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Effective Use of Marble Powder and Waste Brick Powder in Concrete

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Abstract: Concrete is the most widely used construction material, and the demand for natural resources used in concrete production is increasing rapidly. This project investigates the effective use of marble powder and waste brick powder as partial replacement materials in concrete. Marble powder, a by-product of the marble industry, and brick powder, obtained from crushed waste bricks, are utilized to reduce environmental pollution and improve sustainable construction practices. In this study, different proportions of marble powder and brick powder are used as partial replacements for cement in concrete mixes. The fresh and hardened properties of concrete, such as workability, compressive strength, and durability, are evaluated and compared with conventional concrete. The results indicate that an optimum percentage replacement can improve the strength and performance of concrete while reducing cement consumption and construction waste. The use of marble powder and brick powder in concrete not only helps in waste management but also contributes to eco-friendly and cost-effective construction. Therefore, these materials can be considered viable alternatives for producing sustainable concrete with satisfactory engineering properties.

Keywords: Concrete, Marble Powder, Waste Brick Powder, Cement Replacement, Sustainable Construction, Green Concrete, Compressive Strength, Workability, Durability, Waste Utilization.

INTRODUCTION

Concrete is the most widely used construction material worldwide due to its versatility, durability, and ability to be molded into various structural forms. The rapid growth of infrastructure development and urbanization has significantly increased the demand for concrete, resulting in extensive consumption of natural resources such as cement, sand, and aggregates. However, the production of conventional concrete has raised serious environmental concerns. Cement manufacturing is responsible for a substantial amount of global carbon dioxide (CO_2) emissions, while excessive extraction of natural sand and aggregates has led to depletion of natural resources and ecological degradation. Consequently, there is a growing need to develop sustainable construction materials that can reduce environmental impacts while maintaining or improving the performance of concrete. In recent years, the utilization of industrial and construction waste materials as supplementary cementitious materials and aggregate replacements has gained considerable attention among researchers. The incorporation of waste materials in concrete not only reduces the burden on landfills but also contributes to the conservation of natural resources and promotes sustainable construction practices. Among various waste materials, waste marble powder (WMP) and waste brick powder (WBP) have emerged as promising alternatives due to their abundance, low cost, and favorable physical and chemical characteristics. The marble processing industry generates a significant quantity of marble powder during cutting, polishing, and finishing operations. It is estimated that approximately 20–30% of the original marble block is converted into waste powder, which is often disposed of in open areas, causing environmental pollution and adverse effects on soil and water quality. Marble powder is primarily composed of calcium carbonate ($CaCO_3$) and possesses fine particles that can act as fillers within the concrete matrix, improving particle packing density and reducing porosity. Several studies have reported that the partial replacement of cement with marble powder can enhance the mechanical properties and durability of concrete when used at optimum replacement levels. Similarly, the construction and demolition sector generates a large volume of waste bricks due to demolition activities, manufacturing defects, and transportation damage. Disposal of these brick wastes occupies valuable landfill space and creates environmental challenges. Waste brick powder, obtained by crushing and grinding discarded clay bricks, contains a significant amount of silica and alumina, which exhibit pozzolanic activity. The pozzolanic reaction between brick powder and calcium hydroxide produced during cement hydration contributes to the formation of additional calcium silicate hydrate (C-S-H) gel, thereby enhancing the strength and durability characteristics of concrete. Previous studies have independently investigated the effects of marble powder and brick powder on concrete performance. Marble powder has been found to improve workability, reduce voids, and enhance compressive strength at lower replacement percentages. Likewise, waste brick powder has demonstrated potential as a supplementary cementitious material due to its pozzolanic properties and ability to improve long-term strength development. However, limited research has been conducted on the combined utilization of marble powder and waste brick powder in concrete. The synergistic effect of these materials may offer an effective solution for improving concrete performance while simultaneously addressing waste management issues. The combined use of waste marble powder and waste brick powder in concrete can contribute significantly to sustainable development by reducing cement consumption, minimizing environmental pollution, and lowering construction costs. Furthermore, the incorporation of these waste materials supports the principles of the circular economy by transforming industrial and construction wastes into valuable resources. Nevertheless, determining the optimum replacement levels is essential to ensure that the desired mechanical and durability properties of concrete are achieved without compromising workability and structural performance. Therefore, the present study aims to investigate the effectiveness of using waste marble powder and waste brick powder as partial replacement materials in concrete. The study evaluates the influence of different replacement levels on the fresh and hardened properties of concrete, including workability, compressive strength, split tensile strength, flexural strength, and durability characteristics. The findings are expected to provide valuable insights into the sustainable utilization of these waste materials and contribute to the development of environmentally friendly and economically viable concrete for modern construction applications.

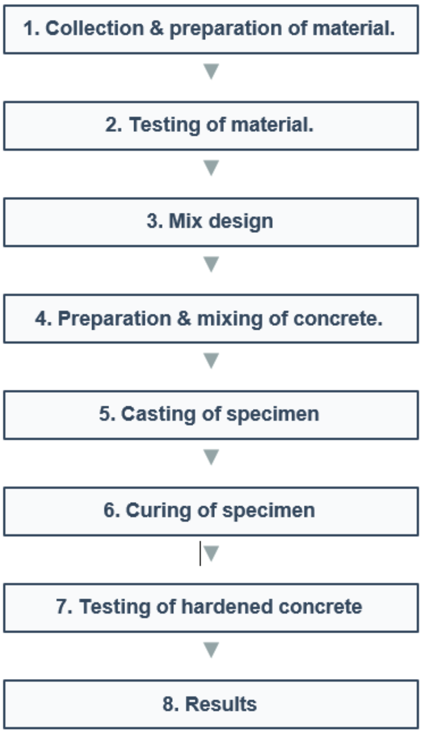
LITERATURE REVIEW

Sushmita Deshpande and Sharma (2025) investigated the combined utilization of marble powder and brick waste powder in M30 concrete. Marble powder was used as a partial replacement for cement at levels of 3%, 6%, 9%, and 12%, while brick waste powder replaced fine aggregate at 10%, 20%, 30%, and 40%. The study reported significant improvements in compressive, split tensile, and flexural strengths at optimum replacement levels. The researchers concluded that marble powder contributed cementitious properties, whereas brick waste powder enhanced particle packing and bonding within the concrete matrix.

Mansoor et al. (2021) evaluated the effect of waste brick powder (WBP) as a partial replacement for cement in mortar mixes. Replacement levels ranged from 10% to 50%. The results indicated that compressive and tensile strengths increased up to a 15% replacement level, beyond which strength gradually decreased. The study also found that WBP reduced permeability and improved durability characteristics due to its pozzolanic behavior and pore-refining effect.

Moreno et al. (2022) conducted a comprehensive review on the utilization of marble powder in concrete, mortar, and brick production. Their findings revealed that marble powder can successfully replace cement or fine aggregate up to 10–15% without adversely affecting compressive strength. The study highlighted that the fine particle size of marble powder improves packing density, reduces voids, and contributes to sustainable construction by reducing cement consumption and waste disposal problems.

METHODOLOGY



Materials

Ordinary Portland Cement (OPC), river sand conforming to IS 383:2016, crushed coarse aggregate of 20 mm maximum size, waste marble powder (MP), and waste brick powder (BP) were used in this study. Marble powder was collected from marble processing industries, while brick powder was obtained from crushed waste bricks. Both materials were dried and sieved through a 90-micron sieve before use.

Material Characterization

The physical properties of cement, fine aggregate, coarse aggregate, marble powder, and brick powder were determined according to relevant Indian Standards. Tests included fineness, specific gravity, water absorption, sieve analysis, setting time, and chemical composition analysis.

Concrete Mix Design

Concrete mixes were designed in accordance with IS 10262:2019. A control mix without replacement was prepared, and cement was partially replaced with a combination of marble powder and waste brick powder at replacement levels of 15%, 20%, and 40% by weight of cement. A constant water-cement ratio was maintained for all mixes.

Preparation and Casting of Specimens

Concrete ingredients were mixed thoroughly in a laboratory mixer to obtain a uniform mix. Workability was evaluated using the slump test. Cube specimens of size 150 mm × 150 mm × 150 mm were cast for compressive strength testing. The specimens were compacted properly to eliminate air voids.

Curing

After 24 hours of casting, the specimens were demoulded and cured in clean water maintained at 27 ± 2°C. The curing periods adopted were 7, 14, and 28 days.

Testing of Hardened Concrete

Compressive strength tests were conducted on cube specimens using a Compression Testing Machine (CTM) in accordance with IS 516:2018. The tests were performed after 7, 14, and 28 days of curing.

Data Analysis

The experimental results were compared with those of the control mix to evaluate the effect of marble powder and waste brick powder on concrete performance. The optimum replacement level was determined based on strength and workability characteristics, and the findings were analyzed from both engineering and sustainability perspectives.

RESULT AND DISCUSSION

The experimental investigation was carried out to evaluate the effect of marble powder (MP) and waste brick powder (WBP) as partial replacement materials in M30 grade concrete. Compressive strength tests were conducted on concrete cube specimens at curing ages of 7, 14, and 28 days. The results obtained for conventional concrete and concrete containing different percentages of marble powder and waste brick powder are presented below.

4.1.1 Compressive Strength of Conventional M30 Concrete

Table 4.1 Compressive Strength Test Results of M30 Control Mix at 7 Days

Sr. No.	Size of Sample (mm)	Compressive Strength (MPa)
1	150.12 × 151.20 × 151.41	22.83
2	151.23 × 149.23 × 151.20	21.47
3	150.21 × 150.47 × 151.82	21.82

Average Compressive Strength = 22.04 MPa

Table 4.2 Compressive Strength Test Results of M30 Control Mix at 14 Days

Sr. No.	Size of Sample (mm)	Compressive Strength (MPa)
1	150.49 × 150.54 × 150.26	32.67
2	150.15 × 150.37 × 150.57	29.86
3	150.53 × 150.71 × 151.37	31.21

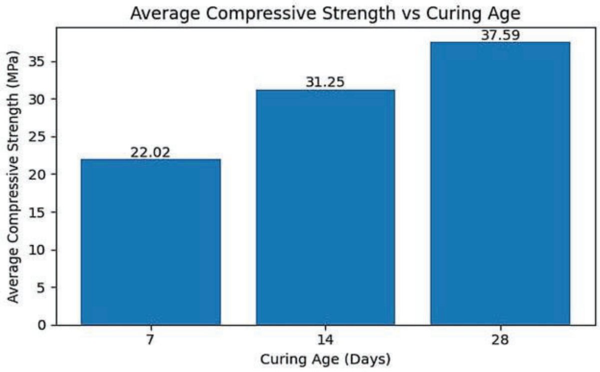
Average Compressive Strength = 31.25 MPa

Table 4.3 Compressive Strength Test Results of M30 Control Mix at 28 Days

Sr. No.	Size of Sample (mm)	Compressive Strength (MPa)
1	150.81 × 151.34 × 151.49	33.70
2	150.98 × 151.23 × 150.41	41.64

3	150.91 × 151.13 × 150.47	37.43

Average Compressive Strength = 37.59 MPa



Discussion

The control concrete achieved compressive strengths of 22.04 MPa, 31.25 MPa, and 37.59 MPa at 7, 14, and 28 days respectively. The continuous increase in strength is attributed to the progressive hydration of cement and formation of calcium silicate hydrate (C-S-H) gel, which enhances the bond between aggregate and cement paste.

4.1.2 Compressive Strength of M30 Concrete with 15% MP + WBP

Table 4.4 Compressive Strength Test Results at 7 Days

Sr. No.	Size of Sample (mm)	Compressive Strength (MPa)
1	150.66 × 150.68 × 151.08	20.78
2	150.75 × 151.38 × 150.98	20.33
3	151.47 × 150.28 × 151.47	21.14

Average Compressive Strength = 20.75 MPa

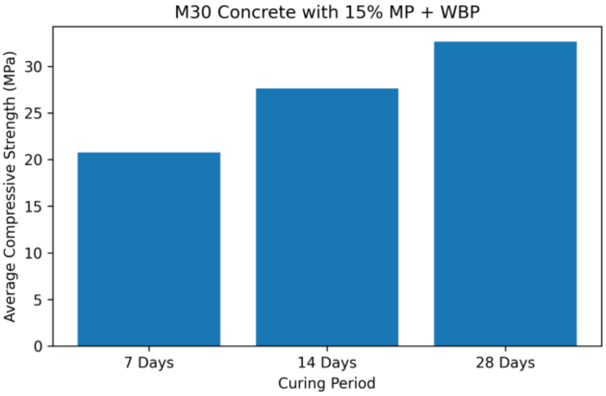
Table 4.5 Compressive Strength Test Results at 14 Days

Sr. No.	Size of Sample (mm)	Compressive Strength (MPa)
1	150.62 × 151.79 × 151.44	28.17
2	151.79 × 150.03 × 150.68	26.91
3	150.53 × 150.71 × 151.37	27.84

Average Compressive Strength = 27.64 MPa

Table 4.6 Compressive Strength Test Results at 28 Days

Sr. No.	Size of Sample (mm)	Compressive Strength (MPa)
1	151.63 × 150.67 × 150.70	33.10
2	150.76 × 150.93 × 151.51	32.19
3	151.46 × 151.49 × 150.26	32.64



Average Compressive Strength = 32.64 MPa

The concrete containing 15% replacement of cement with marble powder and waste brick powder achieved a 28-day compressive strength of 32.64 MPa. Although lower than the control mix, the reduction was limited to approximately 13.17%.

The fine particles of marble powder filled the micro-voids present within the concrete matrix, improving particle packing. Waste brick powder contributed pozzolanic activity, which enhanced bonding between hydration products and aggregates. Therefore, the mix exhibited satisfactory strength performance and can be considered suitable for sustainable concrete applications.

4.1.3 Compressive Strength of M30 Concrete with 20% MP + WBP

Table 4.7 Compressive Strength Test Results at 14 Days

Sr. No.	Size of Sample (mm)	Compressive Strength (MPa)
1	150.17 × 150.24 × 150.22	20.75

2	150.02 × 150.12 × 150.36	21.33
3	150.53 × 150.71 × 151.37	22.25

Average Compressive Strength = 21.96 MPa

Table 4.8 Compressive Strength Test Results at 28 Days

Sr. No.	Size of Sample (mm)	Compressive Strength (MPa)
1	150.77 × 150.61 × 151.12	27.55
2	150.96 × 150.80 × 150.76	26.89
3	150.59 × 150.87 × 150.72	27.97

Average Compressive Strength = 27.47 MPa

Discussion

At 20% replacement, the compressive strength reduced considerably compared to both the control mix and the 15% replacement mix. The reduction may be attributed to the dilution effect caused by the decrease in cement content.

Although marble powder provides filler action and waste brick powder exhibits pozzolanic characteristics, excessive replacement reduces the amount of cement available for hydration. Consequently, the formation of C-S-H gel decreases, leading to lower strength development.

4.1.4 Compressive Strength of M30 Concrete with 40% MP + WBP

Table 4.9 Compressive Strength Test Results at 7 Days

Sr. No.	Size of Sample (mm)	Compressive Strength (MPa)
1	150.12 × 149.63 × 151.22	9.58
2	150.60 × 150.20 × 149.10	10.25
3	149.50 × 150.11 × 151.82	10.50

Average Compressive Strength = 10.12 MPa

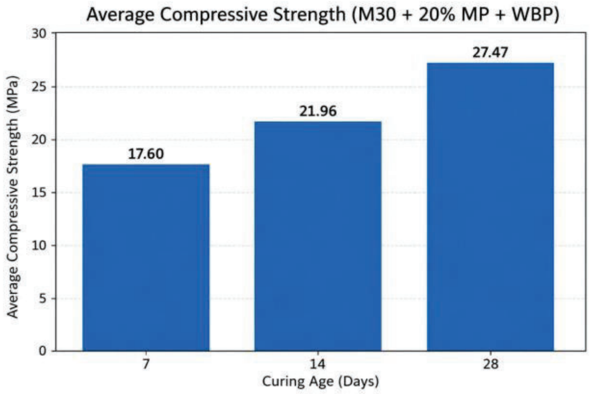
Table 4.10 Compressive Strength Test Results at 14 Days

Sr. No.	Size of Sample (mm)	Compressive Strength (MPa)
1	150.41 × 150.19 × 150.25	20.69
2	150.24 × 150.12 × 150.46	20.89
3	150.53 × 150.71 × 151.37	18.20

Average Compressive Strength = 19.93 MPa

Table 4.11 Compressive Strength Test Results at 28 Days

Sr. No.	Size of Sample (mm)	Compressive Strength (MPa)
1	151.66 × 150.40 × 151.60	15.82
2	150.61 × 150.81 × 151.40	16.53
3	150.53 × 150.71 × 151.37	16.10



Average Compressive Strength = 16.15 MPa

Discussion

The concrete containing 40% replacement exhibited the lowest compressive strength among all mixes. The significant reduction in strength indicates that excessive replacement of cement adversely affects hydration and matrix formation.

The reduction in cement content resulted in insufficient cementitious compounds, leading to poor bonding and increased porosity. Therefore, replacement levels above 20% are not recommended for structural concrete applications.

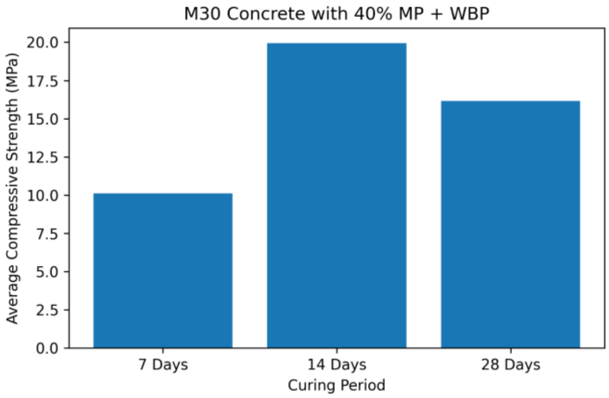
4.2 Comparative Analysis of Compressive Strength

Table 4.12 Comparison of Average Compressive Strength

Mix Type	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
Control Mix	22.04	31.25	37.59
15% MP + WBP	20.75	27.64	32.64
20% MP + WBP	-	21.96	27.47
40% MP + WBP	10.12	19.93	16.15

Percentage Reduction at 28 Days

Mix Type	28-Day Strength (MPa)	Reduction Compared to Control (%)
Control Mix	37.59	0
15% MP + WBP	32.64	13.17
20% MP + WBP	27.47	26.92
40% MP + WBP	16.15	57.04



Discussion

Workability of Concrete

The addition of marble powder and waste brick powder affected the workability of concrete due to their fine particle size and higher surface area. Marble powder improved cohesiveness and reduced segregation, whereas waste brick powder increased water demand because of its porous nature. Consequently, slump values decreased with increasing replacement percentages.

Compressive Strength Analysis

The results indicate that strength increased with curing age for all mixes. However, increasing the replacement percentage beyond 15% resulted in a noticeable reduction in compressive strength. The optimum replacement level among the investigated mixes was found to be 15% MP + WBP.

Durability Performance

The incorporation of marble powder reduced voids and permeability due to its filler effect. Waste brick powder contributed to pore refinement through pozzolanic reactions. These effects are expected to improve long-term durability and resistance to water penetration.

Microstructural Behaviour

Marble powder acted as a micro-filler, improving particle packing and reducing micro-cracks. Waste brick powder reacted with calcium hydroxide produced during cement hydration, forming additional C-S-H gel. These mechanisms contributed to strength development and densification of the concrete matrix.

Environmental Benefits

The use of marble powder and waste brick powder offers several environmental advantages:

- Reduction in cement consumption.
- Utilization of industrial and construction waste.
- Reduction in landfill disposal.
- Conservation of natural resources.
- Lower CO_2 emissions associated with cement production.

Optimum Replacement Percentage

Among all mixes investigated, the concrete containing **15% MP + WBP** exhibited the best overall performance. It achieved a 28-day compressive strength of **32.64 MPa**, which is suitable for many structural applications while providing environmental and economic benefits.

Recommended Replacement Levels

Component	Replaced By	Optimum Percentage
Cement	Marble Powder	10–20%

Fine Aggregate	Waste Brick Powder	10–20%

Role of Sikament RB Admixture

Sikament RB 1126 RM is a sulphonated naphthalene-based superplasticizer used to improve workability while reducing water demand. The recommended dosage ranges from **0.8% to 2.0%** by weight of cementitious material. The admixture enhances cohesion, minimizes segregation, and improves overall concrete quality.

Summary

The experimental investigation demonstrated that the incorporation of marble powder and waste brick powder influences the compressive strength of concrete significantly. The control mix achieved the highest strength, whereas excessive replacement resulted in strength reduction. Among the modified mixes, **15% MP + WBP** provided the most satisfactory balance between strength, sustainability, and economic feasibility. Therefore, it can be recommended as the optimum replacement level for sustainable concrete production.

CONCLUSION

The present study investigated the feasibility of utilizing marble powder (MP) and waste brick powder (WBP) as partial replacement materials in concrete with the objective of developing a sustainable and environmentally friendly construction material. Based on the experimental results and analysis, the following conclusions are drawn:

1. Workability of Concrete

The workability of concrete was influenced by the incorporation of marble powder and waste brick powder. Marble powder, due to its finer particle size, improved the cohesiveness of the concrete mix and reduced segregation and bleeding. However, waste brick powder exhibited higher water absorption characteristics, resulting in a slight reduction in workability with increasing replacement percentages. Nevertheless, the concrete mixes remained workable within the acceptable range for practical applications.

2. Compressive Strength Performance

The compressive strength of concrete increased with curing age for all mixes. The mix containing marble powder and waste brick powder demonstrated satisfactory strength development due to the combined filler effect and pozzolanic activity of the replacement materials. Moderate replacement levels exhibited compressive strengths close to that of conventional concrete, whereas higher replacement percentages resulted in a reduction in strength due to the dilution of cementitious compounds and increased porosity. Excessive replacement adversely affected the hydration process and reduced the formation of strength-giving hydration products.

3. Split Tensile and Flexural Strength

The split tensile strength and flexural strength followed trends similar to compressive strength. The incorporation of marble powder and waste brick powder at moderate replacement levels contributed to improved particle packing and enhanced bonding within the concrete matrix. However, higher replacement percentages reduced the bond between the cement paste and aggregates, leading to lower tensile and flexural strength values.

4. Durability Characteristics

The use of marble powder improved the density of concrete by filling micro-voids and reducing permeability. Waste brick powder contributed additional pozzolanic reactions, which enhanced the microstructure of concrete and supported long-term strength development. Lower replacement levels showed better durability performance with reduced water absorption and improved resistance to environmental deterioration.

5. Optimum Replacement Level

Based on the overall evaluation of workability, strength, and durability characteristics, the replacement of conventional concrete materials with a combination of marble powder and waste brick powder at moderate levels was found to be the most effective. The optimum replacement level provided a desirable balance between mechanical performance and sustainability while maintaining acceptable engineering properties.

6. Environmental and Economic Benefits

The utilization of waste marble powder and waste brick powder offers significant environmental advantages by reducing the disposal of industrial and construction waste materials. The replacement of conventional cement and aggregate materials contributes to the conservation of natural resources, reduction of landfill waste, and lowering of carbon dioxide emissions associated with cement production. Furthermore, the use of locally available waste materials can reduce the overall cost of concrete production, making it an economical alternative for sustainable construction practices.

Overall Conclusion

The study demonstrates that marble powder and waste brick powder can be effectively utilized as supplementary materials in concrete production. Their incorporation enhances sustainability by converting industrial and construction waste into valuable construction resources while reducing dependence on conventional materials. The results indicate that moderate replacement levels can produce concrete with satisfactory mechanical and durability properties suitable for practical construction applications. However, excessive replacement levels lead to a significant reduction in strength and performance and are therefore not recommended for structural concrete. Overall, the use of marble powder and waste brick powder presents a promising approach toward the development of eco-friendly, economical, and sustainable concrete for future construction projects.

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