

## EFFECT OF MARBLE POWDER AS CEMENTITIOUS MATERIALS ON THE PERFORMANCE OF CONCRETE

Shafique Ahmed<sup>\*1</sup>, Manthar Ali Keerio<sup>2</sup>, Naraindas Bheel<sup>3</sup>, Rehan Ali Alias Hussain Ali<sup>4</sup>,  
Abdul Raheem Sawand<sup>5</sup>

<sup>\*1,2,4,5</sup>Department of Civil Engineering Technology, Benazir Bhutto Shaheed University of Technology and Skill Development (BBSU-TECH), Khairpur Mir's, Pakistan.

<sup>3</sup>Department of Civil Engineering, Aror University of Art, Architecture, Heritage, and Design Sukkur, Sindh, Pakistan.

<sup>\*1</sup>shafique12ce@gmail.com

DOI: <https://doi.org/10.5281/zenodo.23281185>

### Keywords

Concrete, Marble Powder, Cementitious materials, Workability, and Compressive Strength.

### Article History

*Received:* 25 June 2026

*Accepted:* 16 September 2026

*Published:* 09 October 2026

Copyright @Author

Corresponding Author: \*  
Shafique Ahmed

### Abstract

Research in recent times has focused more and more on alternatives to concrete manufacturing that are sustainable, cost effective, and socially beneficial. This includes industrial waste, potential advantages of which can be addressed through recycling, reusing and creative approaches. The use of such wastes as supplementary and substitute resources may provide significant energy savings and reduction in Portland cement (PC) consumption and consequently lead to lower carbon dioxide (CO<sub>2</sub>) emissions. Therefore, utilization of marble powder (MP) as a supplementary cementitious material (SCM) in mixture can decrease the environmental impacts and the amount of Portland cement (PC) in the compositions. This study investigates concrete including 0% to 20% of MP as cementitious materials. The core objectives of this study are to assess the effects of MP as a SCM on both fresh and hardened concrete. A total of 15 concrete samples were employed to assess the compressive strength of the material. Besides, the workability decreases with increasing amount of MP in the mix. At 10% MP, the compressive strength increases to 37.80 MPa after 28 days. It has been suggested to utilize 10% MP in construction to provide better results for the building industry in civil engineering.

### INTRODUCTION

The growing environmental problems and depletion of natural resources have forced the construction industry to look for sustainable alternatives of conventional materials especially cement, which is known to release huge amounts of carbon dioxide during its manufacture [1-4]. Marble powder (MP) is a byproduct produced in huge quantities from marble processing industries and due to its chemical composition and wide availability, it is a promising environmentally friendly supplementary material for concrete [5-8]. Waste constitutes about 50-60% of the marble

production, which causes environmental problems like dust pollution and waste disposal problems [9, 10]. MP can be used as a SCM in concrete. This will help in managing the environmental waste and enhance the concrete performance and decrease the carbon footprint of construction activities.

The literature revealed that different studies on SCM by MP showed different effects on mechanical and durability properties of concrete. It has been proved that the utilization of MP at optimum replacement levels increases the strength. The use of finely MP improves particle

compaction and matrix density, potentially increasing concrete strength, especially at lower substitution rates of around 5–15% [5, 6, 11]. Nonetheless, an overabundance of MP substitution may diminish strength due to cement dilution and the comparatively poor pozzolanic reaction of MP [12–14]. Marble powder not only increases strength but also positively influences other properties of concrete like workability, durability against chemical attack and development of micro structure [15, 16]. Ali et al. (2022) indicated that incorporating marble powder and polypropylene fibers into self-compacting concrete enhanced its strength as well as its chloride resistance [17]. The components of marble waste demonstrated enhanced durability, exhibiting superior resistance of marble waste aggregate mixtures to sulfuric acid [18]. The use of marble powder has demonstrated the potential to produce finer pore configurations and improved adhesion of the hydrated components, hence augmenting the mechanical characteristics and longevity of mortar and concrete [6, 19].

The recycling of the marble powder, in addition to the benefits in terms of performances, offers advantages in terms of sustainability, through waste reduction and reduction of the environmental impact related to the cement production. Life cycle assessments showed significant reductions in global warming potential and other environmental indicators, which are attributed to the partial replacement of marble powder for the content of cement, making concrete production more sustainable and aligned with green construction practices [18].

To conclude, the application of MP in concrete is a SCM to improve the characteristics of the

material and to solve environmental and economic problems. The effectiveness depends on the right substitution level and the interaction of the material with other constituents of the concrete mix, with optimal concentrations usually cited to be in the range of 5% to 10%. The present work shows the potential of MP as a sustainable SCM that may improve concrete performance and durability, thus contributing to the development of eco-friendly construction technologies. The aim of the present study is to systematically evaluate the effect of marble powder on the workability and compressive strength of concrete and optimize the utilization of MP in practical applications.

## Materials and Methods

### Materials

Portland Cement (PC) is used as binding agent in this research work, and MP is used as SCM having the particle size of 75  $\mu\text{m}$ . Besides, crushed stone was used as coarse aggregates having the size of 20 mm while the river sand was used as fine aggregate which passed from 4.75 mm in sieve size. Superplasticizer was used as chemical admixture in this study. Additionally, potable water was utilized for mixing and curing of the concrete samples.

### Mix Proportions

In this study, concrete mixtures with 0–20% replacement of PC with MP were used to find the ideal MP formulation. It was used a mix proportion of 1:1.5:3 and a water to cement ratio of 0.45. Table 1 presents the information of the mixture proportions and the required components for producing 1  $\text{m}^3$  of concrete for each mix ratio.

**Table 1: Mix Design of MP modified Concrete**

| Mix ID | Binding Material (%) |    | Quantity of Concrete Constituents ( $\text{kg}/\text{m}^3$ ) |       |      |     |       |
|--------|----------------------|----|--------------------------------------------------------------|-------|------|-----|-------|
|        | PC                   | MP | PC                                                           | MP    | CA   | FA  | Water |
| MP0    | 100                  | 0  | 425                                                          | 0     | 1275 | 638 | 192   |
| MP5    | 95                   | 5  | 403.75                                                       | 21.25 | 1275 | 638 | 192   |
| MP10   | 90                   | 10 | 382.50                                                       | 42.50 | 1275 | 638 | 192   |
| MP15   | 85                   | 15 | 361.25                                                       | 63.75 | 1275 | 638 | 192   |

|      |    |    |        |       |      |     |     |
|------|----|----|--------|-------|------|-----|-----|
| MP20 | 80 | 20 | 340.00 | 85.00 | 1275 | 638 | 192 |
|------|----|----|--------|-------|------|-----|-----|

### Testing Procedure

The slump test was performed on a number of fresh concrete mixtures with varying proportions of MP as a SCM in compliance with BS EN 12350-2. In addition, the compressive strength was done on cubic specimen of 100 mm x 100 mm x 100 mm with different proportions of Portland cement replaced by MP according to BS EN 12390-3.

### RESULTS AND DISCUSSION

#### Slump Test

It carried out to estimate the workability of green mixture with the use of MP as a SCM is presented in Figure 1. The best slump recorded for the control mix is 65 mm. The lowest slump reported is 26 mm with the integration of MP as a SCM in the mix at 20%. The slump of concrete shows to decrease with the addition of MP in the mix. The performance decreases because of the higher specific surface area of MP particles in comparison to PC, which means more water is retained as the quantity of MP in the concrete mix increases.

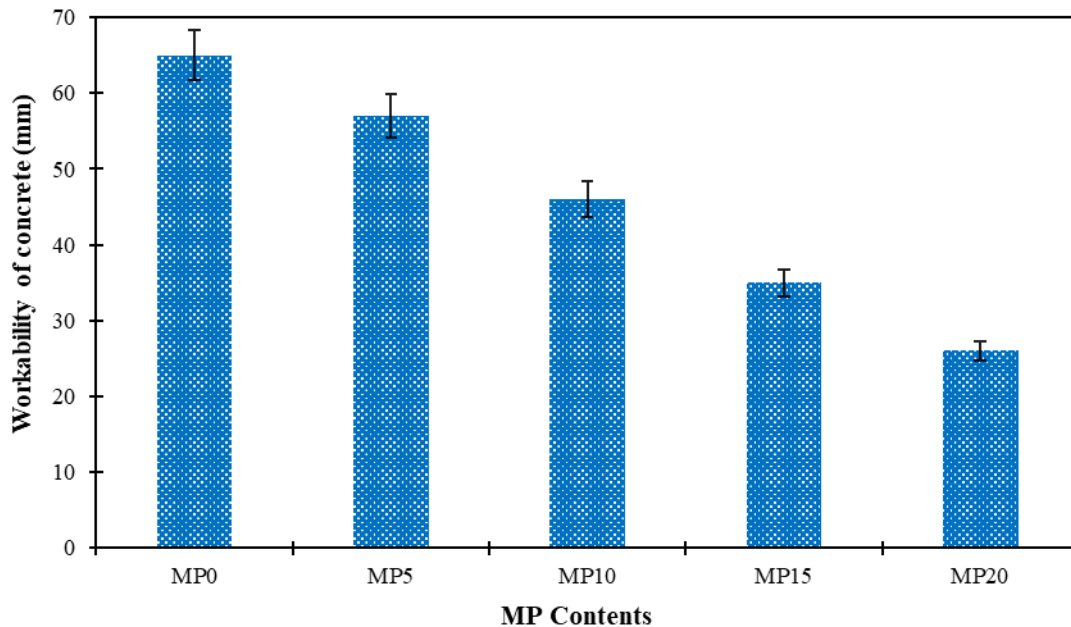


Figure 1: Slump Test of MP modified Concrete

### Compressive Strength (CS)

Figure 2 displays the CS achieved on cubical concrete specimens with MP as a SCM. The optimum CS obtained is 37.80 MPa with 10% MP, and the minimum strength obtained is 26.70 MPa with 20% MP as SCM in concrete after 28 days. The investigational outcomes showed that the CS was improved with the accumulation of up

to 10% MP. The fineness MP particle filled the micropores formed by the various components of concrete. But over this limit, strength starts to decrease as MP dilutes the cement, reducing the pozzolanic interactions of the concrete ingredients.

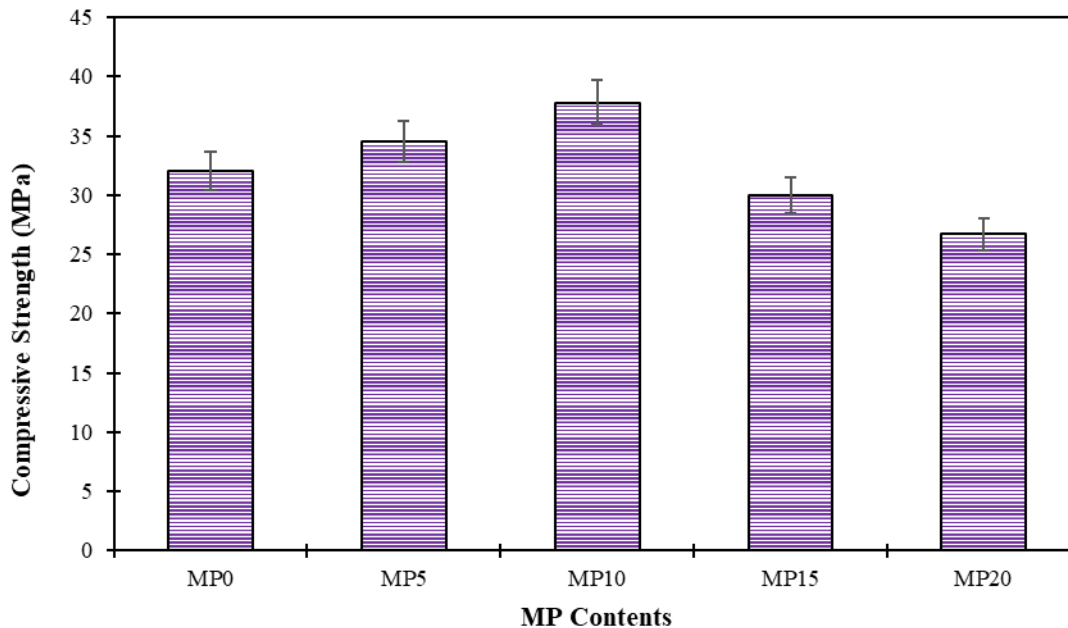


Figure 2: Compressive Strength of MP modified Concrete

### Conclusions

The scientific evaluation demonstrates that the use of MP as SCM in concrete provides better results for the construction sector. The deductions of this inquiry are as follows:

- In all the samples, the workability reduced with the addition of MP when compared to the CM. The reduction in workability is attributed to higher water absorption capacity of MP as a SCM than PC.
- The optimum CS was 37.80 MPa for 10% MP and minimum strength was 26.70 MPa for 20% MP as SCM in concrete. Research indicates that the addition of up to 10% MP enhances the CS of concrete, which is associated to the fineness of MP that fills the micropores inside the material.
- Test results indicate that the best strength is achieved with 10% MP concentration. Hence it is recommended for use in construction industry.

### References

- [1] Golewski, G.L., Green concrete based on quaternary binders with significant reduced of CO<sub>2</sub> emissions, *Energies*. 14 (2021) 4558.
- [2] S.H. Channa, S.A. Mangi, N. Bheel, F.A. Soomro, S.H. Khahro, Short-term analysis on the combined use of sugarcane bagasse ash and rice husk ash as supplementary cementitious material in concrete production, *Environ. Sci. Pollut. Res.* 29 (2022) 3555–3564.
- [3] M.A. Keerio, A. Saand, A. Kumar, N. Bheel, K. Ali, Effect of local metakaolin developed from natural material soorh and coal bottom ash on fresh, hardened properties and embodied carbon of self-compacting concrete, *Environ. Sci. Pollut. Res.* 28 (2021) 60000–60018.
- [4] N. Bheel, K.A. Kalhor, T.A. Memon, Z.U.Z. Lashari, M.A. Soomro, U.A. Memon, Use of Marble Powder and Tile Powder as Cementitious Materials in Concrete, *Eng. Technol. Appl. Sci. Res.* 10 (2020) 5448–5451.
- [5] Hou, W., Zhang, Q., Zhuang, Z. and Zhang, Y., 2024. Sustainable reusing marble powder and granite powder in cement-based materials: a review. *ACS Sustainable Chemistry & Engineering*, 12(7), pp.2484-2510.

- [6] Abbas, M.M. and Muntean, R., 2025. Marble powder as a sustainable cement replacement: a review of mechanical properties. *Sustainability*, 17(2), p.736.
- [7] Bheel, N., Benjeddou, O., Almujiab, H.R., Abbasi, S.A., Sohu, S., Ahmad, M. and Sabri, M.M.S., 2023. Effect of calcined clay and marble dust powder as cementitious material on the mechanical properties and embodied carbon of high strength concrete by using RSM-based modelling. *Heliyon*, 9(4).
- [8] Bheel, N., Nadeem, G., Almaliki, A.H., Al-Sakkaf, Y.K., Dodo, Y.A. and Benjeddou, O., 2024. Effect of low carbon marble dust powder, silica fume, and rice husk ash as tertiary cementitious material on the mechanical properties and embodied carbon of concrete. *Sustainable Chemistry and Pharmacy*, 41, p.101734.
- [9] Rajgor, M.B., Patel, N.C. and Pitroda, J., 2013, December. A study on marble waste management: opportunities and challenges in current age for making value added bricks. In *Proceedings of national conference CRDCE13* (pp. 20-21).
- [10] Demirel, B. and Alyamaç, K.E., 2018. Waste marble powder/dust. In *Waste and supplementary cementitious materials in concrete* (pp. 181-197). Woodhead Publishing.
- [11] Sharma, N., Singh Thakur, M., Goel, P.L. and Sihag, P., 2020. A review: Sustainable compressive strength properties of concrete mix with replacement by marble powder. *Journal of Achievements in Materials and Manufacturing Engineering*, 98(1).
- [12] Kaptan, K., Cunha, S. and Aguiar, J., 2025. The effect of activation methods on the mechanical properties of cement mortars with recycled powder from concrete waste as a cement partial replacement: a review. *Sustainability*, 17(10), p.4502.
- [13] Sathe, S., Patil, S. and Bhosale, Y.N., 2026. Investigation of strength, durability, and microstructure properties of concrete with waste marble powder as a partial replacement of cement. *World Journal of Engineering*, 23(1), pp.71-81.
- [14] Ahmad, J., Zhou, Z. and Deifalla, A.F., 2023. Self-compacting concrete with partially substitution of waste marble: a review. *International Journal of Concrete Structures and Materials*, 17(1), p.25.
- [15] Vardhan, K., Siddique, R. and Goyal, S., 2019. Strength, permeation and microstructural characteristics of concrete incorporating waste marble. *Construction and Building Materials*, 203, pp.45-55.
- [16] Selim, F.A., Hashem, F.S. and Amin, M.S., 2020. Mechanical, microstructural and acid resistance aspects of improved hardened Portland cement pastes incorporating marble dust and fine kaolinite sand. *Construction and Building Materials*, 251, p.118992.
- [17] Ali, A., Hussain, Z., Akbar, M., Elahi, A., Bhatti, S., Imran, M., Zhang, P. and Leslie Ndam, N., 2022. Influence of Marble Powder and Polypropylene Fibers on the Strength and Durability Properties of Self-Compacting Concrete (SCC). *Advances in Materials Science and Engineering*, 2022(1), p.9553382.
- [18] Ahmadi, M., Abdollahzadeh, E., Kashfi, M., Khataei, B. and Razavi, M., 2025. Life cycle assessment and performance evaluation of self-compacting concrete incorporating waste marble powder and aggregates. *Materials*, 18(13), p.2982.
- [19] Kabeer, K.S.A. and Vyas, A.K., 2018. Utilization of marble powder as fine aggregate in mortar mixes. *Construction and building materials*, 165, pp.321-332.