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A Study on Incorporating Coconut Fiber by Weight into Cement and Substituting a Portion of the Cement

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Abstract: -A means of improving mechanical qualities and sustainability is through the use of natural fibers in cementitious materials. This work looks at the possibility of replacing part of the cement binder with coconut fiber by weight added to cement. Examining how different fiber contents affect the mechanical strength and longevity of composite materials is the goal of the study. Compressive and flexural strength tests, as well as extensive mechanical testing and evaluation of durability attributes like water absorption and environmental resistance, are all part of the experimental processes. Cement composites with varying percentages of coconut fiber are also prepared. The fiber-cement interface and hydration products are examined using microstructural examination utilizing scanning electron microscopy (SEM). Microstructural analysis, including scanning electron microscopy (SEM), provided insights into the fiber-matrix interface and the overall morphology of the composites. The findings suggest that the addition of coconut fiber can improve ductility and toughness without significantly compromising compressive strength when appropriately dosed. SEM images revealed enhanced bonding between fibers and the cement matrix, supporting the mechanical improvements observed.

***Key Words*: (Coconut Fiber), (Cement Composites) (Natural Fibers), (Sustainable Construction) (Durability Composite), (Impact Fiber)**

1.INTRODUCTION: -

The transition from the 20th century to the present marked a profound shift in global dynamics compared to its earlier years. The latter half of the century witnessed unparalleled advancements in technology across various fields such as communications, medicine, transportation, and information technology, alongside significant innovations in materials science. These changes extended to the construction industry, evident in remarkable achievements like the Channel Tunnel and the Millennium Wheel, transforming the landscape of architecture and infrastructure. Undoubtedly, these advancements have brought substantial social benefits, enhancing wealth, quality of life, and leisure, especially in industrialized nations. However, this eraof industrial and technological evolution, particularly over the past few decades, has also been accompanied by profound social transformations. These include unpredictable economic upheavals, shifting social norms, and alarming levels of pollution and environmental degradation on a global scale. On a broader scale, these societal changes can be categorized by technological revolutions, rapid population growth, global urbanization trends, and the escalating challenges of pollution and waste management. Yet, perhaps the most overarching influence has been globalization, which impacts not only economics, technology, and societal structures but also exerts significant influence on global climate patterns and weather systems.[1]

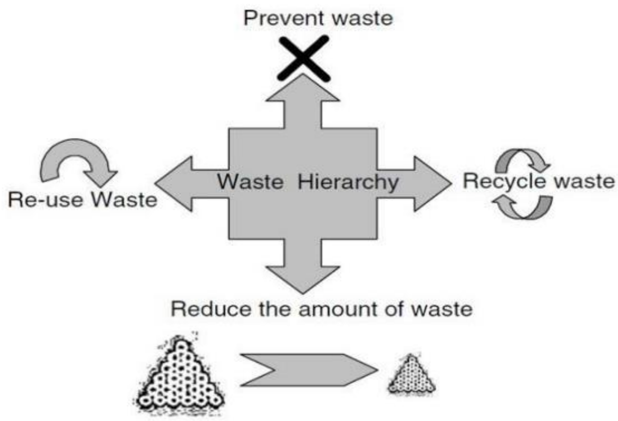


Figure 1 West Hierarchy[1]

Marble Dust: -

Marble is a type of metamorphic rock that forms from limestone, dolomite, or older marble due to heat and pressure within the Earth's crust over time. This process, known as recrystallization, transforms the limestone into coarse-grained calcite. The composition of the resulting marble can vary based on the impurities present in the original limestone before recrystallization India faces a significant environmental challenge with approximately 960 million tons of solid waste generated annually. [2]

Figure 2 Marble Powder [2]

COCONUT FIBER: -

Found between the tough inner shell and the outer coat of the coconut, coir fibers consist of narrow, hollow cells with thick cellulose walls. Initially pale when immature, they become hardened and yellowed as lignin deposits on their walls. Each cell typically measures about 1 mm (0.04 in) in length and 10 to 20 μm (0.0004to 0.0008 in) in diameter. These fibers range from 10 to 30 centimeters (4to 12 in) in length

Figure 3 Coconut Fiber[3]

2. LITERATURE REVIEW: -

Ali A. Aliabdo et al. [1] conducted research on the reuse of waste marble dust in cement and concrete production. The study aimed to explore the feasibility of incorporating marble dust (MD) into cement and concrete. The research was divided into two parts: the first focusing on cement modified with marble dust (marble dust blended cement), and the second on concrete incorporating marble dust as a replacement for cement and sand. Various replacement ratios (0.0%, 5.0%, 7.5%, 10.0%, and 15% by weight) were studied.

Ali Ergün[2] conducted a study on the impact of diatomite and waste marble powder (WMP)as partial substitutes for cement in concrete, focusing on their mechanical properties. The study included compression and flexural tests, revealing that combinations of 10% diatomite, 5% WMP, and 5% WMP + 10% diatomite yielded optimal strength.

D.M. Parbhane et al. [3] investigated the strength properties of coir fiber concrete using M20 grade concrete mixed with different percentages of coconut fiber (coir). Forty-five cylinders were cast and evaluated for split tensile strength and workability at 7, 14, and 28 days.

Lohani T.K. et al. [4] discussed the economic and environmental challenges associated with natural sand in concrete production, particularly its scarcity and environmental impact They proposed quarry dust as a viable alternative, assessing its performance through various tests on M20 grade concrete mixes with 0% to 50% sand replacement.

Majid Ali et al. [5] explored the mechanical and dynamic properties of coconut fiber reinforced concrete (CFRC), emphasizing its toughness and potential for use in earthquake-prone regions. The study examined the effects of fiber content and length on CFRC's mechanical properties, damping ratio, and fundamental frequency. Higher fiber content increased damping but reduced static and dynamic moduli, with 5% fiber content and 5 cm fiber length proving optimal.

M Sivaraja et al. [6] investigated the enhancement of concrete properties through natural fiber reinforcement, focusing on coconut coir and sugarcane bagasse fibers.

Nithin Sam et al. [7] studied the durability of coir fiber reinforced concrete, assessing properties like water absorption, acid resistance, and sulfate resistance.

Prof. P.A. Shirule et al. [8] investigated the partial replacement of cement with marble dust in M20 concrete mixes, evaluating its impact on mechanical properties. They observed that up to 10% replacement enhanced compressive and split tensile strengths, but higher replacements led to strength reduction

Shreeshail B.H. et al. [9] examined the effects of coconut fibers on concrete properties in M30 grade mixes, focusing on flexural, split tensile, and compressive strengths, as well as workability. Optimal results were achieved with 2% fiber content by weight of cement, showing significant strength improvements and potential for reducing cement content and CO_2 emissions.

These are the main goals, which are based on the literature research that was done: -

- It was observed that the work ability of concrete decreases with higher replacements of Marble powder and additions of Coir Fiber.

- Concrete containing 15% Marble dust as a cement replacement showed comparable or slightly lower compressive strength compared to the control mix.
- A significant increase in compressive strength was noted when Marble powder replaced 5% to 10% of the cement by weight.
- Adding 1% to 2% of Coir Fiber by weight of cement resulted in a significant increase in split tensile strength.
- Concrete enhanced with coir fibers demonstrates superior durability characteristics in comparison to plain concrete devoid of fiber reinforcement.

3. METHODOLOGY OF THE STUDY: -

Background Study: A comprehensive literature review was conducted to explore prior research relevant to the current study.

Material Procurement: All necessary materials including fine aggregate, coarse aggregate, rice husk ash, coconut fiber, and super plasticizer were procured and transported to the laboratory.

Material Testing: Tests were performed on the raw materials to assess their properties and suitability for the required mix design.

Mix Proportioning (Mix Design): Mix designs were formulated for concrete with a target slump value of 50-100mm, adhering to the method outlined in IS 10262-2009 for grades M25, M30, and M35.

Specimen Preparation: Concrete samples were prepared in the form of cubes, cylinders, and beams.

Specimen Testing: Various tests such as slump, compressive strength, split tensile strength, flexural strength, and durability were conducted on the prepared concrete specimens.

Data Collection: Data collection primarily focused on the outcomes of these tests conducted on the specimens. Data Analysis and Interpretation: The test results from the specimens were compared with the properties of control concrete, and findings were presented using tables, images, and graphs. Conclusions and recommendations wiredrawn based on the observations and findings.

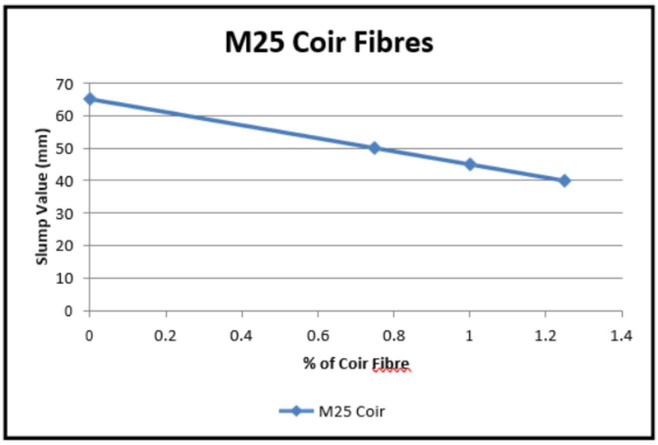
4.RESULTS & DISCUSSION: -

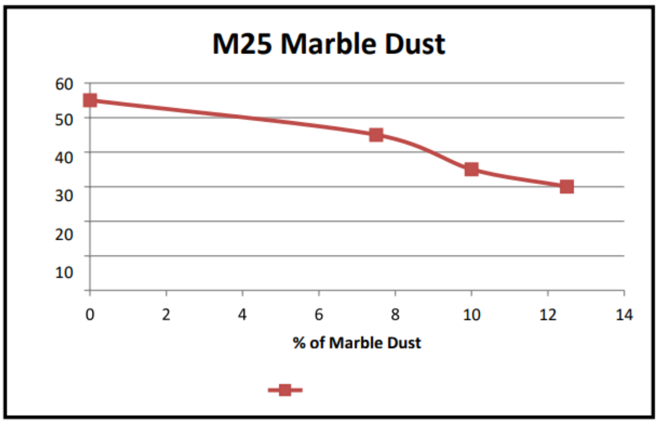
In this chapter, the results of experimental work have been presented in a graphical form. Discussions are carried out on the result obtained.

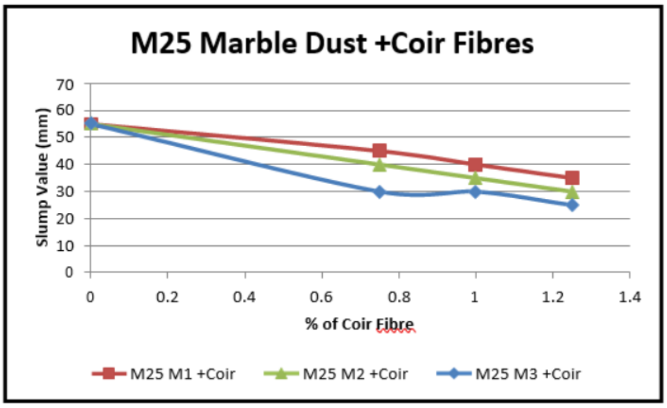
Slump Test Results: -

Slump test Results for M25& M30 grade of concrete: -

From the results replacement of Marble dust and addition of Coir fibres in concrete the slump was decrease. The percentage of replacement of Coir fibres was increases 0.75%,1.0%,1.25% their slump results shown in below graphs.







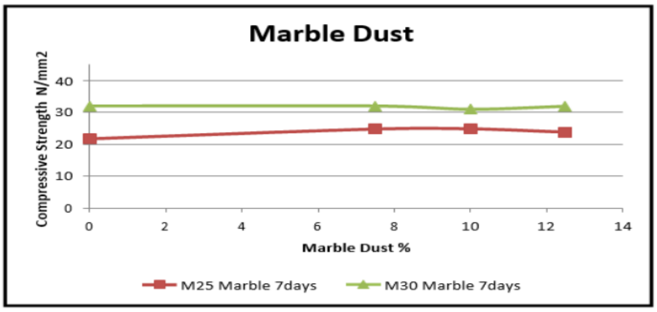
(Graph 1,2,3) Variation in slum value for Coir Fibres (M25) Variation in slum value for Marble Dust + Coir Fibres(M25)

Compressive strength result: -

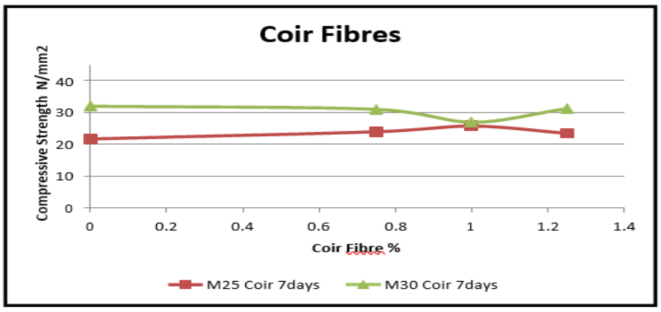
Compressive Strength results for M25 & M30 grade of concrete Bureau of Indian Standards suggests that the compressive strength of concrete be considered as the basis for determining all properties and studying response of concrete. As such more emphasis was given on this test. The compressive strength of concrete was evaluated at the age of 7 days, 28 days and 56 days for the proposition Marble Dust and Coir Fibres discussed earlier.

Table-6.1 Compressive Strength results for M25& M30

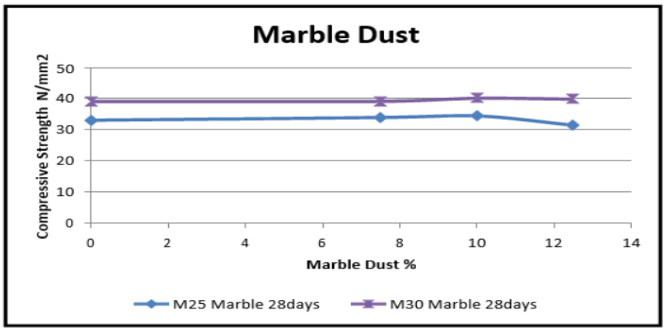
	M25			M30		
Variation	7 days	28 days	56 days	7 days	28 days	56 days
Plain	21.73	33.11	33.45	32	39.1	40.85
M1(7.5%)	24.79	33.98	34.43	32	39.15	40.19
M2(10%)	24.86	34.5	34.98	30.97	40.15	41.65
M3(12.5%)	23.83	31.5	32.45	31.91	39.85	40.32
C1(0.75%)	24	35.55	37.18	31	40.67	41.65
C2(1.0%)	25.8	37.47	38.9	26.92	43.19	44.56
C3(1.25%)	23.51	34.89	36.98	31.25	39.05	41.05
M1C1	28.54	38.49	39.12	32.23	45.1	46.15
M1C2	26.05	37.38	38.65	32.02	44.11	45.65
M1C3	26.84	36.5	37.12	33	44.22	46.12
M2C1	20.43	37.96	38.78	25.95	45.84	47.15
M2C2	27.85	35.19	37.56	29.33	47.17	48.16
M2C3	24.92	41.78	41.98	29.05	48.77	49
M3C1	28.15	37.59	38.15	31.01	44.41	45.86
M3C2	27.28	37.04	38.65	29.04	41.65	38
M3C3	27.37	35.48	36.78	32.45	39.76	40.12



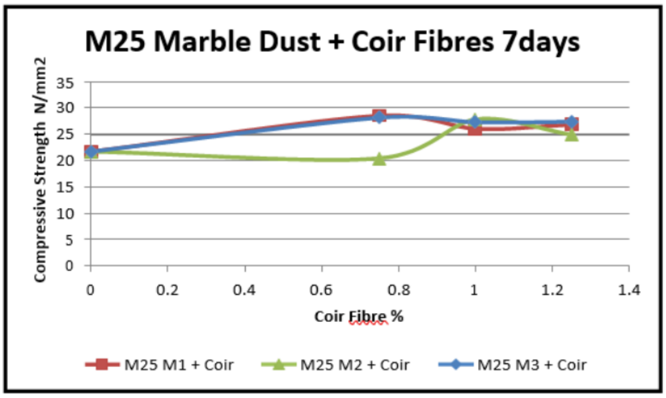
Graph 4 Variation in Compressive strength (7days) for Marble Dust



Graph 5 Variation in Compressive strength (7days) for Coir Fibres



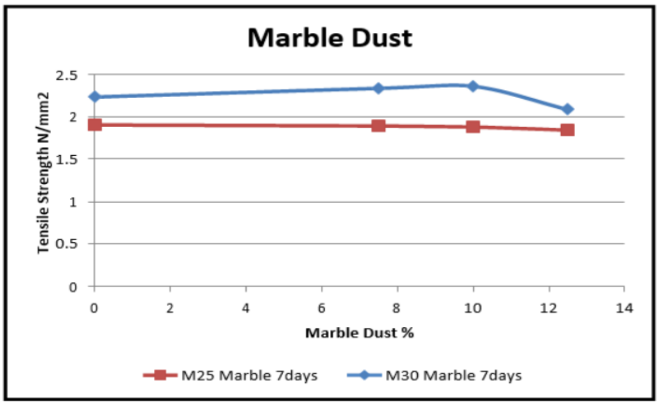
Graph 6 Variation in Compressive strength (28days) for Marble Dust



Graph-6.7 Variation in Compressive strength (7days) for Marble Dust + Coir Fibres(M25)

Split Tensile: -

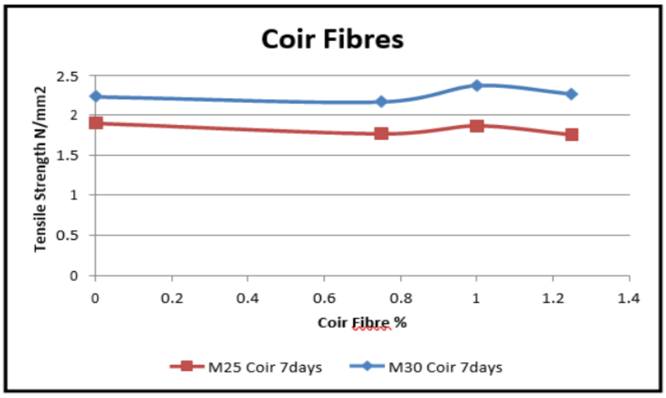
Strength Split Tensile Strength results for M25 & M30 grade of concrete Concrete cylinders were cast to determine split tensile strength. 7 days strength as well as 28 days split tensile strength of concrete was determined for both the grades and results of test shown below in tabular form.



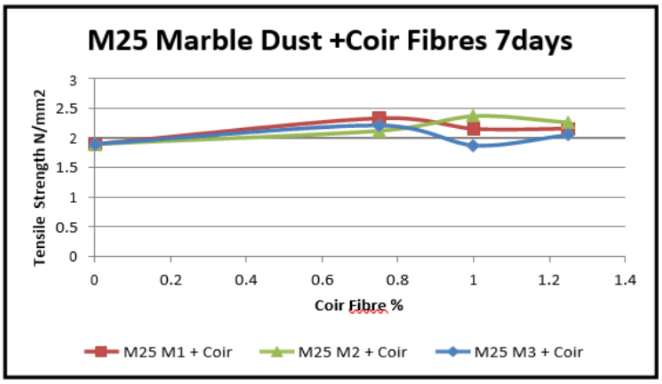
Graph-6.8 Variation in Split Tensile strength (7days) for Marble Dust

Table-6.2 Split Tensile Strength results for M25& M30

	M25		M30	
Variation	7 days	28 days	7 days	28 days
Plain	1.899904	2.19391	2.2293	2.58316
M1(7.5%)	1.88803	2.40623	2.33115	2.76152
M2(10%)	1.87544	2.61854	2.35548	2.66319
M3(12.5%)	1.84006	2.37084	2.08073	2.52925
C1(0.75%)	1.76929	2.33546	2.16565	2.62709
C2(1.0%)	1.86935	2.59194	2.37118	2.64502
C3(1.25%)	1.75757	2.54917	2.26469	2.52093
M1C1	2.33546	2.58316	2.35514	2.78633
M1C2	2.15853	2.37084	2.06699	2.7247
M1C3	2.15853	2.37084	2.30815	2.76008
M2C1	2.12314	2.40623	2.49362	2.61854
M2C2	2.37084	2.58316	2.17938	2.68064
M2C3	2.26469	2.51238	2.31999	2.57472
M3C1	2.21393	2.477	2.39029	2.77696
M3C2	1.87544	2.2293	2.33546	2.5391
M3C3	2.05237	2.12314	2.26469	2.46024



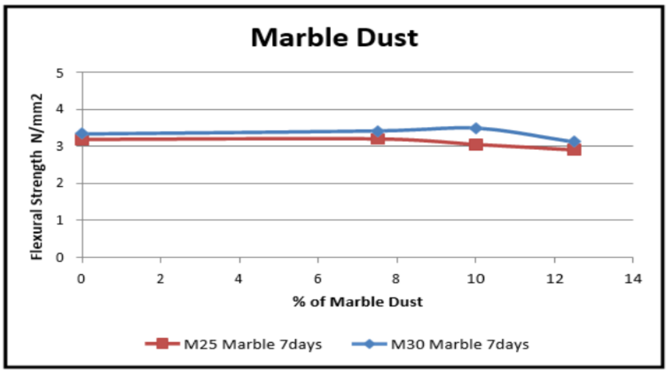
Graph-6.9 Variation in Split Tensile strength (7days) for Coir Fiber



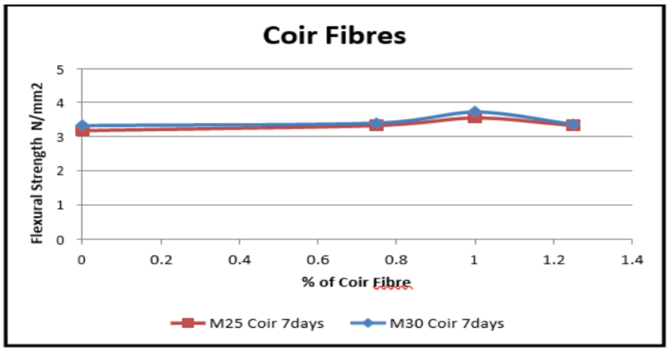
Graph-10 Variation in Split Tensile strength (7days) for Marble Dust + Coir Fibres(M25)

Modulus of Rupture: -

Flexural Strength results for M25 & M30 grade of concrete The Flexural strength of concrete was determined at the age of 7 days. Using the standard set procedure given by IS 516 it was found that all specimens failed between the loading points by developing flexural cracks near about the center of span.



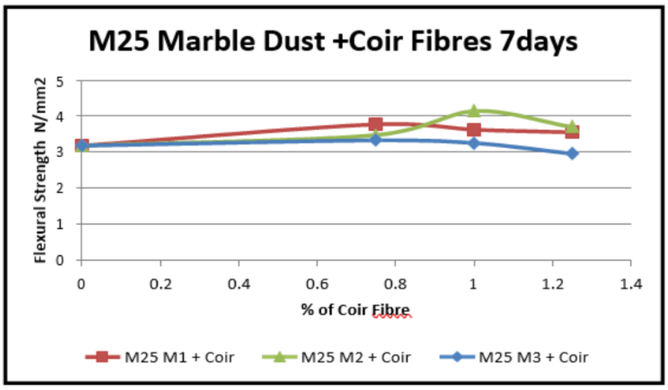
Graph -11 Variation in Flexural strength (7days) for Marble Dust



Graph-12 Variation in Flexural strength (7days) for Coir Fibre

Table-6.3 Flexural Strength results 7days for M25 & M30

7days		
Variation	M25	M30
Plain	3.185185	3.333333
M1(7.5%)	3.197682	3.416971
M2(10%)	3.04901	3.492546
M3(12.5%)	2.900339	3.119627
C1(0.75%)	3.333333	3.407407
C2(1.0%)	3.555556	3.62963
C3(1.25%)	3.333333	3.259259
M1C1	3.777778	3.777778
M1C2	3.62963	3.481481
M1C3	3.555556	3.62963
M2C1	3.481481	3.851852
M2C2	4.148148	3.555556
M2C3	3.703704	4.222222
M3C1	3.333333	4
M3C2	3.259259	3.62963
M3C3	2.962963	3.111111



Graph-13 Variation in Flexural strength (7days) for Marble Dust + Coir Fibres(M25)

Percentage of strength gain in Compressive Strength compare to56days strength on 7days and 28days :-

The compressive strength of concrete was evaluated at the age of 7 days, 28 days and56 days. To know what strength is gained by concrete of grade M25 and M30 as compared with its own 56 days crushing strength, the normalized crushing strength values were considered. These were obtained as the ratio of the crushing strength at required age to that at 56 days. The results obtained are tabulated below.

Table-6.4 Strength gain in compressive strength compare to 56days on 7 and 28days for M25 & M30

Variation	7days (M25)	7days (M30)	Average	28days (M25)	28days (M30)	Average	56days (M25)	56days (M30)
Plain	0.65	0.65	0.65	0.65	0.65	0.65	1.00	1.00
M1(7.5%)	0.72	0.72	0.72	0.72	0.72	0.72	1.00	1.00
M2(10%)	0.71	0.71	0.71	0.71	0.71	0.71	1.00	1.00
M3(12.5%)	0.73	0.73	0.73	0.73	0.73	0.73	1.00	1.00
C1(0.75%)	0.65	0.65	0.65	0.65	0.65	0.65	1.00	1.00
C2(1.0%)	0.66	0.66	0.66	0.66	0.66	0.66	1.00	1.00
C3(1.25%)	0.64	0.64	0.64	0.64	0.64	0.64	1.00	1.00
M1C1	0.73	0.73	0.73	0.73	0.73	0.73	1.00	1.00
M1C2	0.67	0.67	0.67	0.67	0.67	0.67	1.00	1.00
M1C3	0.72	0.72	0.72	0.72	0.72	0.72	1.00	1.00
M2C1	0.53	0.53	0.53	0.53	0.53	0.53	1.00	1.00
M2C2	0.74	0.74	0.74	0.74	0.74	0.74	1.00	1.00
M2C3	0.59	0.59	0.59	0.59	0.59	0.59	1.00	1.00
M3C1	0.74	0.74	0.74	0.74	0.74	0.74	1.00	1.00
M3C2	0.71	0.71	0.71	0.71	0.71	0.71	1.00	1.00
M3C3	0.74	0.74	0.74	0.74	0.74	0.74	1.00	1.00

Percentage of strength gain in Split Tensile Strength compare to 28days strength on 7days. :-

Table-6.5 Strength gain in compressive strength compare to 28days on 7 for M25 & M30:-

Variation	7days (M25)	7days (M30)	Average	28days (M25)	28days (M30)
Plain	0.65	0.65	0.65	0.65	0.65
M1(7.5%)	0.72	0.72	0.72	0.72	0.72
M2(10%)	0.71	0.71	0.71	0.71	0.71
M3(12.5%)	0.73	0.73	0.73	0.73	0.73
C1(0.75%)	0.65	0.65	0.65	0.65	0.65
C2(1.0%)	0.66	0.66	0.66	0.66	0.66
C3(1.25%)	0.64	0.64	0.64	0.64	0.64
M1C1	0.73	0.73	0.73	0.73	0.73
M1C2	0.67	0.67	0.67	0.67	0.67
M1C3	0.72	0.72	0.72	0.72	0.72
M2C1	0.53	0.53	0.53	0.53	0.53
M2C2	0.74	0.74	0.74	0.74	0.74
M2C3	0.59	0.59	0.59	0.59	0.59
M3C1	0.74	0.74	0.74	0.74	0.74
M3C2	0.71	0.71	0.71	0.71	0.71
M3C3	0.74	0.74	0.74	0.74	0.74

Durability of M25 & M30 grade of concrete: -

Lohani et al[4]had carried out durability tests using MgSO4, NaCl and HCl. For the purpose of this dissertation 5% NaCl solution was used. Cubes were immersed for28 days in the NaCl solution so prepared. The loss of weight and loss of strength were studied. Results obtained are as follows.

Table-6.6 Durability result for M25

Variation	Initial weight	Final weight of cube	% Loss of weight	56 days StrengthM25 When immersed in 5% NaCl solution	56 days strength M25 when immersed in potable water	% Reduction in strength
Plain	8464	8462	0.02	33.45	31.63	5.44
M1(7.5%)	8686	8681	0.05	33.85	31.96	5.58
M2(10%)	8619	8617	0.02	34.98	32.81	6.20
M3(12.5%)	8598	8594	0.05	32.45	30.43	6.22
C1(0.75%)	8564	8560	0.05	37.18	36.12	2.85
C2(1.0%)	8492	8491	0.01	38.9	36.88	5.19
C3(1.25%)	8375	8372	0.03	36.98	35.06	5.19
M1C1	8741	8738	0.03	39.12	37.26	4.75
M1C2	8608	8606	0.02	38.65	36.98	4.32
M1C3	8656	8654	0.02	37.12	35.63	4.01
M2C1	8772	8771	0.01	38.78	36.78	5.16
M2C2	8851	8850	0.01	37.56	36.02	4.10
M2C3	8736	8733	0.03	41.98	39.27	6.46
M3C1	8633	8832	0.01	38.15	36.52	4.27
M3C2	8653	8650	0.03	38.65	36.33	6.00
M3C3	8545	8541	0.04	36.78	34.68	5.71

5 CONCLUSIONS

Fresh properties results showed that with increase in amount of Marble Dust (MD)and Coir Fibre (CF) workability decreased for all grade of concrete.

For M25 grade,

- The compressive strength of concrete with 10% of MD replacement and 1.25% of CF addition with cement increase about 20% in comparison with normal concrete.
- The split tensile strength of concrete with 10% of MD replacement and 1% of CF addition with cement increase about 9.28% in comparison with normal concrete.

For M30 grade,

- The compressive strength of concrete with 10% of MD replacement and 1.25% of CF addition with cement increase about 12% in comparison with normal concrete.
- The split tensile strength of concrete with 10% of MD replacement and 0.75% of CF addition with cement increase about 10.6% in comparison with normal concrete.

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