Published by :
https://www.ijert.org/
An International Peer-Reviewed Journal

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 09, RTMSE-2026

Evaluating Strength Properties of Cement Mortar using Marble Waste

Er. Lakhvir Kaur[1], Dr. Gurpreet Singh[2], Dr. Sukhpal Singh[3]
[1,2]Department of Civil Engineering, Punjabi University, Patiala (Punjab).
[3]Department of Physics, Punjabi University, Patiala (Punjab).
E-mail: lakhvir1177@gmail.com

Abstract: **A large amount of marble waste is produced by processing units of marble stones, such as sawing, polishing, etc., which give rise to disposal issues of this waste. This waste is detrimental to the soil, water bodies, and human health. On the other hand, the infrastructure development continually provokes the construction industries to extract natural materials. With the goal of protecting the natural resources and environment, waste marble powder (WMp) can be utilized in cementitious materials as a substitute of sand. In this experimental work, sand was replaced with marble powder at various rates, namely 0, 10, 30, and 90% by volume. Specimens of cement mortar were cast to examine the mortar's strength, including compressive strength and flexural strength, along with density. The strength of the mortar increased with rising WMp content compared to the conventional mix. The maximum increase in strength against compression was achieved in a mix containing 30% WMp, which was approx. 30% higher than 0% mortar. Pursuant to the results of this research, the leftover marble powder may be used to replace the sand and help to preserve the natural resources.**

Keywords: **Mortar, waste marble, compressive strength, water absorption.**

1. INTRODUCTION

Since the start of the twentieth century, systematic approaches have been implemented for the utilization of industrial by-products in cement-based composites to support sustainability [1, 2]. Firstly, the research study focused on industrial waste as a cement replacement to reduce the carbon footprint and mitigate the over-exploitation of natural resources required to produce cement. Now, efforts have been shifted toward exploring sustainable alternatives for natural aggregates [2]. Therefore, the primary aim of this study is to utilize by-products as aggregates in cement-based composites (concrete and mortar) and to mitigate the consumption of natural resources, such as sand and stone, without compromising the quality of the concrete/mortar, while also contributing to waste management practices.

From ancient times, mortar has been employed in the construction field for various purposes, such as plastering walls, filling gaps between bricks and stones, and more. Mortar is basically composed of cement, sand, and water, depending on its applications [3]. Annually, approximately 100 million tons of mortar are produced [4]. Increase in construction activities to meet the needs of humanity, fine aggregates are being extracted from the river beds, and the continued depletion of natural resources [5]. Keeping these issues as a priority, it is necessary to incorporate by-products in cementitious composites. Several authors investigated the incorporation of different industrial waste materials into concrete and mortar to manage disposal issues and to improve the performance of cementitious composites, which is worthwhile [6, 7].

The numerous waste materials possess both physical and structural properties akin to the virgin materials; therefore, can be employed as fine aggregate substitution in cement mortar. Of these materials, marble waste is the one such material that affects the prolificacy of soil and can lead to health problems [8]. Due to its desirable properties, marble

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 09, RTMSE-2026

has been utilized in the construction field for ages. Marble debris is generated from the sawing and processing operations of marble stones. According to reports, India generates around three million tons of marble powder debris every year [9]. This large amount of marble powder waste, if it is discarded in either an open area or landfills, leads to a reduction of soil aeration and permeability, ultimately affecting the fertility of the land. Additionally, it poses threats to human health and disrupts the biotic system [10]. Thus, it can be employed as a partial or complete substitute for natural fine aggregates to effectively solve worrying issues. Its use in mortar/ concrete will lead to resolving the disposal issues of waste, and minimize the overuse of natural materials. Numerous researchers have investigated the use of marble powder waste in lieu of river fine aggregates [11-14]. The outcomes of the studies suggest that marble waste has the capacity to be used as sand and improve the properties of the resultant composite.

2. EXPERIMENTAL PROGRAM

2.1 Materials and their properties

For this current experimental program, OPC- 43 grade cement having a specific gravity of 3.12 as per the guidelines of [15] was used for cement mortar mix. Locally available sand conforming to Zone III as per [16] with a specific gravity of 2.59 was used. WMp belonged to Zone III and had a specific gravity of 2.70, which was used.

2.2 Cement mortar mix proportions

A mix of cement mortar with 1 part cement and 3 parts sand was considered for casting the reference samples with a water-cement ratio and a polymer-cement ratio of 0.02. Styrene-butadiene rubber (SBR) polymer forms a polymeric film in the mix and reduces the amount of water. Various replacement ratios for sand, such as 0, 10, 30, and 90 percent by volume with waste marble powder (WMp), were employed, and these mixes are named, such as WMp-0, WMp-10, WMp-30, and WMp-90, respectively. The load-bearing capacity of mortar was determined, which represents its resistance against compression. For this test, cubic (70.6mm sides) samples were tested after standard curing time. Flexural strength test represents the strength against bending, which was performed on beams (40x40x160 mm). The water absorption was determined with (70.6 mm) cubic samples as per the code [17].

3. RESULTS AND DISCUSSION

3.1 Compressive strength

After completion of the curing span of 28 days, cubic specimens of various mixes were tested on a universal testing machine for the investigation of their compressive strength. *Figure 1* illustrates the compressive-strength of various mortar mixes. A significant improvement in strength was achieved by incorporating waste marble powder into mortar under a specified curing time span. The increase in strength for WMp-30 was clearly evident in the figure. in comparison to the controlled mortar. Notable increases in characteristic strength were observed for WMp-30 and MWp-60 after 28 days of curing. This enhancement in strength with various percentages of marble powder can be attributed to the physical properties of WMp, as it has filler ability and reduces the voids, resulting in a less porous mortar with higher compressive strength.

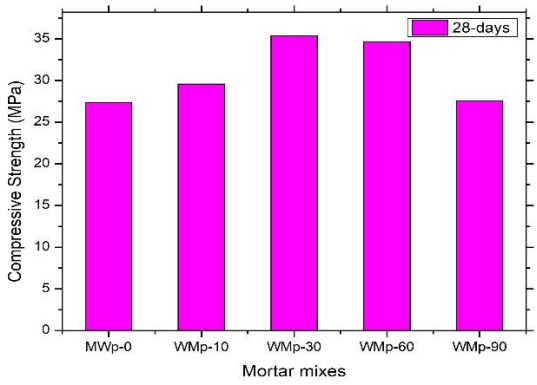

Figure 1 Compressive strength of various mortar mixes

3.2 Flexural strength

A similar trend to that seen in the compressive strength graph also became apparent in the flexural strength of mortar samples. After 28 days of curing, the flexural strength of various mortar beam specimens having different marble powder as sand is depicted in **Error! Reference source not found.** . Mortar prepared with waste marble powder exhibited

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 09, RTMSE-2026

higher flexural strength than mortar with 0% marble powder. The highest strength was observed at 30% replacement ratio of fine particles. The addition of WMp boosted the flexural strength after 28 days of curing for WMp-30 compared to the conventional outcome. Thus, the waste marble powder as fine aggregates in mortar samples achieved higher flexural strength than the conventional mortar samples.

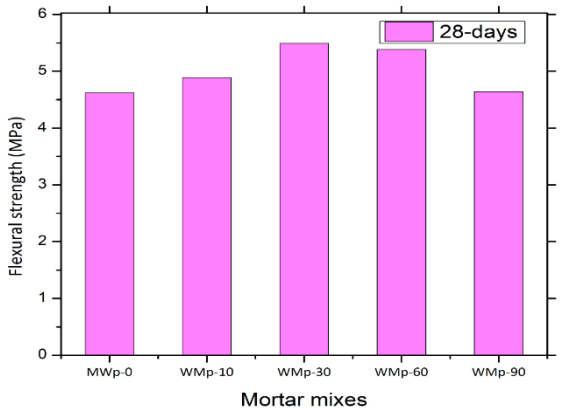

Figure 2 Flexural strength of different mortar mixes

3.3 Density

A variation in the density of different mixes is represented in *Figure 3*. The various elements that affect the density of mortar mass include compaction and the types of materials. The results of density show that the inclusion of waste marble potentially increases the density of samples due to the physical properties of WMp. The finer particles and density of marble reduce the pores in the structure, resulting in a compact mortar rather than conventional mortar.

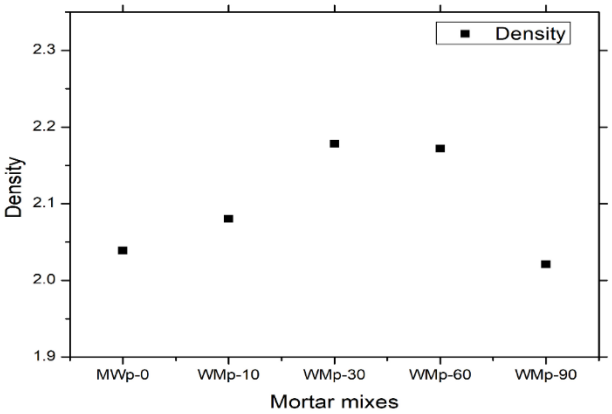

Figure 3 Density of mortar mixes with WMp

4. STATISTICAL ANALYSIS

It has been observed that compressive, flexural strength, and density are directly correlated. It is stated that the replacement of sand with marble powder in mortar mix exerts a favorable impact on strength and durability properties. From statistical analysis, the coefficient of correlation, i.e., R^2 values were obtained from the equation for the mentioned properties. *Figure 4* and

Figure 5 indicate the value of R^2 and the equations between the properties.

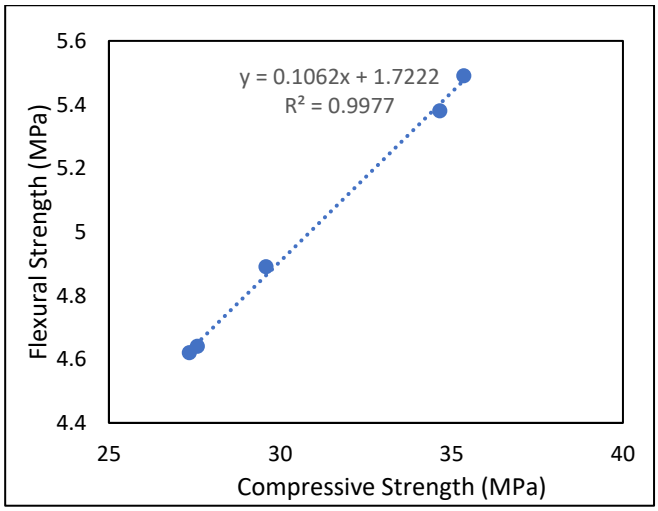

Figure 4 Compressive strength vs flexural strength

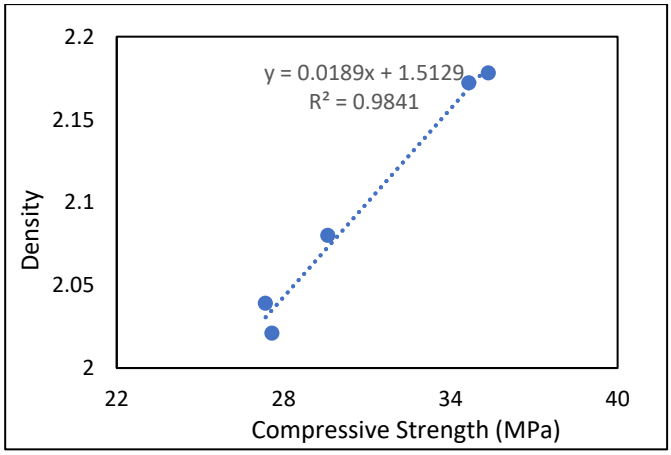

Figure 5 Compressive strength vs density

5. CONCLUSIONS

From the experimental program, the following inferences are obtained:

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 09, RTMSE-2026

- The replacement of sand with marble powder in mortar got substantial increment in compressive strength. All mixes attained a higher strength with the inclusion of WMp than the conventional mix. Adding marble waste as sand at a 30% replacement rate resulted in the maximum increase in compressive strength compared to WMp-0 at 28 days. Consequently, the optimal strength is observed at 30% replacement level.
- The flexural strength of mortar incorporated with marble exceeded that of conventional mortar. This rise in strength was due to the higher content of lime, which improved the binding; resulted from the hydration process. Furthermore, at 30% replacement amount, the maximum flexural strength was achieved.
- The statistical analysis reported a high correlation between the properties of different mortar mixes, which shows a positive relationship between them.
- According to the experimental results, it is speculated that the waste marble powder has the potential to be used as supplant of sand and improve the properties of mortar. Additionally, its application in construction helps to preserve the natural resources and environment.

6. REFERENCES

[1] Naik, T.R., "Sustainability of Concrete Construction" Practice Periodical on Structural Design and Construction, 2008. **13**(2): p. 98-103.
[2] Vardhan, K., R. Siddique, and S. Goyal, "Influence of marble waste as partial replacement of fine aggregates on strength and drying shrinkage of concrete". Construction and Building Materials, 2019. **228**: p. 116730.
[3] López-Uceda, A., Fernandez-Ledesma, E., Jimenez, J.R. and Fernandez-Rodriguez, J.M., "Performance of Sustainable Mortars Made with Filler from Different Construction By-Products". Materials, 2022. **15**(7): p. 2636.
[4] Barbosa, M.T.G., W.J.d. Santos, and C.V.G. Coura, "High quality of mortar with marble waste aggregate". Ambiente Construído, 2018. **18**: p. 387-399.
[5] Baxi, A., D.K. Patel, and G. Bhatt, "Use of fly ash as partial replacement of sand in concrete". Discovery, 2018. **54**(267): p. 102-108.
[6] Tavakoli, D., M. Hashempour, and A. Heidari, "Use of waste materials in concrete: A review". Pertanika J. Sci. Technol, 2018. **26**(2): p. 499-522.
[7] Aggarwal, Y. and Siddique, Rafat, "Microstructure and properties of concrete using bottom ash and waste foundry sand as partial replacement of fine aggregates". Construction and Building Materials, 2014. **54**: p. 210-223. .
[8] Rao, B.K., "Study on marble powder as partial replacement of cement in normal compacting concrete". IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X, 2016. **13**(4): p. 01-05.
[9] Vardhan, K., Goyal, Shweta, Siddique, Rafat, Singh, M., "Mechanical properties and microstructural analysis of cement mortar incorporating marble powder as partial replacement of cement". Construction and Building Materials, 2015. **96**: p. 615-621.
[10] Elsafi, M., Almousa, N., Al-Harbi, N., Almutiri, M.N., Yasmin, S., and Sayyed M.I., et al., "Ecofriendly and radiation shielding properties of newly developed epoxy with waste marble and WO3 nanoparticles". Journal of Materials Research and Technology, 2023. **22**: p. 269-277.
[11] Demirel, B., "The effect of the using waste marble dust as fine sand on the mechanical properties of the concrete". International journal of the physical sciences, 2010. **5**(9): p. 1372-1380.
[12] Lakshmi, H., "Partial Replacement of fine and coarse aggregate by using marble powder and demolished waste". Intnl. J. of Adv. Res. in Sc. & Engg., 2017. **6**: p. 298-303.
[13] Gameiro, F., J. De Brito, and D.C. Da Silva, "Durability performance of structural concrete containing fine aggregates from waste generated by marble quarrying industry". Engineering Structures, 2014. **59**: p. 654-662.
[14] Kabeer, K.I.S.A. and A.K. Vyas, "Utilization of marble powder as fine aggregate in mortar mixes". Construction and Building Materials, 2018. **165**: p. 321-332.
[15] BIS:8112, Ordinary Portland cement, 43 grade-specification. Bureau of Indian Standards, New Delhi, India, 2013.
[16] BIS:383, Coarse and Fine Aggregates for Concrete-Specification, Bureau of Indian Standards, New Delhi, 2016.
[17] ASTM, Standard Test Method for Density, Absorption, and Voids in Hardened Concrete, Annual Book of ASTM Standards (Pennsylvania, USA), 2006. C642.

(This work is licensed under a Creative Commons Attribution 4.0 International License.)