Study of Strength of Concrete with doping of ceramic dust.

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ABSTRACT- Investigating the Influence of Ceramic Dust and Polypropylene Fiber on the Mechanical Properties of Concrete

This research focuses on the utilization of mineral admixtures such as ceramic dust, fly ash, and metakoline to produce high-performance concrete. The study examines the impact of ceramic dust percentage and polypropylene fiber on the mechanical properties of concrete. The aim is to understand the effects of substituting cement with ceramic dust, polypropylene fibers.

KEYWORDS- Ceramic Dust, Polypropylene Fibers, Concrete, Strength, Waste.

I. INTRODUCTION

The utilization of concrete and mortar as cost-effective, durable, and structurally strong building materials makes them highly desirable for construction . Their malleability in their fresh state allows for easy shaping according to specific requirements. However, the inherent weaknesses such as low tensile strength, susceptibility to moisture fluctuations, and vulnerability to failure necessitate the use of fiber reinforcement to overcome these limitations in a practical and affordable manner. Fiber reinforcement, especially with polypropylene fibers, significantly improves key qualities of these materials, including flexural strength, durability, fatigue resistance, impact permeability, and abrasion resistance. The ceramic industry faces challenges in waste disposal, with ceramic waste being irresponsibly dumped, leading to environmental pollution and land occupation issues. By incorporating ceramic waste into concrete, significant cost savings, energy efficiency, and reduced environmental impact can be achieved. Additionally, the development of new concrete technologies, such as using pozzolanic materials and nanotechnology, presents opportunities to reduce the reliance on natural resources and improve overall construction practices. By replacing cement with ceramic dust and polypropylene fibers, environmentally friendly building techniques can be realized, as demonstrated by the findings of this study.

The need for cost-effective methods to cope with the demands of expanding road networks in India is particularly crucial due to limited fiscal resources. Utilizing locally available soil as granular layers in pavement construction can significantly reduce construction costs. This approach involves the use of stabilizers, which offer an economical solution for pavement construction and maintenance. Addressing the issue of waste disposal generated by industries is another important aspect. By repurposing these waste materials for engineering purposes, the problems associated with disposal and environmental impact can be mitigated.

In a pavement section, bituminous layers are typically placed over a base and/or sub-base, which are compacted on a suitable subgrade. The soil subgrade plays a critical role in the pavement section, as inadequate bearing capacity can lead to rutting in the granular base and subbase layers, eventually resulting in fatigue cracking in the bituminous layers. Therefore, improving the properties and performance of the soil subgrade is essential for ensuring the longevity and stability of the pavement structure.

II. MATERIALS AND METHODS

In this study, OPC Grade 43 cement was selected as the type of cement used [22]. Fine aggregates were obtained from Standard Ennore sand, while crushed stone with a maximum graded aggregate size of 12.5mm was used. The concrete mixture adhered to the guidelines set by the Indian standard code IS 456-2000, which specifies the use of potable water for concrete production [23]. Sand classification was conducted following the standards outlined in IS 383 (1970). All materials were procured from local vendors, ensuring accessibility and availability. The concrete making and casting processes followed the procedures outlined in IS 516:1959, which was reaffirmed in 1999.

To ensure accuracy, the quantities of cement, coarse aggregates (20mm and 10mm size), fine aggregate, and water were individually weighed for each batch, with a precision of 0.1 kilogram. For testing the compressive strength, cube specimens measuring 150 millimeters in length were used, as specified by the Indian standard specifications BIS: 516-1959. The splitting tensile strength was measured on cylindrical specimens with a diameter of 150 millimeters and a length of 300 millimeters after 7, 28, and 90 days of ageing, following the recommendations of the Indian standard specifications BIS: 516-1959.

Table 1: Mix proportion for ceramic dust & polypropylene fiber per m3 concrete

Designation	Cement (kg)	Sand (kg)	Coarse Aggregate (kg)	Ceramic dust(%)	Ceramic dust(kg)	Polyproplene fiber(%)	Polyproplene fiber(kg)	Water (L)
CM0	300	735	1245	0	0	0	0	135
CM1	285	735	1245	5	15	0	0	135
CM2	270	735	1245	10	30	0	0	135
CM3	255	735	1245	15	45	0	0	135
CM4	240	735	1245	20	60	0	0	135
CM5	254.25	735	1245	15	45	0.25	0.75	135
CM6	253.5	735	1245	15	45	0.5	1.5	135
CM7	252.75	735	1245	15	45	0.75	2.25	135
CM8	252	735	1245	15	45	1	3	135

III. RESULT AND DISCUSSIONS

A. Workability

The addition of ceramic dust to the concrete mixture has a detrimental effect on its workability. The results of the slump cone test revealed that the workability of the control mix was 95 millimeters. However, as ceramic dust was gradually incorporated, the workability gradually decreased, reaching a minimum value of 75 millimeters when 20 percent ceramic dust was added. This reduction in workability can be attributed to the small particle size of the ceramic dust [14].

Furthermore, even a small percentage of polypropylene fibers exacerbates the decline in workability, with a workability value of only 51 millimeters when 1.0 percent of polypropylene fiber is added. This decrease in workability can be attributed to increased particle packing and enhanced intermolecular forces resulting from the presence of the fibers. As the fibers act as fillers and reinforcing materials, their inclusion ultimately leads to a loss in workability [24] (Figure 1).

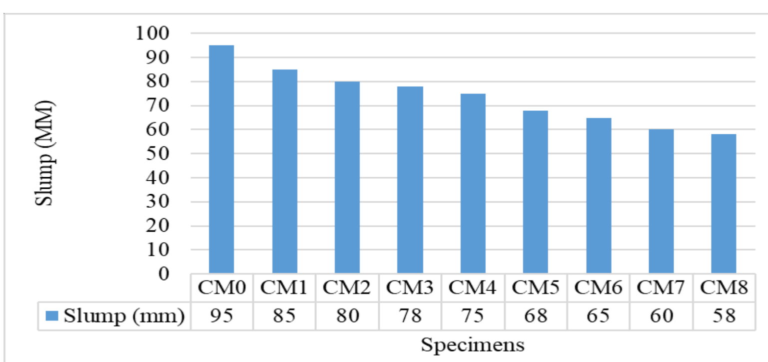
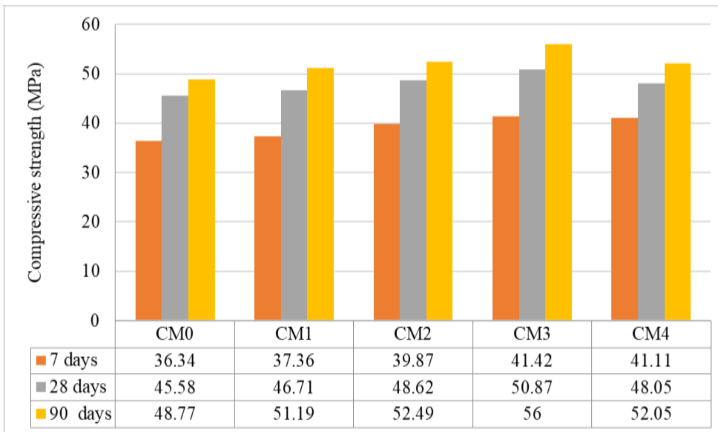


Figure 1: Variation of workability

B. Compressive Strength

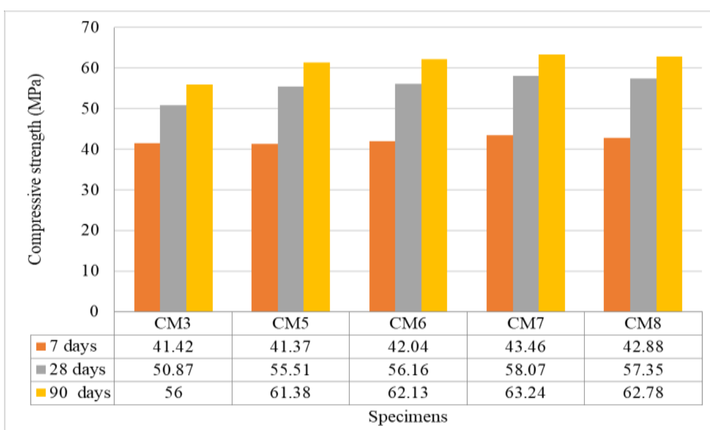
Using a compression testing machine and 150-millimeter cubes, the compressive strength of the concrete mix was determined after 7, 28, and 90 days. A comparison with the control mix, which had no additives, revealed that the compressive strength increased in all mixtures and curing periods. At 7 days, the addition of 5 percent, 10 percent, 15 percent, and 20 percent ceramic dust resulted in a percentage increase in compressive strength of 2.81 percent, 9.71 percent, 13.98 percent, and 13.13 percent, respectively. At 28 days, the percentage increases were 2.48 percent, 6.67 percent, 11.61 percent, and 5.42 percent, and at 90 days, they were 4.96 percent, 7.63 percent, 14.82 percent, and 6.73 percent, respectively.

The improvement in compressive strength in the concrete containing ceramic dust can be attributed to enhanced packing percentage and reduced voids. This led to an enhancement in the microstructure and improved binding between the aggregate and the paste. The addition of ceramic dust improved the link between the sand, aggregate, and the hydrated cement matrix, resulting in an increase in compressive strength (Figure 2).



	CM0	CM1	CM2	CM3	CM4
7 days	36.34	37.36	39.87	41.42	41.11
28 days	45.58	46.71	48.62	50.87	48.05
90 days	48.77	51.19	52.49	56	52.05

Figure 2: Variation of compressive strength with addition of ceramic dust



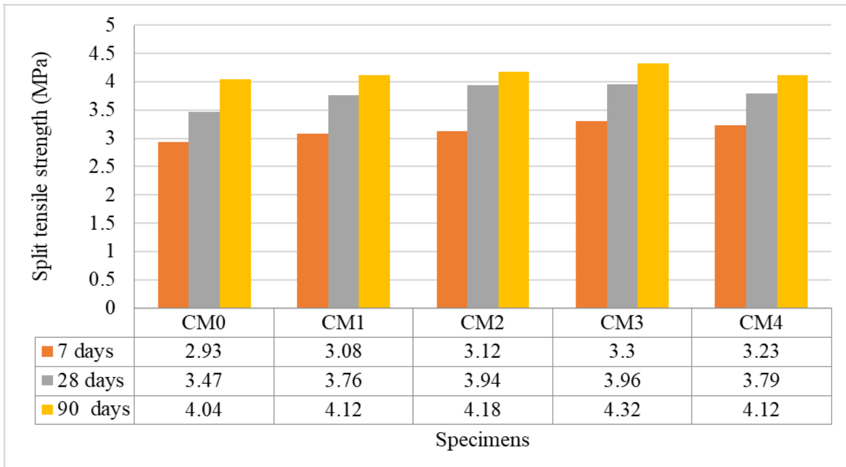
	CM3	CM5	CM6	CM7	CM8
7 days	41.42	41.37	42.04	43.46	42.88
28 days	50.87	55.51	56.16	58.07	57.35
90 days	56	61.38	62.13	63.24	62.78

Figure 3: Variation of compressive strength with addition of polypropylene fibers

The addition of polypropylene fibers to the concrete mix resulted in an increase in the material's compressive strength. The presence of polypropylene fibers acted as a reinforcing material, reducing the number of microcracks in the concrete . This reduction in microcracks contributed to a more compact concrete structure, leading to an improvement in compressive strength. The optimal combination of ceramic dust and polypropylene fibers in terms of their percentage content resulted in a significant increase in the compressive strength of the material. This increase indicates that the pozzolanic properties of ceramic dust and the crack-limiting effect of fibers can enhance the compressive strength of concrete to a greater extent than before (Figure 3).

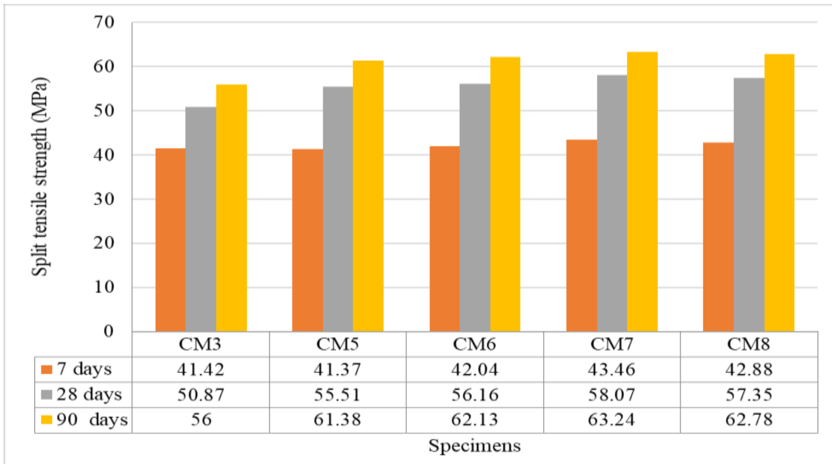
C. Split Tensile Strength

The split tensile strength of the concrete mix was determined using a compression testing machine with cylinders measuring 150 mm in diameter and 300 mm in height [27]. In comparison to the control mix without any additives, it was observed that the split tensile strength increased for all mixtures and curing durations. The study revealed that the addition of high percentages of ceramic dust did not significantly enhance the split tensile strength, and beyond a certain percentage (15%), a decline in the split tensile strength was observed [19]. Furthermore, the inclusion of polypropylene fibers resulted in an improvement in the split tensile strength of the material.



	CM0	CM1	CM2	CM3	CM4
7 days	2.93	3.08	3.12	3.3	3.23
28 days	3.47	3.76	3.94	3.96	3.79
90 days	4.04	4.12	4.18	4.32	4.12

Figure 4: Variation of compressive strength with addition of ceramic dust



	CM3	CM5	CM6	CM7	CM8
7 days	41.42	41.37	42.04	43.46	42.88
28 days	50.87	55.51	56.16	58.07	57.35
90 days	56	61.38	62.13	63.24	62.78

Figure 5: Variation of compressive strength with addition of polypropylene fibers

The inclusion of polypropylene fibers resulted in a percentage increase in split tensile strength of 10.92 percent, 17.06 percent, 21.16 percent, and 33.11 percent for the addition of 0.25 percent, 0.50 percent, 0.75 percent, and 1.0 percent fibers, respectively, after 7 days of curing. Similarly, after 28 days, the percentage increase was 14.41 percent, 20.17 percent, 26.80 percent, and 36.31 percent, and after 90 days, it was 2.97 percent, 4.21 percent, 12.87 percent, and 21.78 percent [28]. These findings highlight the positive impact of polypropylene fibers on enhancing the split tensile strength over different curing ages.

In contrast, the addition of ceramic dust to the concrete mix did not exhibit a pozzolanic behavior and instead resulted in a decrease in the split tensile strength of the composite material. On the other hand, the inclusion of polypropylene fibers contributed to a denser concrete matrix and exerted a filler effect, leading to improved particle distribution and an increase in the split tensile strength [29]. The optimal combination of ceramic dust and polypropylene fibers resulted in a significant enhancement of the split tensile strength in the composite material.

This improvement can be attributed to the enhanced dispersion of polypropylene fibers in the concrete specimens when ceramic dust is present, which ultimately contributes to the enhancement of the split tensile strength [30]. Overall, the combined effect of ceramic dust and polypropylene fibers in the concrete mix results in a notable increase in the split tensile strength, indicating the potential for enhanced performance of the concrete material.

IV. CONCLUSION

The objective of this study was to investigate the effects of substituting cement with ceramic dust, polypropylene fibers, or a combination of both in concrete. Based on the findings of this research, the following conclusions can be drawn:

The inclusion of ceramic dust, polypropylene fibers, or their combination reduces the workability of concrete. This is primarily due to the improved packing of ceramic dust particles and the enhanced intermolecular forces resulting from the dual role of the fibers as both fillers and reinforcing materials in the concrete.

The compressive strength and split tensile strength of the concrete mix increase over time, but the percentage increase in compressive strength varies depending on the duration of concrete curing.

The addition of ceramic dust up to 15 percent enhances both the compressive strength and split tensile strength of the concrete, after which both strengths start to decrease. Similarly, the inclusion of polypropylene fibers increases the compressive strength and split tensile strength up to 0.75 percent, beyond which there is a decline in both strengths.

It was observed that the split tensile strength of all concrete mixes with additives showed improvement compared to the control mix without additives. This improvement can be attributed to the enhanced dispersion of polypropylene fibers in the concrete specimens due to the addition of ceramic dust, leading to an increase in the split tensile strength.

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