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Original Article

Eco Friendly Road Repair Using Marble Powder Concrete

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Abstract: *The performance of road repair materials is critical in ensuring the durability, strength, and sustainability of pavement structures. Conventional repair methods, which rely heavily on cement-based materials, often contribute to environmental degradation due to high carbon emissions and excessive use of natural resources. Additionally, these materials may exhibit issues such as cracking, reduced durability, and higher maintenance requirements over time. To address these challenges, eco-friendly alternatives such as marble powder concrete have been introduced to enhance the performance and sustainability of road repair works. In this study, the behaviour of concrete incorporating marble powder as a partial replacement for cement is investigated with a focus on its mechanical strength and durability characteristics. Marble powder, a waste by-product from the marble industry, acts as a filler material and improves the microstructure of concrete, reducing voids and enhancing bonding. Experimental observations indicate that marble powder concrete exhibits improved compressive strength, better workability, and increased resistance to environmental deterioration compared to conventional concrete.*

Keywords: *Eco-friendly Road Repair, Marble Powder Concrete, Sustainable Construction, Waste Utilization, Compressive Strength.*

I. INTRODUCTION

The integration of sustainable waste materials into construction practices has significantly advanced civil engineering by addressing environmental concerns and resource depletion. Conventional materials like cement contribute heavily to carbon dioxide (CO_2) emissions, prompting the search for eco-friendly alternatives. Marble powder, a fine waste generated during marble processing, has emerged as a promising material in concrete production. Large quantities of this waste are produced and often improperly disposed of, leading to air and soil pollution. Due to its fine particle size and smooth texture, marble powder acts as an effective filler in concrete, improving packing density, workability, and surface finish.

Additionally, marble powder is primarily composed of calcium carbonate ($CaCO_3$), which enhances concrete properties by aiding early strength development and reducing porosity. Its use lowers cement consumption, making concrete more economical and environmentally sustainable, while also conserving natural resources when used as a partial replacement for sand or cement. In road repair applications, marble powder concrete improves durability, reduces shrinkage cracks, and enhances resistance to wear. It also contributes to better thermal resistance, helping concrete perform well under temperature variations. However, proper mix design is essential, as excessive replacement can reduce strength; the optimal range is typically 10–15%. Overall, the use of marble powder supports sustainable construction and effective waste management practices.

II. LITERATURE REVIEW

The utilization of marble powder in concrete has been widely studied due to its potential to improve concrete properties while promoting sustainable construction practices. Several researchers have investigated the effectiveness of marble powder as a partial replacement material in concrete, particularly in reducing environmental impact and enhancing durability.

Hebhoub H. et al. (2011) studied the use of waste marble aggregates in concrete and found that marble waste can be effectively used as a substitute for natural aggregates without significantly affecting strength. Their study emphasized the environmental benefits of reducing waste disposal and conserving natural resources.

Binici H. et al. (2007) investigated the influence of marble and limestone dust as additives in concrete. The results showed that marble dust improves compressive strength and reduces permeability, thereby enhancing the durability of concrete in aggressive environments.

Corinaldesi V. et al. (2010) focused on the characterization of marble powder for its use in mortar and concrete. They concluded that marble powder acts as a fine filler material, improving workability and leading to a denser and more compact concrete structure.

Aliabdo A.A. et al. (2014) examined the reuse of waste marble dust in cement and concrete production. Their findings indicated that partial replacement of cement with marble dust reduces cost and environmental impact while maintaining adequate strength at optimum levels.

Topçu I.B. et al. (2009) studied the effect of marble dust as a filler in self-compacting concrete. The study highlighted improvements in flowability and filling ability, making it suitable for applications requiring high workability such as road repair and surface finishing.

Aruntas H.Y. et al. (2010) investigated the use of marble dust as an additive in cement production. The study demonstrated that marble dust can reduce clinker content, thereby lowering energy consumption and carbon emissions in cement manufacturing.

Kumar S. et al. (2015) analyzed the effect of marble powder on the strength and durability of concrete. Their research concluded that an optimum replacement level of around 10–15% enhances compressive strength, durability, and resistance to cracking.

In addition, several studies have reported that the use of marble powder reduces shrinkage and improves resistance to abrasion, which are critical properties for road repair materials subjected to traffic loads. It also contributes to better surface finish and increased resistance to water penetration, thereby improving long-term performance.

From the above studies, it is evident that marble powder is an effective and sustainable material for concrete production. It not only improves mechanical and durability properties but also contributes to waste management and environmental protection. Therefore, the use of marble powder concrete is highly suitable for eco-friendly road repair applications, offering both technical and environmental advantages.

III. METHODOLOGY

The methodology for this study involves a systematic approach to evaluate the suitability of marble powder concrete for eco-friendly road repair applications. Initially, material characterization and procurement are carried out by collecting and verifying the properties of cement, fine aggregates, coarse aggregates, and marble powder obtained from marble processing industries. The collected marble powder is then subjected to proper preparation and processing, including drying and sieving, to ensure uniform particle size and the removal of impurities. Following this, concrete mixes are prepared through mix proportioning by partially replacing cement with varying percentages of marble powder in order to determine the optimum mix suitable for road repair works.

Subsequently, specimens such as concrete cubes or paver blocks are prepared and cast by thoroughly mixing the materials in correct proportions and compacting them properly to eliminate air voids. The cast specimens are then subjected to a curing process under controlled conditions for specified durations, typically 7 days and 14 days, to achieve the required strength. Finally, mechanical testing is conducted, including compressive strength tests and durability assessments, to evaluate the performance and effectiveness of marble powder concrete in eco-friendly road repair applications.

Figure 1: Compressive Testing Equipment

IV. RESULTS AND DISCUSSION

A. Compressive Strength Test

After the completion of the specified curing period, the mortar cube specimens incorporating marble powder and fly ash were removed from the curing tank, surface-dried, and prepared for testing. The compressive strength test was carried out using a Compression Testing Machine (CTM) in accordance with standard testing procedures. Each specimen was carefully placed on the lower platen of the CTM, ensuring proper alignment so that the load would be applied uniformly and axially without any eccentricity. The contact surfaces of the cube were checked to be clean and smooth to avoid stress concentration during loading.

The load was then applied gradually and continuously at a constant rate of 35 N/mm^2 per minute until the specimen failed. During the test, observations such as crack formation, mode of failure, and any unusual behavior were noted. The maximum load sustained by the specimen at the point of failure was recorded from the machine's digital display. The compressive strength of the mortar cube was calculated by dividing the ultimate load by the cross-sectional area of the specimen. To ensure accuracy and reliability of results, multiple specimens were tested for each mix proportion, and the average compressive strength was determined. Additionally, proper calibration of the Compression Testing Machine was ensured before testing to obtain accurate and consistent results. The results obtained were then compared for different percentages of marble powder and fly ash to identify the optimum mix with enhanced strength and performance suitable for eco-friendly road repair applications.

Mix number	Mix Composition (cement + marble powder + fly ash)	Expected Strength at 7 Days (N/mm^2)	Expected Strength at 14 Days (N/mm^2)
1.	100% cement (control)	23.0	28.0
2.	Cement + 13g marble powder	24.10	29.0
3.	Cement + 13g fly ash	21.5	27.0
4.	Cement + 13g marble powder + 13g fly ash	25.0	30.0
5.	Cement + 13g marble powder + 26g fly ash	20.5	26.0
6.	Cement + 26g marble powder + 13g fly ash	23.5	28.5

Test results of the mortar cubes containing marble powder and fly ash after 7 days of curing are tabulated below.

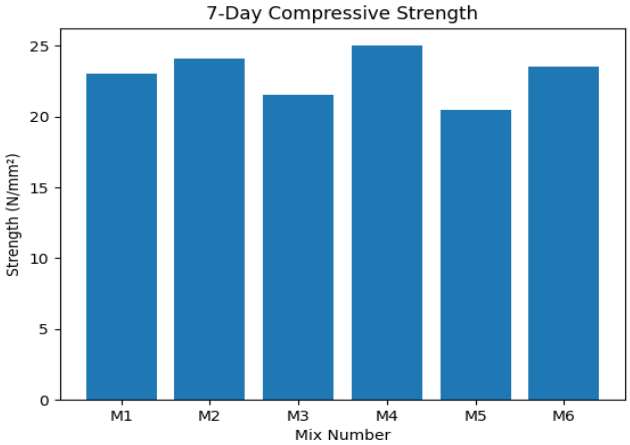

Figure 1: Compressive Strength Of Concrete On 7 Days

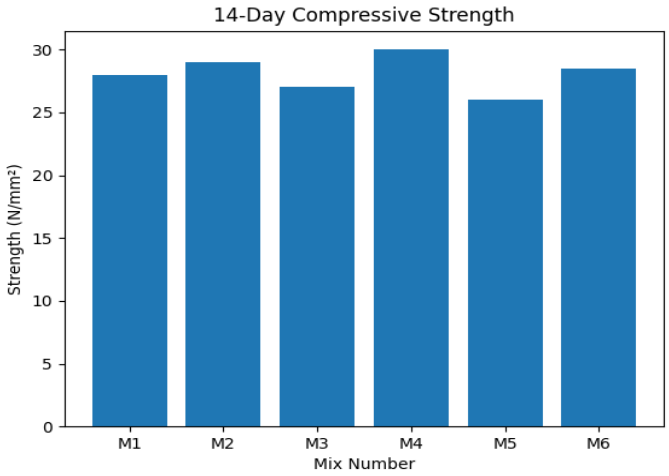

Figure 2: Compressive Strength Of Concrete On 14 Days

V. CONCLUSION

Available data shows significant improvements in the performance of concrete when marble powder is used as a partial replacement for cement in eco-friendly road repair applications. Results from compressive strength tests at 7 and 14 days indicate that mixes containing marble powder, especially in combination with fly ash, exhibit higher strength and better performance compared to conventional concrete. The increase in strength values and improved mix density provide clear evidence that the durability and load-bearing capacity of the concrete are enhanced with the inclusion of marble powder.

In addition, with respect to durability performance, marble powder concrete does not show any reduction in workability or structural integrity. Instead, it improves resistance to cracking and environmental effects due to reduced permeability and better particle bonding. The findings indicate that the strength and durability provided by marble powder are achieved without compromising the quality of the concrete. Thus, the use of marble powder in road repair offers an effective solution for enhancing mechanical performance, increasing service life, and promoting sustainability. Future research should focus on long-term performance evaluation, field applications under varying traffic conditions, and optimization of mix proportions to ensure practical and large-scale implementation in construction projects.

VI. REFERENCES

[1] Hebhoub H. et al. (2011) studied the use of waste marble aggregates in concrete and found that marble waste can be effectively used as a substitute for natural aggregates without significantly affecting strength. Their study emphasized the environmental benefits of reducing waste disposal and conserving natural resources.

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