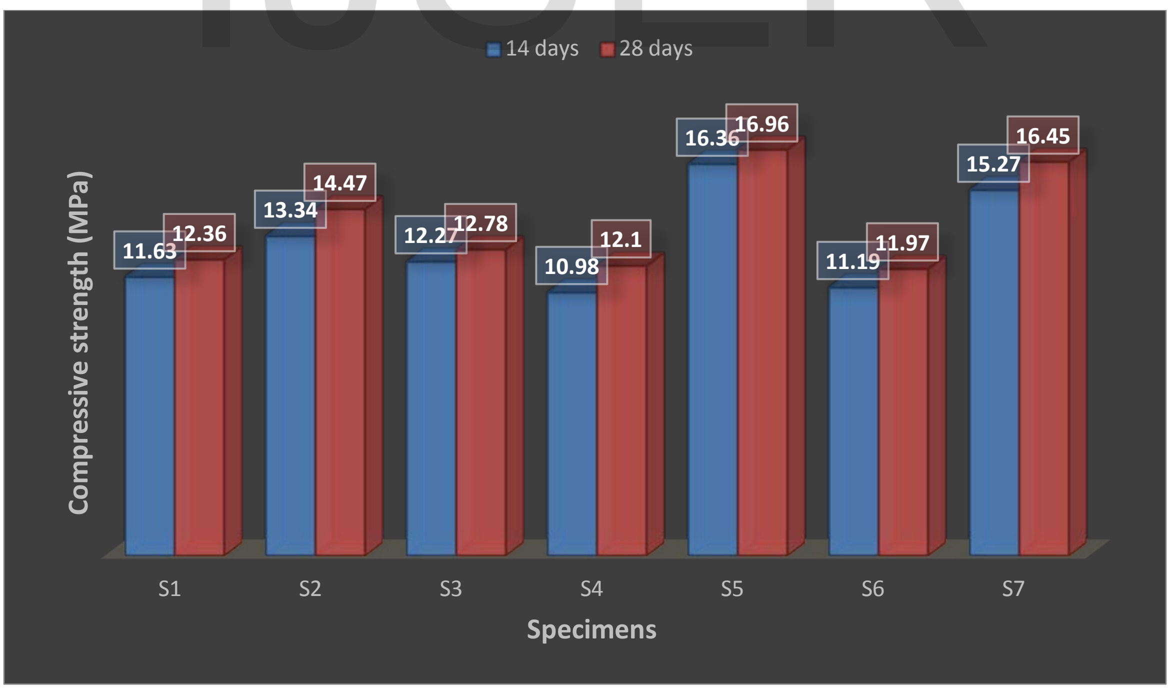

Fig 2: Compressive strength for all mixes with different ratios

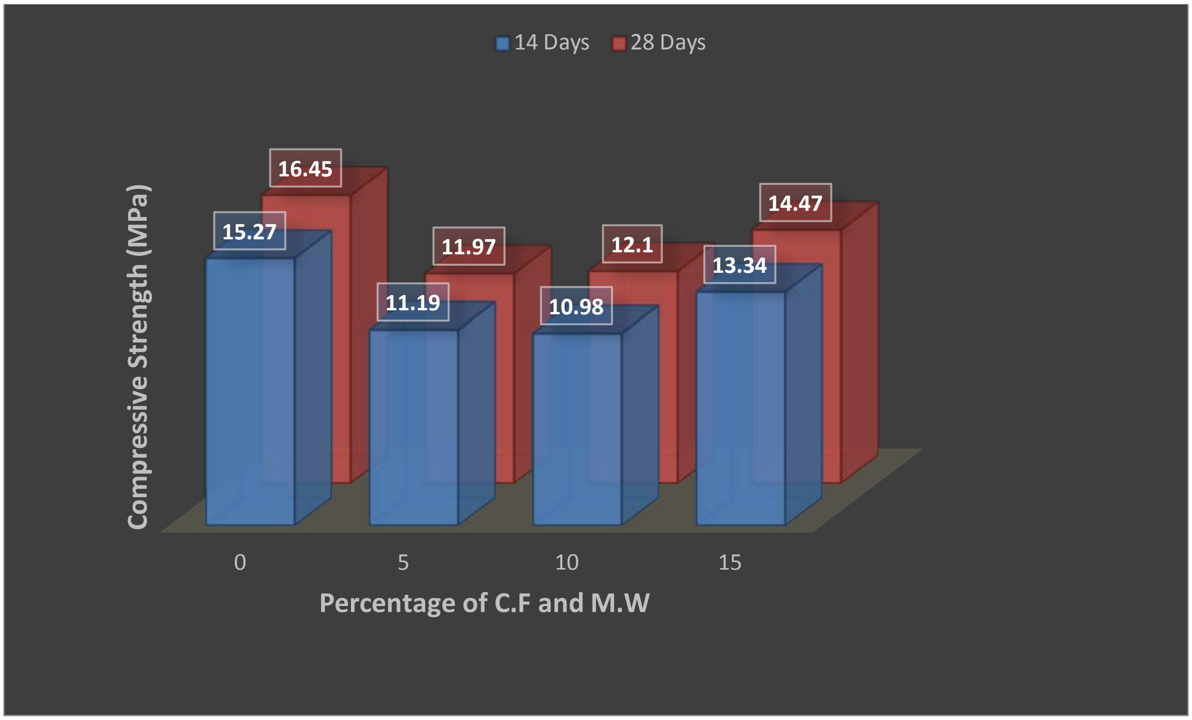

Fig 3: Compressive strength of specimens versus Ratios of C.F and M.W.

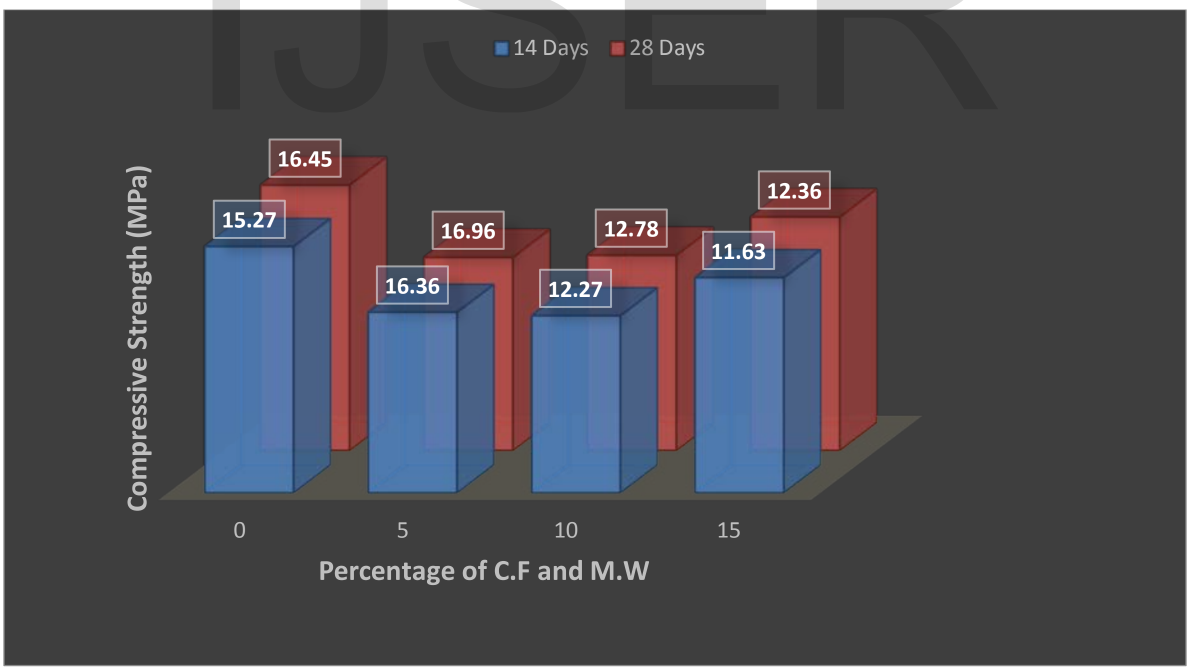

Fig 4: Compressive strength of specimens versus Ratios of C.F and M.W.

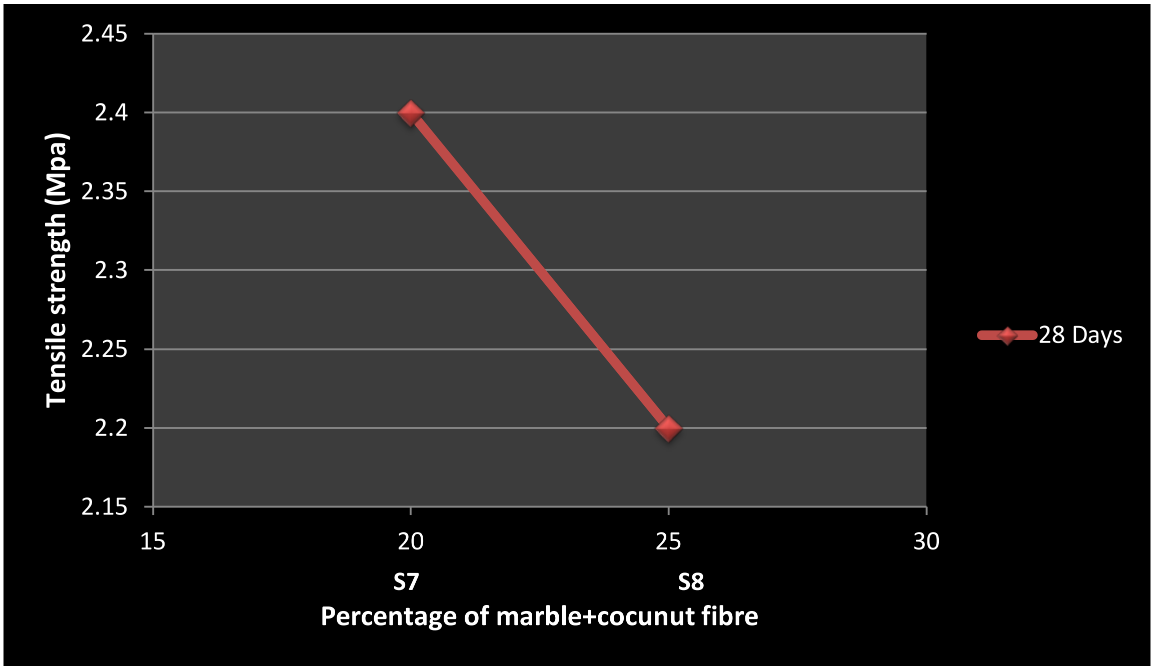

Fig 5: Tensile strength for all mixes at 28 Days

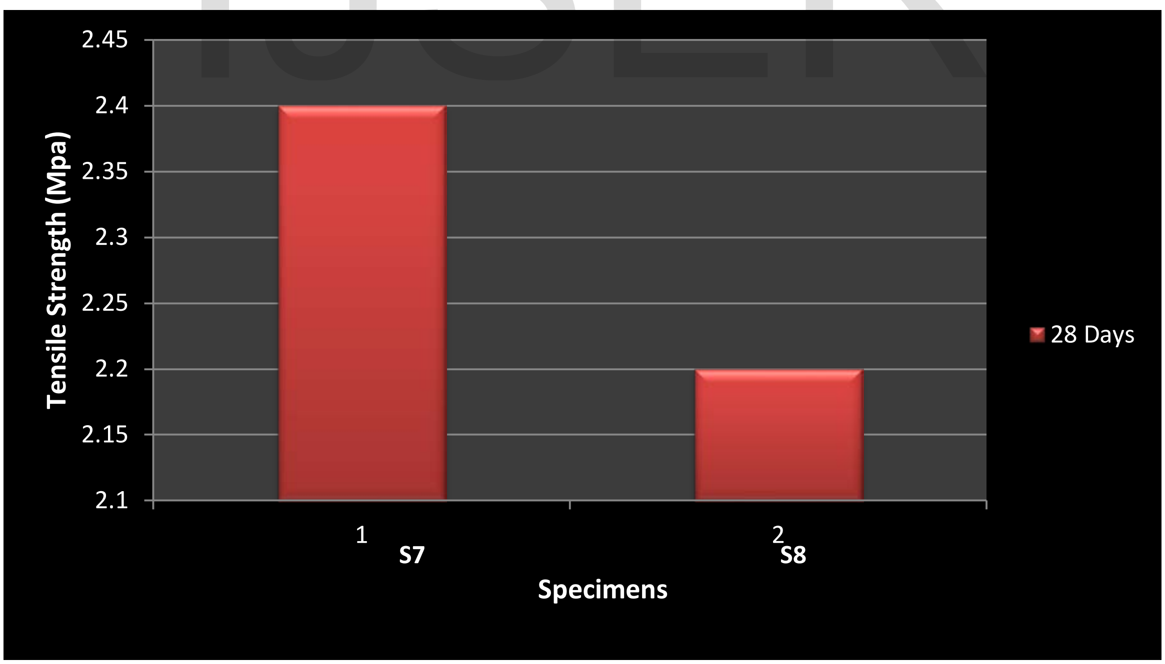

Fig 6: Tensile strength for all mixes with different ratios

Conclusion:

From the above study, it can be concluded that the marble waste and coconut fiber can be used as admixture in concrete. It can be seen that marble waste can increase the compressive strength of concrete and coconut fiber maintain the internal temperature of concrete structure so weathering effects will be negligible. In experiments, used different percentages of marble waste and coconut fiber and observed that if both percentages of marble waste and coconut fiber will same then the compressive strength increases than the concrete without marble waste and coconut fiber. And also it can be observed that tensile strength increases with the use of coconut fiber and marble waste.

Recommendation:

Coconut fibre and Marble waste increase the compressive and Tensile strength if their proper percentage can be use as replacement of cement. If they have same ratio then compressive strength increases and also their proper percentage can increase the tensile strength. So, it can be recommend that by using coconut fibre and marble waste up to an optimum percentage as replacement of cement can increase the strength and above or below this percentage strength of concrete decreases.

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