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OPTIMIZING CONCRETE PERFORMANCE WITH MARBLE POWDER AS A SUPPLEMENTARY CEMENTITIOUS MATERIAL

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ABSTRACT

This study explores the potential use of waste marble powder (WMP) as a partial replacement for cement in concrete to improve performance and sustainability. Marble industries generate large quantities of powder during cutting and polishing, creating disposal challenges and environmental concerns. Experimental investigations were conducted using M30 grade concrete with marble powder replacing cement by 5%, 10%, 15%, and 20% by weight. Compressive and split tensile strength tests were performed at different curing periods. Results revealed an increase in workability and strength up to 10% replacement, beyond which a decline occurred. The study concludes that marble powder can be used effectively as a supplementary cementitious material to produce sustainable and eco-friendly concrete.

Keywords: Marble Powder, Sustainable Concrete, Supplementary Cementitious Material, Compressive Strength, Tensile Strength, Eco-Friendly Construction.

1. INTRODUCTION

Concrete remains one of the most widely used construction materials due to its versatility, strength, and durability. However, cement production—an essential component of concrete—is a major contributor to global CO_2 emissions, accounting for nearly 8% of total emissions. To mitigate environmental impacts, researchers have focused on replacing cement with industrial by-products and waste materials such as fly ash, GGBS, silica fume, and marble powder. Marble processing generates significant waste, with approximately 25% of the original block lost as dust or slurry. This waste can be utilized in concrete as a cement replacement to enhance performance while reducing environmental pollution.

2. LITERATURE REVIEW

BabooRai et al. (2011) investigated the influence of marble powder and granules in concrete and found that up to 10% replacement improves workability and compressive strength.

Vaidevi (2013) studied the partial replacement of cement with marble dust and observed that 10% replacement provided the best strength results with cost savings.

Soundhararajan et al. (2013) demonstrated that up to 10% marble powder replacement enhances mechanical properties such as compressive and tensile strength.

Manju Pawar et al. (2014) reported similar findings, emphasizing that 12.5% replacement yields optimal results. These studies collectively suggest that marble powder is an effective supplementary material for sustainable concrete production.

3. METHODOLOGY

M30 grade concrete was designed as per IS 10262:2009 and IS 456:2000 guidelines. Cement was partially replaced with marble powder by 5%, 10%, 15%, and 20% by weight. The mix proportions were prepared, and tests were conducted to determine the compressive and split tensile strength after 7 and 28 days of curing. Standard tests were also performed to determine the fineness, consistency, and setting time of cement and aggregates to ensure material suitability.

Table 1. Compressive Strength Results

Marble Powder (%)	7 Days (MPa)	28 Days (MPa)
0.0	28.5	38.5
5.0	30.2	40.0
10.0	32.5	42.2
15.0	31.8	41.0
20.0	29.5	39.0

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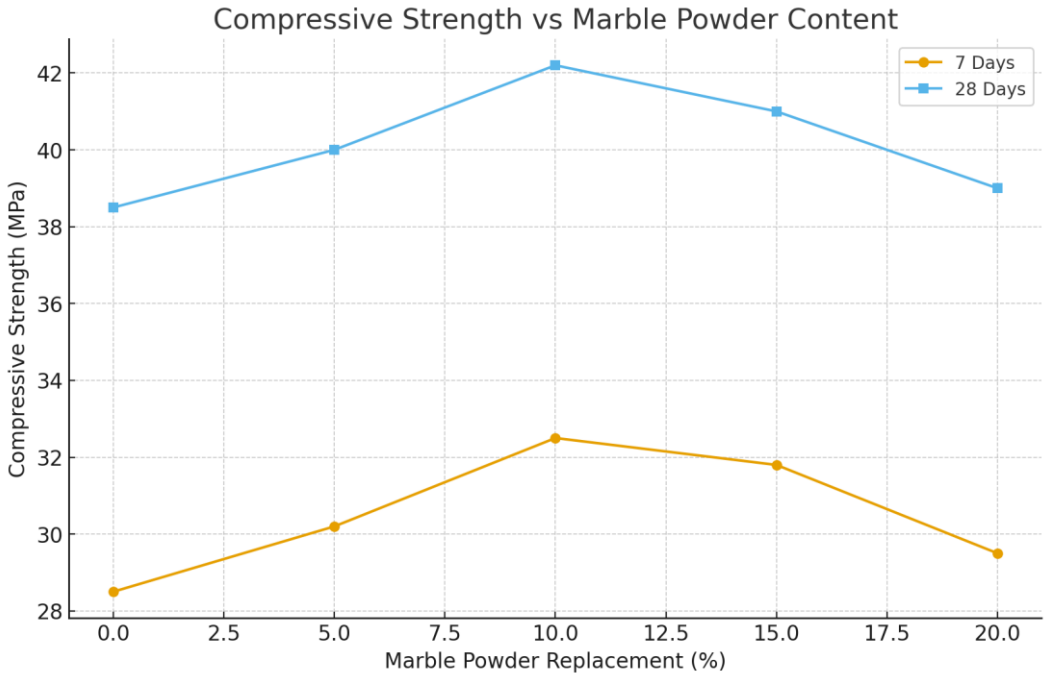

Figure 1: Variation of Compressive Strength with Marble Powder Percentage.

Table 2. Split Tensile Strength Results

Marble Powder (%)	7 Days (MPa)	28 Days (MPa)
0.0	2.5	3.1
5.0	2.7	3.3
10.0	2.9	3.5
15.0	2.8	3.4
20.0	2.6	3.2

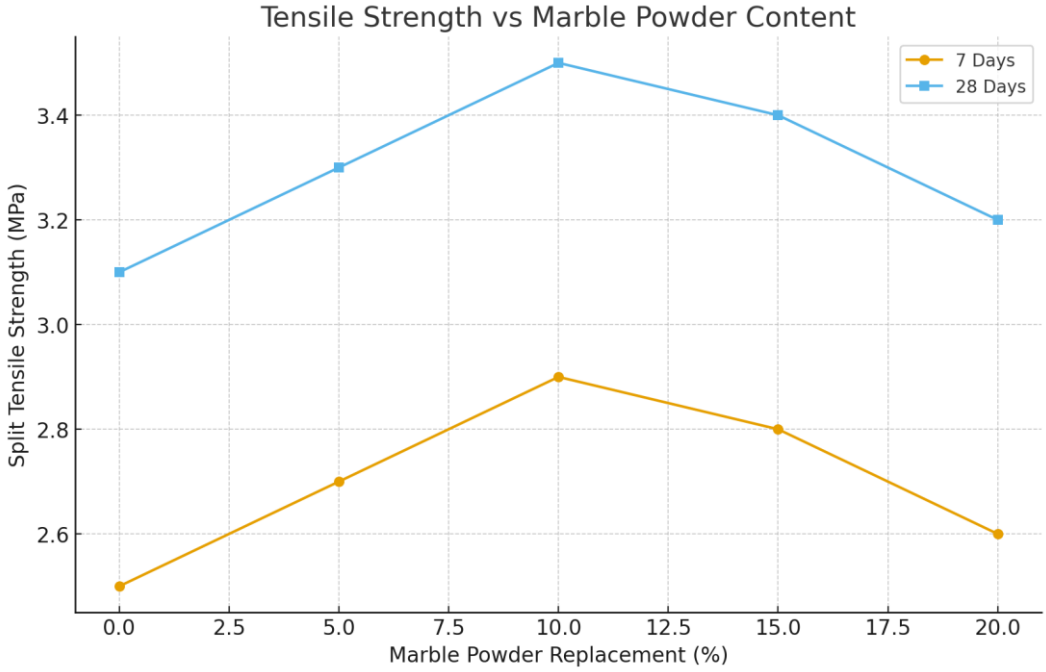

Figure 2: Variation of Split Tensile Strength with Marble Powder Percentage.

4. RESULTS AND DISCUSSION

The results indicate that the inclusion of marble powder improves both compressive and tensile strength of concrete up to an optimum level of 10% replacement. At this level, the fine particles of marble powder fill voids within the

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concrete matrix, enhancing compaction and bond strength. Beyond 10%, excess powder causes dilution of cementitious material, reducing the overall strength. The split tensile strength follows a similar trend, confirming improved bonding and microstructure due to marble powder's filler effect.

5. CONCLUSION

This research confirms that marble powder can be used as a partial replacement for cement up to 10% without adversely affecting strength properties. The use of marble powder reduces environmental pollution, decreases cement consumption, and promotes sustainable construction. Future studies may explore long-term durability aspects such as permeability, shrinkage, and microstructural analysis to further validate its application in various grades of concrete.

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