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Strength Analysis of Ceramic Dust Based Concrete with Partial Replacement of Cement by Polypropylene Fiber

Ashish Chadel

Assistant Professor, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India

ABSTRACT- The utilisation of mineral admixtures such as ceramic dust, fly ash, and metakoline, amongst others, will result in the production of high-performance concrete. The effect that the percentage of ceramic dust and polypropylene fibre has on the mechanical properties of concrete has been investigated in this study. The purpose of this research was to investigate what happened when ceramic dust, polypropylene fibres, or a combination of the two were used to substitute cement in cement concrete. Ceramic dust content was varied as 5%, 10%, 15%, and 20% by weight replacement of cement, and polypropylene fibre was varied as 0.25%, 0.50%, 0.75%, and 1.0% by weight replacement of cement in order to investigate the effects of these two additives on the workability, compressive strength, and split tensile strength of concrete after 7, 28, and 90 days of curing time. The performance of the concrete in terms of its mechanical qualities was improved manyfolds with the addition of polypropylene fibres and ceramic dust; however, the results are astonishing when both types of additives are used together.

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

I. INTRODUCTION

The binder materials, in the form of concrete or mortar, are appealing for use as building materials due to their low cost, durability, and suitable compressive strength for structural application [1]. This makes them an ideal option for construction. In addition, when they are in their fresh form, they can be easily shaped into intricate shapes in accordance with the requirements [2]. The fact that it has a low tensile strength and impact, as well as the fact that it is susceptible to fluctuations in moisture, are the reasons for its failure [3]. The use of reinforcement by fibres can give a method that is practical, feasible, and reasonably priced for overcoming those inadequacies [4]. The use of fibres as reinforcement in concrete, mortar, and cement paste has the potential to alter a great deal of the qualities of these building materials [5]. In particular, the flexural strength, sturdiness, fatigue, impact permeability, and abrasion resistance can all be significantly improved [6]. For the most part, polypropylene fibres are used for the reinforcement of mortars, the control of shrinkage cracking, the improvement of impact resistance and the splitting of the finished parts in prefabricated elements, and in special concretes [7]. Polypropylene fibre is a composite product manufactured in vast quantities, and it can either consist of continuous fibres or discontinuous fibres of polypropylene that are embedded in a plastic matrix [8]. In particular, the use of polypropylene fibres in these applications is predominant. In this particular piece of research, the effect that the proportion of polypropylene fibre has on the mechanical qualities of concrete is investigated [9].

Even though certain areas have been notified and marked for dumping, the Ceramic Industries are still dumping the powder in any nearby pit or vacant space that is close to their unit [10]. Specifically after the powder has dried, this contributes to severe dust and environmental pollution in addition to the occupation of an enormous expanse of solid ground. After the powder has dried, it is necessary to dispose of the Ceramic waste as quickly as possible and use it in the construction industry [11]. The ceramic industry is under increasing pressure to find a solution to the problem of what to do with the growing amount of waste ceramic products produce every day. The use of the replacement materials results in a reduction in overall costs, as well as savings in terms of both energy and money, as well as a diminished impact on the natural environment [12]. Waste was incorporated into concrete and evaluated as a potential replacement.

Each year, hundreds of mounds of rubbish are disposed of in landfills, which results in the occupation of valuable land and the degradation of that property over time. Due to increased urbanisation and industrialization, which involves the development of bases and other comforts, emerging nations like India are prone to experiencing depletion of their natural resources, which is a regular issue [13]. One hundred million tonnes of ceramic are produced every year in India. Within the ceramics sector, complete production often results in the generation of between 15 and 30 percent waste material. Ceramic waste lasts a long time, is heavy, and is very resistant to the biological, chemical, and physical factors that might cause degradation. Despite the fact that notified sites have been identified for dumping, the Ceramic Industries are nevertheless dumping the powder in any neighbouring pit or vacant spot that is close to their unit [14]. Specifically after the powder has dried, this contributes to severe dust and environmental pollution in addition to the occupation of an enormous expanse of solid ground. After the powder has dried, it is necessary to dispose of the Ceramic waste as quickly as possible and use it in the construction industry. The ceramic industry is under increasing pressure to find a solution to the problem of what to do with the growing amount of trash ceramic products produce every day [15]. The development of new concrete technologies has the potential to cut down on the utilisation of natural resources. They have compelled us to concentrate on recovery, the recycling of natural resources, and the discovery of other options. The usage of the replacement materials results in a decrease in overall costs, as well as savings in terms of both energy and money, as well as a diminished impact on the natural environment [16].

esearchers from all over the world have tried a variety of approaches in order to solve the problem described above [17]. These include pozzolanic reactions of calcium hydroxide, which involve the utilisation of cementitious materials in order to obtain extra calcium silicate hydrate materials, and void filling with cementitious materials. In order to make use of the calcium hydroxide and generate more calcium silicate hydrate, the supplemental cementitious materials have been considered for use in the cement matrix in a more general capacity as pozzolanic materials [18]. In the cement matrix, partially replacing cement with supplementary cementitious materials will not only improve the mechanical properties of the cement, but it will also result in an increase in the workability of the cement, as well as a change in the amount of time it takes for the cement to become solid. At this juncture, industry experts are profiting from nanotechnology in order to improve a new generation of cement materials that overcome the aforementioned drawbacks and work toward achieving reasonable solid constructions [19]. The more modern materials can be generated by intermixing of the elements that already exist on the component level [20]. Pozzolanic materials have been used individually to replace cement by a number of researchers; however, the study on the combination of two pozzolanic materials has not been found to be very prevalent [21].

The current investigation was built on the foundation of two primary research approaches: first, a review of the relevant prior research; and second, an investigation into the impact of replacing cement with ceramic dust and polypropylene fibre. According to the findings of the study, environmentally friendly building techniques can be achieved by removing cement from the mix and replacing it with ceramic dust and polypropylene fibres.

II. MATERIALS AND METHODS

OPC Grade 43 cement is the type of cement utilized in this study [22]. Standard Ennore sand was used as fine aggregates. Crushed stone with maximum 12.5mm graded aggregates (nominal size) were used. According to the Indian standard code, IS 456-2000, the use of potable water in concrete is typically deemed to be satisfactory [23]. The classification of sand was carried out in accordance with IS: 383. (1970). Al materials were procured from the local vendor. Making and casting were both done in accordance with IS 516: 19595, which was reaffirmed in 1999, hence the technique in its entirety was used. To an accuracy of 0.1 kilogramme, the quantities of cement, coarse aggregate (20mm and 10mm size), fine aggregate, and water were weighed individually for each batch. For the compressive strength test, cube specimens with a length of 150 millimetres were employed, as required by the Indian standard specifications BIS: 516-1959. In accordance with the Indian recommended specifications BIS: 516-1959, the splitting tensile strength was measured on cylinders measuring 150 millimetres in diameter and 300 millimetres in length after 7, 28, and 90 days of ageing.

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*

By adding ceramic dust to the concrete, the workability of the concrete will be reduced. According to
the results of the slump cone test, the workability of the control mix was 95 millimetres, but this value drops gradually when ceramic dust is added and reaches a low of 75 millimetres when 20 percent ceramic dust is added. The small size of the ceramic dust particles was the cause of the decline in workability [14]. When even a tiny number of polypropylene fibres are added, the workability of the material declines even further, and it falls to 51

millimetres when only 1.0 percent of polypropylene fibre is added. This drop in workability was caused by greater packing and better intermolecular forces. Since the fibres operate as a filler and reinforcing material, which ultimately leads to a loss in workability, this was the cause for the observation [24] (figure 1).

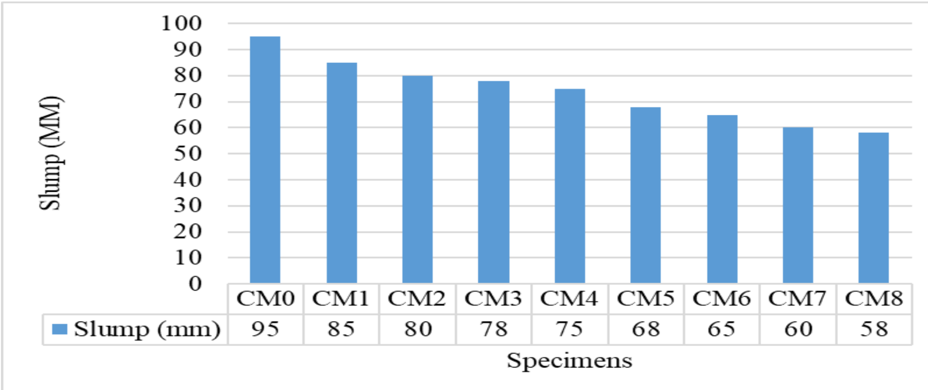


Figure 1: Variation of workability

B. Compressive Strength

With the assistance of a compression testing machine and a 150-millimeter cube, we were able to determine the compressive strength of the concrete mix after 7, 28, and 90 days. When compared to the control mix, which did not contain any additives, it was discovered that the compressive strength increased throughout all mixtures and days. It was discovered that the percentage increase in compressive strength with the addition of 5 percent, 10 percent, 15 percent, and 20 percent ceramic dust was 2.81 percent, 9.71 percent, 13.98 percent, and 13.13 percent at 7 days, 2.48 percent, 6.67 percent, 11.61 percent, and 5.42 percent at 28 days, and 4.96 percent, 7.63 percent, 14.82 percent, and 6.73 percent at 90 days of curing ages, respectively. In concrete containing ceramic dust, an improvement in the packing percentage and a reduction in the number of voids were responsible for the increase in compressive strength [25]. The primary reasons for the increase in compressive strength were the enhancement of the microstructure and the improvement in the binding between the aggregate and the paste. The increase in compressive strength that came about as a result of adding ceramic dust to the concrete mix was due to an enhancement in the link that existed between the sand, aggregate in the mix, and the hydrated cement matrix [26] (figure 2).

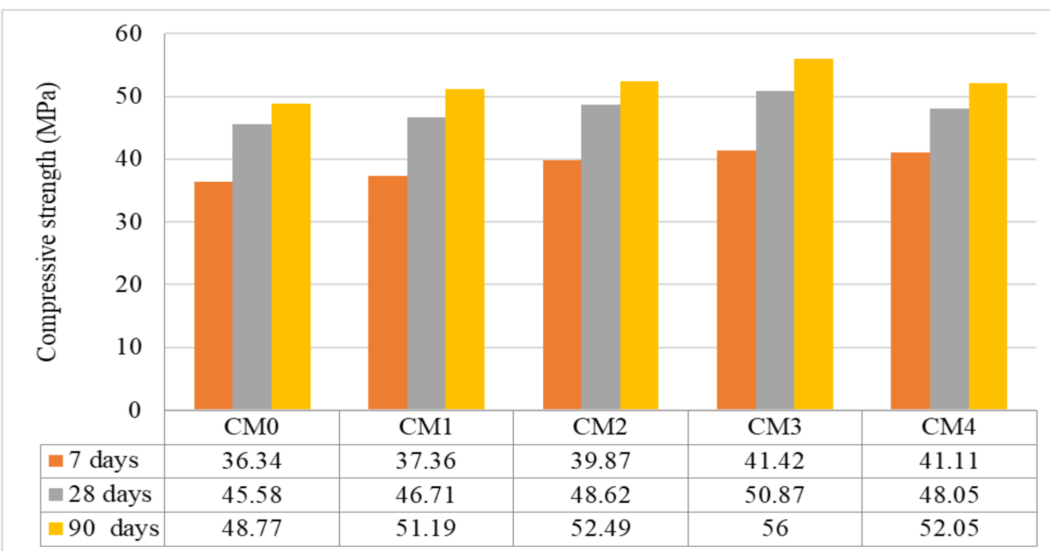


Figure 2: Variation of compressive strength with addition of ceramic dust

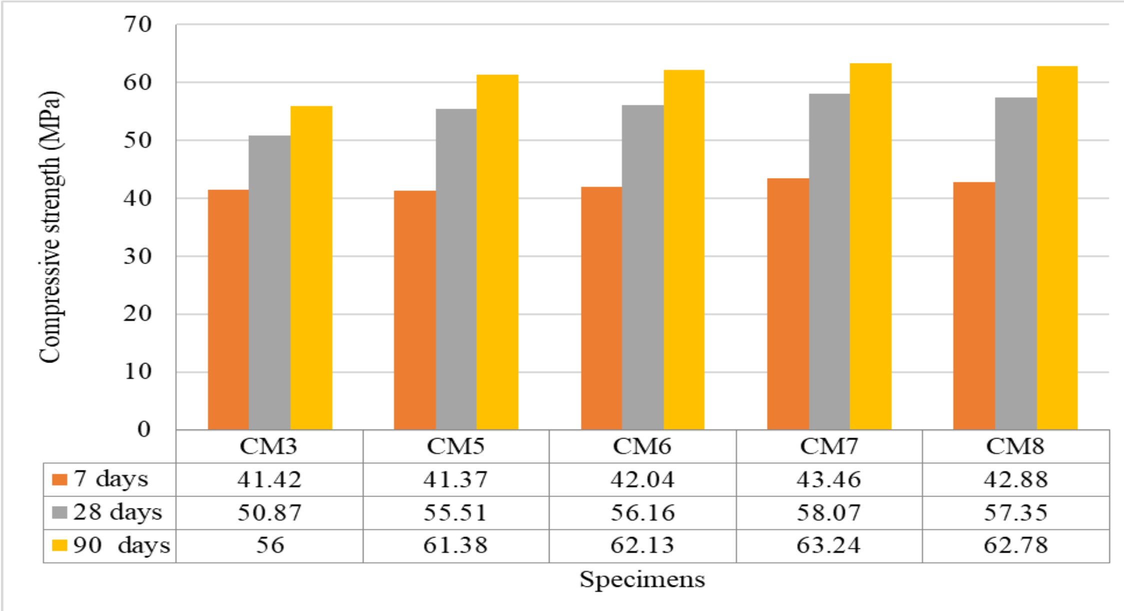


Figure 3: Variation of compressive strength with addition of polypropylene fibers

With the addition of polypropylene fibres, we also saw an increase in the material's compressive strength. Because polypropylene fibres act as a reinforcing material, the increase in their number led to a reduction in the number of microcracks that were present in the concrete [8]. This, in turn, led to an increase in the compactness of the concrete, which in turn led to an increase in the compressive strength. The optimal amount of ceramic dust and polypropylene fibres to add to concrete (the amount in percent age at which maximum compressive strength is achieved) resulted in a significant increase in the material's compressive strength. The rise suggests that the pozzolanic capabilities of ceramic dust and also the crack limitation impact of fibre can boost the compressive strength of concrete at a much greater rate than before [9] (Figure 3).

C. Split Tensile Strength

Using a compression testing machine with cylinders that were 150 mm in diameter and 300 mm in height, we determined the split strength of the concrete mix after 7, 28, and 90 days [27]. When compared to the control mix that did not contain any additives, it was discovered that the split tensile strength increased across all mixtures on all days. Studies unequivocally demonstrated that adding very high percentages of ceramic dust did not considerably boost the splitting tensile strength, and that above a percentage of 15 percent, a drop in the splitting tensile strength was seen [19]. It was found that the inclusion of polypropylene fibres led to an increase in the split tensile strength of the material.

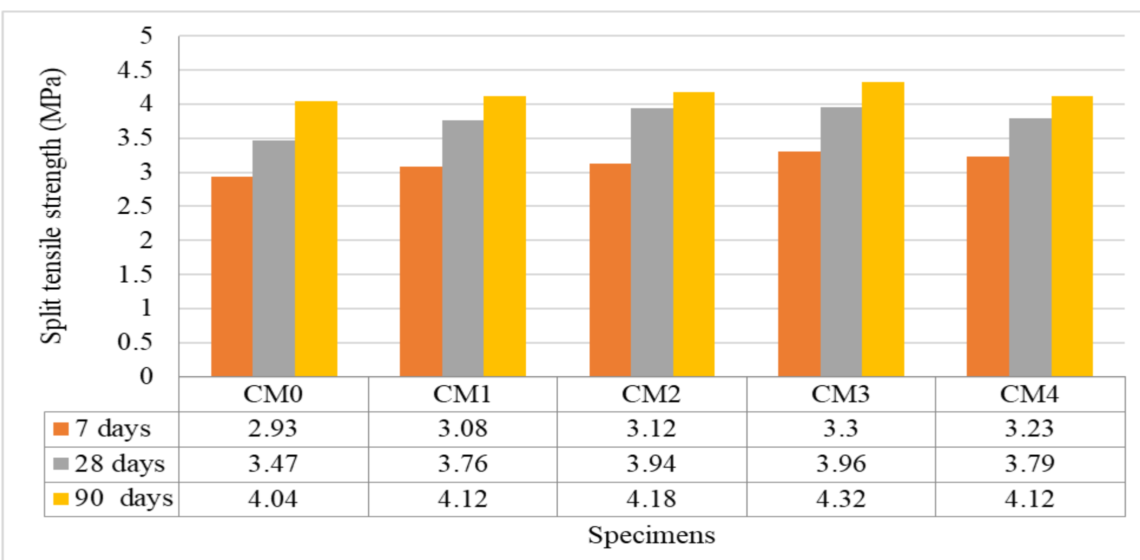
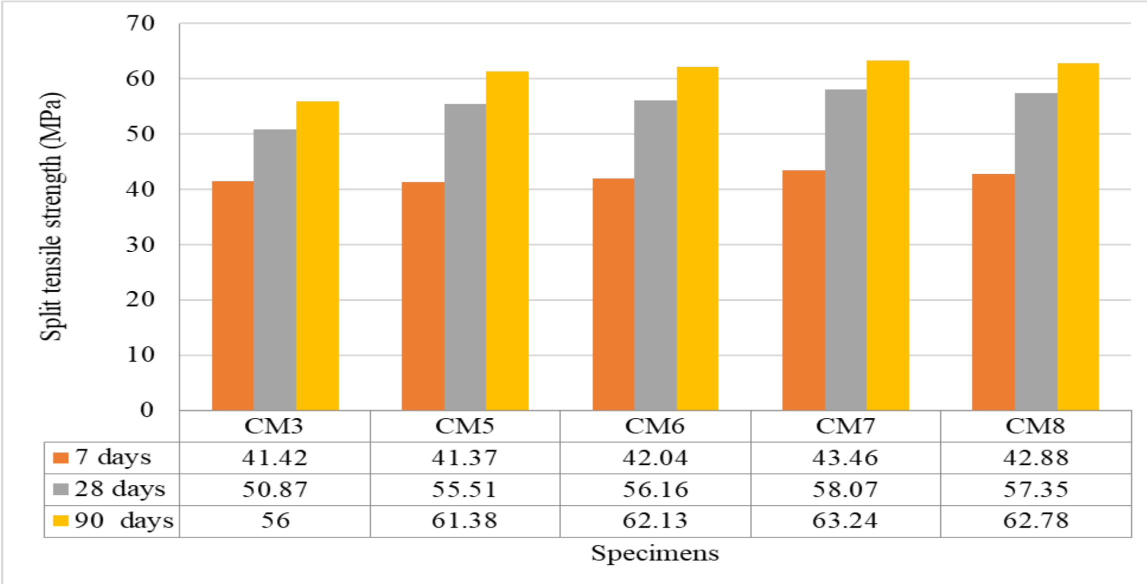


Figure 4: Variation of compressive strength with addition of ceramic dust



	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 53: Variation of compressive strength with addition of polypropylene fibers

The percentage increase in split tensile strength was found to be 10.92 percent, 17.06 percent, 21.16 percent, and 33.11 percent after the addition of 0.25 percent, 0.50 percent, 0.75 percent, and 1.0 percent polypropylene fibres after 7 days, 14.41 percent, 20.17 percent, 26.80 percent, and 36.31 percent after 28 days, and 2.97 percent, 4.21 percent, 12.87 percent, and 21.78 percent after 90 days of curing ages. These results were found at 7, 28, and 90 days of curing ages, respectively. This was the outcome of a superior filler effect brought about by the addition of polypropylene fibres, which led to a better distribution of particles throughout the material [28]. The addition of ceramic dust to the concrete mix does not cause it to behave in a pozzolanic manner, which leads to a decrease in the split tensile strength of the finished product. The polypropylene fibres cause the concrete to become denser, and their filler effect and reinforcing qualities contribute to an increase in the split tensile strength of the concrete [29]. The combination of ceramic dust with polypropylene fibres at the optimal content results in a significant increase in the split tensile strength of the composite material. This could be because the addition of ceramic dust enhances the dispersion of the polypropylene fibres in the concrete specimens, leading to an improvement in the split tensile strength of the concrete [7].

IV. CONCLUSION

The purpose of this research was to investigate what happened when ceramic dust, polypropylene fibres, or a combination of the two were used to substitute cement in cement concreteThe following deductions are tenable in light of the findings of this investigation:

- The addition of ceramic dust and polypropylene fibre, as well as their combination, reduces the workability of concrete. This is due to the better packing of ceramic dust and the improved intermolecular forces that result from the fibres' dual role as a filler and a material for reinforcing the concrete.
- The compressive strength and split tensile strength of concrete mix both grow with age, but the percentage age increase in compressive strength varies depending on how long the concrete has been allowed to cure.
- The compressive strength and split tensile strength both increase with the addition of ceramic dust up to 15 percent, after which they both decrease. Similarly, the polypropylene fibre addition results in an increase in compressive strength and split tensile strength up to 0.75 percent, after which they both decrease.
- It was discovered that the split tensile strength increased for all mixes with additives at all days in comparison to the control mix which did not contain any additives. This was attributed to the fact that adding ceramic dust improves the dispersion of the polypropylene fibres in the concrete specimens, which in turn results in an increase in the split tensile strength.

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