Journal of
Construction Engineering,
Technology & Management

ISSN: 2249-4723 (Online)
ISSN: 2347-7253 (Print)
Volume 14, Issue 2, 2024
May–August
DOI (Journal): 10.37591/JoCETM

https://journals.stmjournals.com/jocetm

Review JoCETM

# Study of the Effect of Partial Replacement of Cement with Marble Powder and Partial Replacement of Sand with *Surkhi*

Apurva P. Pimpalkar[1,*], S.A. Bhalchandra[2]

***Abstract***

*The construction industry worldwide has made remarkable progress in building innovative structures using different materials. Today's increasing population demands more sustainable ways of living. Waste matter produced in the day-to-day life as well as industrial waste have become a cause of concern. Many waste materials have been used in construction industry, for example, fly ash, saw dust, natural fibers residue, etc. Keeping in mind the above concern a low-cost, environment-friendly, and sustainable options are to be explored. Bricks are one of the key elements in building structures and are used worldwide. Different combination of materials used in conventional bricks have given better properties than conventional bricks. Bricks are ground into a powder to create surkhi, an artificial pozzolanic material. Surkhi is also used in waterproofing cement mortars and concrete. It also possesses the property to make concrete more resistant towards alkalis and salt solutions. Similarly waste marble powder a residue from marble cutting acts a fine replacement to cement. It provides strength to concrete up to certain proportions of replacement. The paper focuses on combination of replacing cement with marble powder and replacing the fine aggregate with surkhi, both waste materials used to provide a sustainable option in construction industry. Trials of various proportion mixes were done and compressive strength of each was tested and determined.*

**Keywords:** Marble powder, *surkhi*, compressive strength, concrete, mix proportions, sustainability

## INTRODUCTION

In modern construction practices, concrete stands as a cornerstone material, renowned for its versatility, strength, and durability. However, the conventional production processes of concrete rely heavily on finite natural resources, such as sand and cement, which pose significant environmental challenges and economic burdens. In response, researchers and engineers have increasingly turned their attention to alternative materials and substitute techniques to address these concerns while enhancing concrete performance. One such promising approach is the partial replacement of sand with *surkhi* and cement with marble powder in concrete formulations. This innovative strategy presents a myriad of benefits that extend beyond mere cost savings and sustainability considerations.

Moreover, the core of this strategy is sustainability. Partial replacement mitigates the demand for natural resources, conserving precious

***Author for Correspondence**
Apurva. P. Pimpalkar
Email: apurvapimpalkar02@gmail.com

[1]M. Tech Student, Department of Applied Mechanics, Government College of Engineering, Chh. Sambhajinagar (Aurangabad), Maharashtra, India
[2]Professor, Department of Applied Mechanics, Government College of Engineering Chh. Sambhajinagar (Aurangabad), Maharashtra, India

Received Date: July 08, 2024
Accepted Date: July 16, 2024
Published Date: July 18, 2024

**Citation:** Apurva P. Pimpalkar, S.A. Bhalchandra. Study of the Effect of Partial Replacement of Cement with Marble Powder and Partial Replacement of Sand with *Surkhi*. Journal of Construction Engineering, Technology & Management. 2024; 14(2): 46–54p.

 

sand deposits and alleviating the environmental strain associated with sand mining. Additionally, by utilizing waste materials like marble powder, derived from industrial processes, this method promotes economic principles by repurposing materials that would otherwise contribute to landfill waste. Cost efficiency emerges as a compelling advantage on a large scale. By incorporating alternative materials like *surkhi* and marble powder, which are often more readily available and economically viable compared to traditional counterparts, construction costs can be significantly reduced and more sustainable option can be made available.

Beyond cost and sustainability, the integration of *surkhi* and marble powder enhances the workability of concrete mixes. These materials act as fillers, improving cohesion and facilitating ease of placement during construction, thereby streamlining the building process. Furthermore, the mechanical properties of concrete are notably enhanced through partial replacement. *Surkhi's* pozzolanic properties foster the formation of additional cementitious compounds, augmenting compressive strength, flexural strength, and overall durability. Meanwhile, marble powder improves packing density and reduces porosity within the concrete matrix, reduces shrinkage and cracking tendencies, thus extending the service life of structures.

## AIM AND OBJECTIVES

Specific objectives of the research were

- To examine the behavior of concrete incorporating marble powder and *surkhi*.
- To evaluate the mechanical properties of concrete containing *surkhi* and marble powder, with a focus on compressive strength.
- To provide a sustainable option in construction industry.

## LITERATURE REVIEW

Polydorou et al. [1] investigated that industrial quarry waste build-up is yet another environmental issue and health threat. The danger could be reduced significantly or even resolved by inclusion of quarry waste in concrete and cementitious materials. By using quarry waste as a substitute for aggregate, cement, or additional cementitious material, it is possible to address the issue of waste accumulation while also making concrete and mortar compositions more sustainable. Quarry waste integration not only improves sustainability but also solves interfacial transition zone (ITZ) problems in concrete composites and improves some of the mechanical qualities of concrete. The use of quarry waste as a substitute for cement and aggregate was covered in this study, along with how it affects the durability and fresh and hardened properties of concrete, such as workability, density, splitting tensile strength, flexural strength, compressive strength, water absorption, and chloride resistance [1].

Arif et al. [2] reviewed that to determine whether waste brick powder (WBP) could be used successfully in place of cement in concrete. Comparing the replacement levels to the reference concrete, they were maintained at 5% and 10%. The tests included microscopic examination, Schmidt Hammer, ultrasonic pulse velocity, slump, density, compressive, flexural, and splitting tensile strengths. The workability increased as a result of the WBP's particle size and shape, according to the data. The smooth surfaces and rounded edges of WBP particles lubricate the mixture and produce a ball-bearing effect. The reduced density of WBP is the cause of the density drop. The improvement in concrete quality was indicated by the rise in compressive, split tensile, and flexural strengths. Waste brick powder's physical and chemical characteristics meet the needs of a pozzolanic material for concrete. The workability of concrete is improved by adding brick powder up to 30% more of the slump can be experienced if WBP is used to replace 10% of ordinary Portland cement (OPC). Concrete gains greater flexural, split tensile, and compressive strength when WBP is applied.

Compressive, tensile, and flexural strengths increase by 18%, 17%, and 3.5% in the fresh condition and by 10%, 24%, and 12% in the hardened state, respectively, when 10% of the cement is replaced with WBP [2].

 

Mansoor et al. [3] stated that the goal of the investigation was to determine the ideal amount of WBP to replace some of the cement. Three sets of tests were conducted for this purpose: mechanical, permeation properties, and fresh properties. The percentages of substituting ratios in the eight variations that follow are 10%, 15%, 20%, 25%, 30%, 35%, 40%, and 50%. In addition to the reference mix without powder replacements, the experimental programs comprise three groups of tests: transport properties (water absorption ratio, rate of water absorption, i.e., sorptivity, and permeable void ratio), fresh properties (flow test and fresh density), and mechanical properties (dry density, compressive strength, and flexural strength). However, for mixtures with a brick powder percentage of up to 20%, it was discovered that the in-hardened state's density was marginally higher than the reference mix. The results indicate that mixes incorporating WBP exhibit greater strength compared to the control mix. The combination with 15% WBP for both was tested for its maximum strength for both compressive and tensile strength.

On the other hand, a tiny rise in dry density was seen for brick powder at 10% and 15%. For a constant water/binder ratio, it was discovered that the flowability, or workability, of fresh mixes reduced linearly as the quantity of waste brick powder rose. The findings show that WBP-containing mixes had stronger results than control mixes. Both the compressive and tensile strengths of the specimens were tested, and the mix containing 15% WBP showed the highest strength [3].

Singhal et al. [4] found that the increase in demand is causing the output of marble to climb. From mining to the finished product, marble must pass through a number of procedures in the production process. When marble stone is prepared, a large quantity of waste is created. This waste can take many different forms, such as slurry, grits, boulders, and pebbles. When these wastes are dumped on roadsides, forest land, etc., they are not properly disposed of, which degrades the ecology around them. Findings indicate that while adding fly ash to replace 35% of the cement improved the fresh qualities, adding more admixture was necessary to achieve the necessary workability when replacing fine aggregate with marble slurry powder (MSP). The compaction factor increases when fly ash takes the place of OPC by 35%. However, adding MSP in place of fine aggregate reduced the workability.

The fresh density of the mix reduces after 35% OPC replacement by fly ash in comparison to the control mix. The combination of F35M20, however, was shown to have the optimum fresh density value. At 28 days, the flexural strength of all the replacement mixes was less than that of the control mix. But a mix that substituted 20% MSP for fine aggregate was able to reach the desired 28-day flexural strength (F35M20) [4].

Singh et al. [5] reviewed that recently, there has been a lot of interest in research on using marble powder in place of some of the cement in concrete. This research presents the influence of dried marble powder on concrete particle packing. The impact of marble powder on the hydration process, strength activity index, and potential causes of the strength increase have all been studied experimentally. Furthermore, two mathematical models for marble powder added to concrete were created utilizing statistical techniques and experimental data. The first model relates the proportion of marble powder replacement to the ratios of 28 -day compressive strength between control concrete and concrete that has had some of its cement replaced by marble powder. The second model that has been suggested offers streamlined and adjusted relationships for the water-cement law in cases when marble powder is used in place of some cement. Based on an analysis of the literature and experimental findings, recommendations have been proposed for using marble powder as a partial substitute for cement in concrete [5].

Ashish et al. [6] stated that the current study investigates whether adding more cementitious ingredients to marble powder can make it feasible to use it in two better ways. In nine different concrete compositions, sand was partially substituted with up to 15% marble powder and cement with up to 4% additional cementitious material. Tests such as compressive strength, split tensile strength, ultrasonic pulse velocity, carbonation, and microstructure analysis were performed on concrete that was created with marble powder and eight additional cementitious ingredients in order to evaluate its varied attributes. Additionally, 11 mixed cement paste preparations employed marble powder in place of some of the cement [6].

Aliabdo et al. [7] determined that leftover marble dust could be used to manufacture cement and concrete. The research project is divided into two main sections. The first section explores the characteristics of cement that has been modified with the addition of marble dust. The second section examines the properties of concrete when marble dust is used as a substitute for both cement and sand. The replacement ratios with weights of 0.0%, 5.0%, 7.5%, 10.0%, and 15% were studied. The corresponding water-to-powder (w/p) or water-to-cement (w/c) ratios were 0.50 and 0.40, respectively, when substituting cement or sand. Marble dust had a filling effect on the concrete rather than a major contribution to the hydration. The use of marble dust does not significantly affect the cement pastes' initial or final setting times. Replacing cement with marble dust enhances the compressive strength of cement mortar. When 10.0% marble dust is substituted for either sand or cement, the greatest improvement in steel-concrete bond strength is observed. However, it performed worse than concrete made with marble dust as a replacement for cement. This was apparent in the concrete that was created by substituting marble dust for sand. When dust is used in place of cement or sand during the first setting. There is minimal impact on the mixture when marble dust is added up to 15.0% by weight in place of cement or sand [7].

## MATERIALS USED

### Cement

Ordinary Portland cement (OPC) with a specific gravity of 3.15 was utilized. Specifically, UltraTech's OPC grade 53 was selected, meeting the BIS standards outlined in IS:12269-1987.

### Fine Aggregate

River sand served as the fine aggregate, and testing was performed according to the guidelines specified in IS 2386 (Part I).

The sand accessible locally passed through 4.75 mm I.S. sieve and was retained on 75 µm sieve. The specific gravity was 2.58. The fineness aggregates used in the sample was 2.65 and sand was falling under Zone II [8–11].

### *Coarse Aggregate*

Coarse aggregates if size 20 mm and 10 mm were used with specific gravity 2.73 and 2.62, respectively. A total of 60% 20-mm aggregates and 40% 10-mm aggregates were used. The aggregates were passed through 40 mm sieve and retained on 4.75 mm sieve.

### *Surkhi*

Natural brick powder was used. Bricks were bought from local vendors and crushed to powder and passed through 75 µm sieve.

### *Marble Powder*

Marble powder collected from the local vendors. A crystal white marble powder was used.

## METHODOLOGY

Mix proportions for grade of M-30 grade were designed by replacing cement and fine aggregate with marble powder and *surkhi*, respectively, in different variations. Mix design was designed as per IS 10262:2019 with water cement ratio of 0.45, to achieve a target strength of 38.25 N/mm$^2$. Tweleve different proportions were designed where M states the percentage of cement replaced with marble powder and S states the replacement of *surkhi* with fine aggregate sand. Three different sets of proportions were made with a total of 12 variations, 4 variations in each set with same cement percentage replaced with different *surkhi* replacing sand variations.

- *Set 1* [M6S10, M6S120, M6S30, M6S40]
- *Set 2* [M9S10, M9S20, M9S30, M9S40]
- *Set 3* [ M12S10, M12S20, M12S30, M12S40]

Table 1 shows the variations with their full forms and percent replacements. The proportions were as follows.

## EXPERIMENTAL ANALYSIS

Fresh concrete was prepared and was poured in the cube specimen of 150 mm × 150 mm × 150 mm. Three specimens for 7 days and 3 specimens for 28 days of each variations were cast and cured. In total, 72 specimens were cast. Automated compression testing machine (CTM) was used for testing the specimens. The compressive strength was calculated using the formula:

$$f_c = P/A$$

- where $f_c$ = compressive strength (N/mm$^2$)
- P = maximum load (N)
- A = cross section of sample (mm$^2$)

## RESULTS AND DISCUSSION

Twelve different variations were cast and were tested for compressive strength of 7 days and 28 days of curing.

Six cubes of each variation were cast for 7 days and 28 days. Varying results were obtained with different percent combinations of replacing cement and sand with marble powder and *surkhi*, respectively. The observations and readings of the different proportions are given below.

The first set of proportions were taken of 6% replacement of cement with marble powder and sand replacement with *surkhi* with percent varying from 10% to 40%.

Table 2 shows the readings of 7 days and 28 days compressive strength of the above variations.

Figure 1 depicts comparison of compressive strengths for 7 days and 28 days of 6% replacement of cement with marble powder and sand replacement with *surkhi* varying from 10% to 40%.

**Table 1.** Abbreviations of variations.

| S.N. | Variations Abbreviations | Percent Variations |
|---|---|---|
| 1 | M6S10 | 6% marble powder; 10% *surkhi* |
| 2 | M6S20 | 6% marble powder; 20% *surkhi* |
| 3 | M6S30 | 6% marble powder; 30% *surkhi* |
| 4 | M6S40 | 6% marble powder; 40% *surkhi* |
| 5 | M9S10 | 9% marble powder; 10% *surkhi* |
| 6 | M9S20 | 9% marble powder; 20% *surkhi* |
| 7 | M9S30 | 9% marble powder; 30% *surkhi* |
| 8 | M9S40 | 9% marble powder; 40% *surkhi* |
| 9 | M12S10 | 12% marble powder; 10% *surkhi* |
| 10 | M12S20 | 12% marble powder; 20% *surkhi* |
| 11 | M12S30 | 12% marble powder; 30% *surkhi* |
| 12 | M12S40 | 12% marble powder; 40% *surkhi* |

 

**Table 2.** Readings of 7 days and 28 days compressive strength Set 1 variations.

| Mix Proportions | 7 Days Strength in $N/mm^2$ | 28 Days Strength in $N/mm^2$ |
|---|---|---|
| M6S10 | 17.33 | 30.22 |
| M6S20 | 19.55 | 31.11 |
| M6S30 | 20 | 33.33 |
| M6S40 | 22.22 | 34.66 |

**Table 3.** Readings of 7 days and 28 days compressive strength Set 2 variations.

| Mix Proportions | 7 Days Strength in $N/mm^2$ | 28 Days Strength in $N/mm^2$ |
|---|---|---|
| M9S10 | 21.33 | 39.33 |
| M9S20 | 22.66 | 40.44 |
| M9S30 | 24.44 | 44.44 |
| M9S40 | 26.66 | 42.66 |

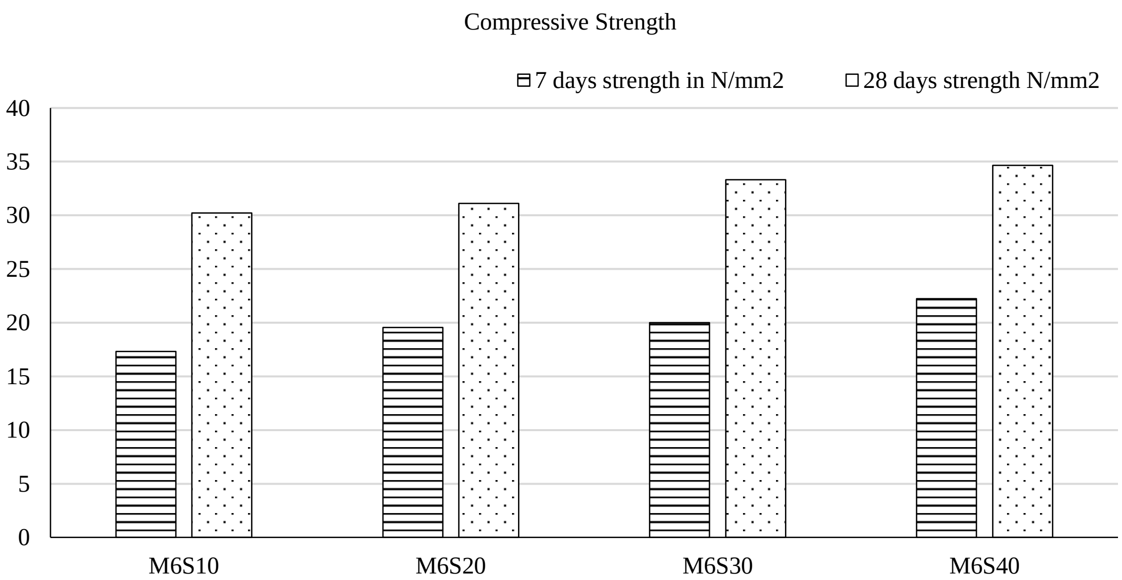


**Figure 1.** Comparison of 7 days and 28 days strength of Set 1 variations.

The second set of proportions were taken of 9% replacement of cement with marble powder and sand replacement with surkhi varying from 10% to 40%.

Table 3 shows the readings of 7 days and 28 days compressive strength of the above variations.

Figure 2 depicts comparison of compressive strengths for 7 days and 28 days of 9% replacement of cement with marble powder and sand replacement with *surkhi* varying from 10% to 40%.

The third set of proportions were taken of 12% replacement of cement with marble powder and sand replacement with *surkhi* varying from 10% to 40%.

Table 4 shows the readings of 7 days and 28 days compressive strength of the above variations.

Figure 3 depicts comparison of compressive strengths for 7 days and 28 days of 12% replacement of cement with marble powder and sand replacement with *surkhi* varying from 10% to 40%.

 

Journal of Construction Engineering, Technology & Management
Volume 14, Issue 2
ISSN: 2249-4723 (Online), ISSN: 2347-7253 (Print)

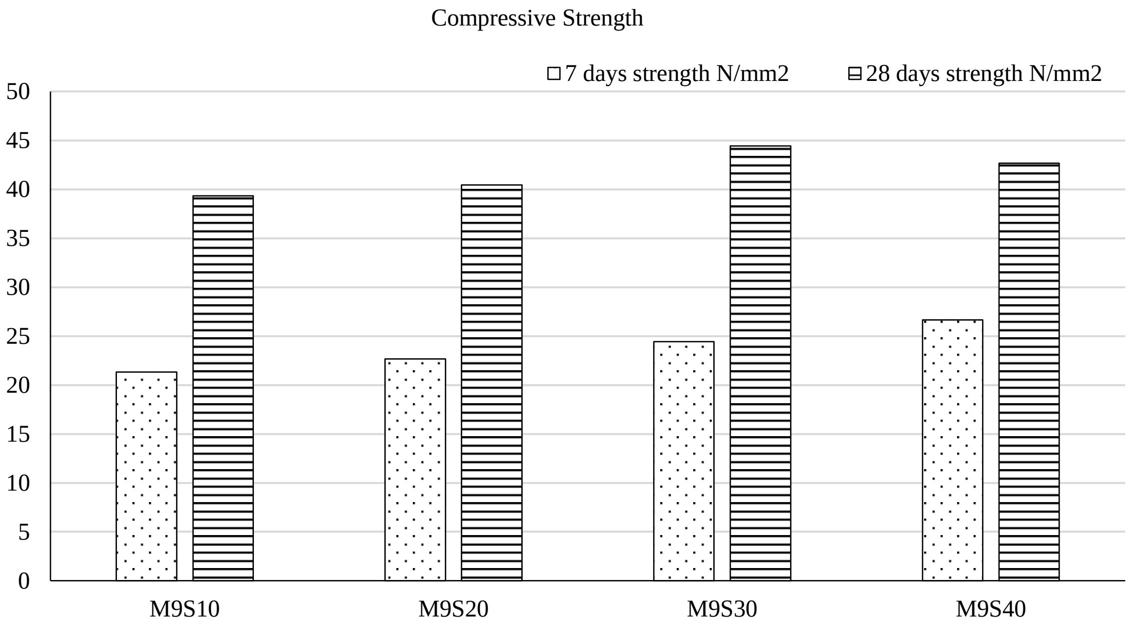


**Figure 2.** Comparison of 7 days and 28 days strength of Set 2 variations.

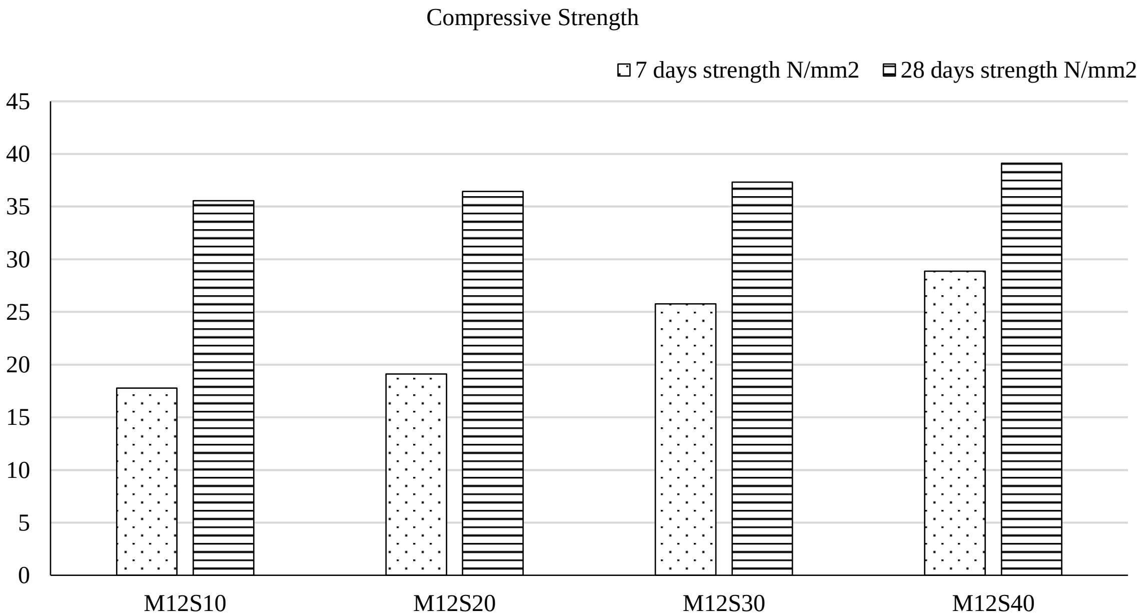


**Figure 3.** Comparison of 7 days and 28 days strength of Set 3 variations.

**Table 4.** Readings of 7 days and 28 days compressive strength Set 3 variations.

| Mix Proportions | 7 Days Strength in N/mm$^2$ | 28 Days Strength in N/mm$^2$ |
|---|---|---|
| M12S10 | 17.77 | 35.55 |
| M12S20 | 19.11 | 36.44 |
| M12S30 | 25.77 | 37.33 |
| M12S40 | 28.88 | 39.11 |

## CONCLUSIONS AND FINDINGS

The experimental analysis was done on replacing cement with marble powder and sand with *surkhi* in various proportions. Different specimens were cast and the compressive strength test was taken on 7 days and 28 days, respectively. As per the IS 10262:2019, the average compressive strength of cubes at

7 days should not be less than 65% and that at 28 days should not be less than 90%. The conclusions were drawn from the results:

1. All variations with marble powder replacing cement with 9 % as well as 12% and *surkhi* replacing sand variations with 10%, 20%, 30%, 40% shows an increase in the 28th day compressive strength of cubes.
2. A slight reduction in 7 days strength of variation with 9% marble powder replacement and 10% and 20% *surkhi* was observed.
3. Proportion mix with 9% marble powder replacement and 30% and 40% *surkhi* showed satisfactory 7th day strength.
4. Similarly, reduction in 7 days strength of variation with 12% marble powder replacement and 10% and 20% *surkhi* was observed.
5. A satisfactory gain in 7 days strength with 12% marble powder replacement and 30% and 40% *surkhi* was seen.
6. Proportion mix of 6% marble powder and 40% *surkhi* satisfies the 28 days criteria for compressive strength while all other proportions with 6% marble powder are observed to decrease the compressive strength significantly.
7. It is observed that percent increase in surkhi with respect to marble powder in variation increases the compressive strength.
8. A noticeable decrease in compressive strength is observed when percent of *surkhi* decreases with increased percent of marble powder (Figures 4 and 5).


**Figure 4.** The cast specimens.

**Figure 5.** Compression testing machine (CTM).

**REFERENCES**

1. Polydorou T, Kyriakides N, Neocleous K, Hadjimitsis D. Use of quarry waste in concrete and cementitious mortars. In: Colangelo F, Cioffi R, Farina I, editors. Handbook of Sustainable Concrete and Industrial Waste Management. Amsterdam, Netherlands: Elsevier; 2022. 289–304.
2. Arif R, Khitab A, Kırgız MS, Khan RBN, Tayyab S, Khan RA, Anwar W, Arshad MT. Experimental analysis on partial replacement of cement with brick powder in concrete. Case Stud Construct Mater. 2021; 15: e00749.
3. Mansoor SS, Hama SM, Hamdullah DN. Effectiveness of replacing cement partially with waste brick powder in mortar. J Eng Sci. 2021; 131: 401–408.
4. Singhal V, Nagar R, Agrawal V. Use of marble slurry powder and fly ash to obtain sustainable concrete. Mater Today Proc. 2021; 44 (Part 6): 4387–4392.
5. Singh M, Srivastava A, Bhunia D. Analytical and experimental investigations on using waste marble powder in concrete. J Mater Civil Eng. 2019; 31 (4): 04019011.
6. Ashish DA. Concrete made with waste marble powder and supplementary cementitious material for sustainable development. J Cleaner Prod. 2019; 211: 716–729.
7. Aliabdo AA, Abd Elmoaty M, Auda EM. Re-use of waste marble dust in the production of cement and concrete. Construct Build Mater. 2013; 50: 28–41.
8. Hebhoub H, Aoun H, Belachia M, Houari H, Ghorbel E. Use of waste marble aggregates in concrete. Construct Build Mater. 2011; 25 (3): 1167–1171.
9. Corinaldesi V, Moriconi G, Naik TR. Characterization of marble powder for its use in mortar and concrete. Construct Build Mater. 2009; 11: 113–117.
10. Ge Z, Gao Z, Sun R, Zheng L. Mix design of concrete with recycled clay-brick-powder using the orthogonal design method. Construct Build Mater. 2012; 31: 289–293.
11. Soutsos MN, Tang K, Millard SG. Concrete building blocks made with recycled demolition aggregate. Construct Build Mater. 2011; 25 (2): 726–735.

 