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# The Effect of Using Volcanic Sand from Mount Soputan as a Substitute for Fine Aggregate in the Production of Bricks

Syanne Pangemanan[1*], Josep A. J. Sumajouw[2], Don R. G. Kabo[3], Barakati K. Manginsihi[4]

Politeknik Negeri Manado

**Corresponding Author**: Syanne Pangemanan syannepangemanan70@gmail.com

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ABSTRACT

Concrete blocks are a type of building unit shaped like bricks, made from a primary mix of Portland cement, water, and fine aggregate, used for wall construction. The purpose of this study is to assess the effect of using volcanic sand from Mount Soputan as a substitute for fine aggregate on the water absorption and compressive strength of concrete blocks. Based on absorption tests at 28 days, high water absorption values were observed during immersion periods of 1, 5, 10, 30, 60 minutes, and 24 hours. The highest absorption value was found in normal concrete blocks at 1.30%, and with 20% volcanic sand addition at 1.16%. High water absorption is due to the larger pores in these concrete blocks compared to other variations. Conversely, the lowest water absorption was observed in the 30% volcanic sand variation at 0.80% and the 40% volcanic sand variation at 0.75%. According to the compressive strength test results, the highest compressive strength was found in the 40% volcanic sand mixture at 28 days, with a value of 250.95 kg/cm². Meanwhile, the lowest 28-day compressive strength among all mixtures was found in the normal concrete blocks, with a value of 164.50 kg/cm². Among the volcanic sand mixtures, the lowest 28-day compressive strength was found in the 20% volcanic sand variation, with a value of 176.82 kg/cm². Therefore, it can be concluded that the use of volcanic sand as a partial substitute for fine aggregate affects the compressive strength of concrete blocks, with the 40% substitution level giving the best performance in this study.Therefore, it can be concluded that the use of volcanic sand in the production of concrete blocks significantly affects their compressive strength

## INTRODUCTION

In the modern era, many home construction projects in major cities across Indonesia have begun using concrete blocks as a wall material. The use of wooden and brick walls is gradually being phased out. The availability of eco-friendly building materials can help reduce the Earth's surface temperature and minimize the use of air conditioning, thereby saving on energy costs.

Recent studies have shown that volcanic materials have potential as alternative construction materials because their mineral composition and particle characteristics can influence the mechanical and physical properties of cement-based products. Aulia et al. (2024) reported that volcanic sand substitution in high-strength concrete affected compressive strength, absorption, modulus of elasticity, and crack patterns. Their study found that 10% volcanic sand substitution improved compressive strength, while higher substitution levels tended to reduce performance. Similarly, Gil-Martín et al. (2025) found that volcanic ash could be used as a partial replacement for cement or sand in mortar, with promising results when used within an optimum substitution range.

However, most previous studies have focused on concrete, high-strength concrete, or mortar, while limited studies have specifically examined the use of local volcanic sand as a partial substitute for fine aggregate in concrete blocks. In addition, the performance of concrete blocks is not only determined by compressive strength but also by water absorption and conformity with the Indonesian standard SNI 03-0349-1989. Therefore, the research gap addressed in this study is the limited experimental evidence on the optimum percentage of Mount Soputan volcanic sand substitution in concrete block production based on compressive strength, water absorption, and quality classification according to SNI requirements. The novelty of this study lies in the use of local volcanic sand from Mount Soputan as a fine aggregate substitute in concrete blocks and the evaluation of its technical feasibility through laboratory testing and standard-based performance classification.

Based on the above explanation, this study aims to measure the compressive strength and water absorption of volcanic sand used as a substitute for fine aggregate in the production of concrete blocks. Although sand is abundant, it is a non-renewable resource. The improper use of sand can lead to environmental pollution and resource depletion. One way to address this issue is through the dredging of volcanic materials, which can also help reduce river siltation.

## METHODS

### Place and Time of Research

This study was conducted in Kombos Timur, Singkil District, Manado City. This location was chosen because of the availability of equipment and a suitable site for the production of the concrete block test specimens. The study was conducted over approximately five months, from April to August 2023, covering the production, curing, and testing of the test specimens.

### Data Types and Data Collection Methods

The types of data used in this study are primary data and literature review. Primary data is data obtained or collected directly in the field by the researcher from the relevant individuals.

The method used in this study is a laboratory experimental method, with testing conducted at the Materials Testing Laboratory of the Manado State Polytechnic. The main objects of this study are standard concrete blocks and modified concrete blocks that use volcanic sand as a substitute for fine aggregate in the production of concrete blocks, with substitution rates of 0%, 10%, 20%, 30%, and 40%. Tests will be conducted to determine the compressive strength and water absorption of the concrete blocks.

### Statistical Analysis

The compressive strength data were analyzed statistically to determine whether volcanic sand substitution and curing age significantly affected the strength of concrete blocks. A two-way analysis of variance (ANOVA) was used with two independent factors: volcanic sand substitution level (0%, 10%, 20%, 30%, and 40%) and curing age (7, 14, and 28 days). In addition, one-way ANOVA was conducted at each curing age to evaluate the effect of mixture variation separately. When significant differences were found, Tukey's Honestly Significant Difference (HSD) post-hoc test was used to identify differences between mixture groups. The normality of residuals was checked using the Shapiro-Wilk test, while the homogeneity of variance was checked using Levene's test. The level of significance was set at $\alpha = 0.05$.

**Statistical Analysis of Compressive Strength Results**

The two-way ANOVA results showed that both volcanic sand substitution level and curing age had a significant effect on compressive strength. The effect of mixture variation was significant, $F(4,45) = 11.031$, $p < 0.001$, and the effect of curing age was also significant, $F(2,45) = 14.909$, $p < 0.001$. However, the interaction between mixture variation and curing age was not significant, $F(8,45) = 0.309$, $p = 0.959$. This indicates that the increase in compressive strength was influenced independently by the substitution level and curing age, but the pattern of strength development over time was relatively consistent across the mixture variations.

The one-way ANOVA results showed that the effect of mixture variation was significant at 7 days, $F = 5.520$, $p = 0.006$, and at 14 days, $F = 4.733$, $p = 0.011$. At 28 days, the effect was not statistically significant at the 5% level, $F = 2.390$, $p = 0.097$, although the 40% volcanic sand mixture produced the highest average compressive strength. Therefore, the statement that the 40% volcanic sand mixture produced the highest strength should be interpreted as a descriptive trend at 28 days, while the overall ANOVA across all ages confirms that volcanic sand substitution significantly affects compressive strength.

Table 2. Statistical Analysis

| **Source of Variation** | | **df** | **F-value** | **p-value** | **Interpretation** |
|---|---|---|---|---|---|
| Volcanic sand substitution | | 4 | 11.031 | <0.001 | Significant |
| Curing age | | 2 | 14.909 | <0.001 | Significant |
| Interaction | | 8 | 0.309 | 0.959 | Not significant |

## Results and Discussion

Research results obtained from testing concrete blocks at the Materials Testing Laboratory of the Civil Engineering Department at Manado State Polytechnic, including compressive strength testing and water absorption testing of the concrete blocks

Compressive Strength Testing

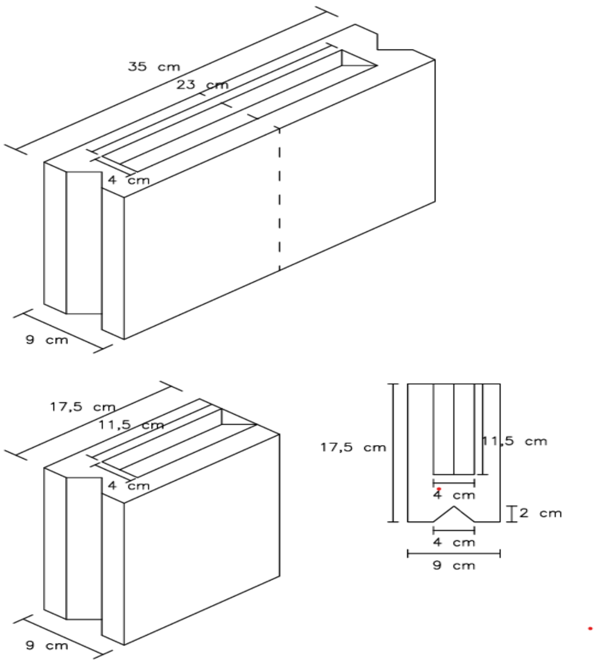


Figure 1. Sketch of Batako

The calculation of bricks as shown in Figure 3.1 is as follows:

A1 = 17,5 cm x 9 cm
= 157,5 cm2
B1 = 11,5 cm x 4 cm
= 46 cm2
C1 = ½ x 4 cm x 2 cm
= 4 cm2
A1 – (B1 + C1) = 157,5 cm2 – (46 cm2 + 4 cm2)
= 107,5 cm2

The compressive strength test results for each concrete block sample were calculated using the compressive strength formula, as shown in Equation 2.8. The test results yielded the compressive strength values for each sample, as well as the average values for each mixture variation and curing age, which are presented in Tables 3.1 through 3.5 and Figure 3.2.

Table 3. Average Compressive Strength of Normal Concrete Bricks

| No. | Concrete Block Code | Casting Date | Test Date | Age (Days) | Initial Weight (kg) | Length, P | Width, L | Height, T | Cross-Sectional Area ($cm^2$) A = P × L | Compressive Load (kgf) | Compressive Strength ($kg/cm^2$) | Compressive Strength (MPa) | Average Compressive Strength (MPa) | Average Compressive Strength ($kg/cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | S1 | 13-Jun-24 | 20-Jun-24 | 7 | 4.465 | 11.5 | 4 | 18 | 46 | 5056 | 109.91 | 10.8 | 10.08 | 102.81 |
| 2 | S2 | 13-Jun-24 | 20-Jun-24 | | 4.575 | 11.5 | 4 | 18 | 46 | 5063 | 110.07 | 10.8 | | |
| 3 | S3 | 13-Jun-24 | 20-Jun-24 | | 4.285 | 11.5 | 4 | 18 | 46 | 4493 | 97.674 | 9.58 | | |
| 4 | S4 | 13-Jun-24 | 20-Jun-24 | | 4.475 | 11.5 | 4 | 18 | 46 | 4305 | 93.587 | 9.18 | | |
| 1 | S1 | 13-Jun-24 | 27-Jun-24 | 14 | 4.55 | 11.5 | 4 | 18 | 46 | 7543 | 163.98 | 16.08 | 15.66 | 159.663 |
| 2 | S2 | 13-Jun-24 | 27-Jun-24 | | 4.61 | 11.5 | 4 | 18 | 46 | 6540 | 142.17 | 13.94 | | |
| 3 | S3 | 13-Jun-24 | 27-Jun-24 | | 4.415 | 11.5 | 4 | 18 | 46 | 6514 | 141.61 | 13.89 | | |
| 4 | S4 | 13-Jun-24 | 27-Jun-24 | | 4.415 | 11.5 | 4 | 18 | 46 | 8781 | 190.89 | 18.72 | | |
| 1 | S1 | 13-Jun-24 | 11-Jul-24 | 28 | 4.845 | 11.5 | 4 | 18 | 46 | 9415 | 204.67 | 20.07 | 16.13 | 164.5 |
| 2 | S2 | 13-Jun-24 | 11-Jul-24 | | 4.875 | 11.5 | 4 | 18 | 46 | 9652 | 209.83 | 20.58 | | |
| 3 | S3 | 13-Jun-24 | 11-Jul-24 | | 4.565 | 11.5 | 4 | 18 | 46 | 5763 | 125.28 | 12.29 | | |
| 4 | S4 | 13-Jun-24 | 11-Jul-24 | | 4.62 | 11.5 | 4 | 18 | 46 | 5438 | 118.22 | 11.59 | | |

Table 4. Average Compressive Strength of 10% PV Concrete Bricks

| No. | Concrete Block Code | Casting Date | Test Date | Age (Days) | Initial Weight (kg) | Length, P | Width, L | Height, T | Cross-Sectional Area ($cm^2$) A = P × L | Compressive Load (kgf) | Compressive Strength ($kg/cm^2$) | Compressive Strength (MPa) | Average Compressive Strength (MPa) | Average Compressive Strength ($kg/cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | S1 | 13-Jun-24 | 20-Jun-24 | 7 | 4.79 | 11.5 | 4 | 18 | 46 | 2762 | 60.043 | 5.89 | 9.81 | 100.049 |
| 2 | S2 | 13-Jun-24 | 20-Jun-24 | | 4.76 | 11.5 | 4 | 18 | 46 | 4925 | 107.07 | 10.5 | | |
| 3 | S3 | 13-Jun-24 | 20-Jun-24 | | 4.795 | 11.5 | 4 | 18 | 46 | 4419 | 96.065 | 9.42 | | |
| 4 | S4 | 13-Jun-24 | 20-Jun-24 | | 4.935 | 11.5 | 4 | 18 | 46 | 6303 | 137.02 | 13.4 | | |
| 1 | S1 | 13-Jun-24 | 27-Jun-24 | 14 | 4.625 | 11.5 | 4 | 18 | 46 | 5804 | 126.17 | 12.4 | 12.58 | 128.283 |
| 2 | S2 | 13-Jun-24 | 27-Jun-24 | | 4.71 | 11.5 | 4 | 18 | 46 | 3256 | 70.783 | 6.94 | | |
| 3 | S3 | 13-Jun-24 | 27-Jun-24 | | 4.695 | 11.5 | 4 | 18 | 46 | 7530 | 163.7 | 16.1 | | |
| 4 | S4 | 13-Jun-24 | 27-Jun-24 | | 4.595 | 11.5 | 4 | 18 | 46 | 7014 | 152.48 | 15 | | |
| 1 | S1 | 13-Jun-24 | 11-Jul-24 | 28 | 4.85 | 11.5 | 4 | 18 | 46 | 6785 | 147.5 | 14.5 | 17.34 | 176.821 |
| 2 | S2 | 13-Jun-24 | 11-Jul-24 | | 4.765 | 11.5 | 4 | 18 | 46 | 9260 | 201.3 | 19.7 | | |
| 3 | S3 | 13-Jun-24 | 11-Jul-24 | | 4.69 | 11.5 | 4 | 18 | 46 | 7772 | 168.96 | 16.6 | | |
| 4 | S4 | 13-Jun-24 | 11-Jul-24 | | 4.68 | 11.5 | 4 | 18 | 46 | 8718 | 189.52 | 18.6 | | |

Table 5. Average Compressive Strength of 20% PV Concrete Bricks

| No. | Concrete Block Code | Casting Date | Test Date | Age (Days) | Initial Weight (kg) | Length, P | Width, L | Height, T | Cross-Sectional Area ($cm^2$) A = P × L | Compressive Load (kgf) | Compressive Strength ($kg/cm^2$) | Compressive Strength (MPa) | Average Compressive Strength (MPa) | Average Compressive Strength ($kg/cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | S1 | 13-Jun-24 | 20-Jun-24 | 7 | 4.63 | 11.5 | 4 | 18 | 46 | 3327 | 72.326 | 7.09 | 12.78 | 130.293 |
| 2 | S2 | 13-Jun-24 | 20-Jun-24 | | 4.73 | 11.5 | 4 | 18 | 46 | 6842 | 148.74 | 14.6 | | |
| 3 | S3 | 13-Jun-24 | 20-Jun-24 | | 4.76 | 11.5 | 4 | 18 | 46 | 6671 | 145.02 | 14.2 | | |
| 4 | S4 | 13-Jun-24 | 20-Jun-24 | | 4.82 | 11.5 | 4 | 18 | 46 | 7134 | 155.09 | 15.2 | | |
| 1 | S1 | 13-Jun-24 | 27-Jun-24 | 14 | 4.825 | 11.5 | 4 | 18 | 46 | 6584 | 143.13 | 14 | 14.43 | 146.207 |
| 2 | S2 | 13-Jun-24 | 27-Jun-24 | | 4.8 | 11.5 | 4 | 18 | 46 | 8551 | 185.89 | 18.2 | | |
| 3 | S3 | 13-Jun-24 | 27-Jun-24 | | 4.865 | 11.5 | 4 | 18 | 46 | 5662 | 123.09 | 12.1 | | |
| 4 | S4 | 13-Jun-24 | 27-Jun-24 | | 4.905 | 11.5 | 4 | 18 | 46 | 6105 | 132.72 | 13 | | |
| 1 | S1 | 13-Jun-24 | 11-Jul-24 | 28 | 4.755 | 11.5 | 4 | 18 | 46 | 11334 | 246.39 | 24.2 | 17.34 | 188.315 |
| 2 | S2 | 13-Jun-24 | 11-Jul-24 | | 5.025 | 11.5 | 4 | 18 | 46 | 10265 | 223.15 | 21.9 | | |
| 3 | S3 | 13-Jun-24 | 11-Jul-24 | | 4.82 | 11.5 | 4 | 18 | 46 | 7088 | 154.09 | 15.1 | | |
| 4 | S4 | 13-Jun-24 | 11-Jul-24 | | 4.795 | 11.5 | 4 | 18 | 46 | 5963 | 129.63 | 12.7 | | |

Table 6. Average Compressive Strength of 30% PV Concrete Bricks

| No. | Concrete Block Code | Casting Date | Test Date | Age (Days) | Initial Weight (kg) | Length, P | Width, L | Height, T | Cross-Sectional Area ($cm^2$) A = P × L | Compressive Load (kgf) | Compressive Strength ($kg/cm^2$) | Compressive Strength (MPa) | Average Compressive Strength (MPa) | Average Compressive Strength ($kg/cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | S1 | 13-Jun-24 | 20-Jun-24 | 7 | 4.67 | 11.5 | 4 | 18 | 46 | 6887 | 149.72 | 14.7 | 12.87 | 131.261 |
| 2 | S2 | 13-Jun-24 | 20-Jun-24 | | 4.755 | 11.5 | 4 | 18 | 46 | 7746 | 168.39 | 16.5 | | |
| 3 | S3 | 13-Jun-24 | 20-Jun-24 | | 4.57 | 11.5 | 4 | 18 | 46 | 6144 | 133.57 | 13.1 | | |
| 4 | S4 | 13-Jun-24 | 20-Jun-24 | | 4.755 | 11.5 | 4 | 18 | 46 | 3375 | 73.37 | 7.2 | | |
| 1 | S1 | 13-Jun-24 | 27-Jun-24 | 14 | 4.73 | 11.5 | 4 | 18 | 46 | 10562 | 229.61 | 22.5 | 17.46 | 178.005 |
| 2 | S2 | 13-Jun-24 | 27-Jun-24 | | 4.74 | 11.5 | 4 | 18 | 46 | 5793 | 125.93 | 12.3 | | |
| 3 | S3 | 13-Jun-24 | 27-Jun-24 | | 4.45 | 11.5 | 4 | 18 | 46 | 9377 | 203.85 | 20 | | |
| 4 | S4 | 13-Jun-24 | 27-Jun-24 | | 4.645 | 11.5 | 4 | 18 | 46 | 7021 | 152.63 | 15 | | |
| 1 | S1 | 13-Jun-24 | 11-Jul-24 | 28 | 4.8 | 11.5 | 4 | 18 | 46 | 8806 | 191.43 | 18.8 | 19.24 | 196.179 |
| 2 | S2 | 13-Jun-24 | 11-Jul-24 | | 4.81 | 11.5 | 4 | 18 | 46 | 11579 | 251.72 | 24.7 | | |
| 3 | S3 | 13-Jun-24 | 11-Jul-24 | | 4.735 | 11.5 | 4 | 18 | 46 | 9772 | 212.43 | 20.8 | | |
| 4 | S4 | 13-Jun-24 | 11-Jul-24 | | 4.705 | 11.5 | 4 | 18 | 46 | 5940 | 129.13 | 12.7 | | |

Table 7. Average Compressive Strength of 40% PV Concrete Bricks

| No. | Concrete Block Code | Casting Date | Test Date | Age (Days) | Initial Weight (kg) | Length, P | Width, L | Height, T | Cross-Sectional Area (cm²) A = P × L | Compressive Load (kgf) | Compressive Strength (kg/cm²) | Compressive Strength (MPa) | Average Compressive Strength (MPa) | Average Compressive Strength (kg/cm²) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | S1 | 13-Jun-24 | 20-Jun-24 | 7 | 4.77 | 11.5 | 4 | 18 | 46 | 9008 | 195.83 | 19.2 | 18.62 | 189.908 |
| 2 | S2 | 13-Jun-24 | 20-Jun-24 | | 4.825 | 11.5 | 4 | 18 | 46 | 8017 | 174.28 | 17.1 | | |
| 3 | S3 | 13-Jun-24 | 20-Jun-24 | | 4.935 | 11.5 | 4 | 18 | 46 | 9993 | 217.24 | 21.3 | | |
| 4 | S4 | 13-Jun-24 | 20-Jun-24 | | 4.955 | 11.5 | 4 | 18 | 46 | 7925 | 172.28 | 16.9 | | |
| 1 | S1 | 13-Jun-24 | 27-Jun-24 | 14 | 4.85 | 11.5 | 4 | 18 | 46 | 9869 | 214.54 | 21 | 23.1 | 235.576 |
| 2 | S2 | 13-Jun-24 | 27-Jun-24 | | 4.835 | 11.5 | 4 | 18 | 46 | 13364 | 290.52 | 28.5 | | |
| 3 | S3 | 13-Jun-24 | 27-Jun-24 | | 4.755 | 11.5 | 4 | 18 | 46 | 11415 | 248.15 | 24.3 | | |
| 4 | S4 | 13-Jun-24 | 27-Jun-24 | | 4.905 | 11.5 | 4 | 18 | 46 | 8698 | 189.09 | 18.5 | | |
| 1 | S1 | 13-Jun-24 | 11-Jul-24 | 28 | 4.99 | 11.5 | 4 | 18 | 46 | 10955 | 238.15 | 23.4 | 24.61 | 250.946 |
| 2 | S2 | 13-Jun-24 | 11-Jul-24 | | 4.93 | 11.5 | 4 | 18 | 46 | 12705 | 276.2 | 27.1 | | |
| 3 | S3 | 13-Jun-24 | 11-Jul-24 | | 4.91 | 11.5 | 4 | 18 | 46 | 10304 | 224 | 22 | | |
| 4 | S4 | 13-Jun-24 | 11-Jul-24 | | 4.905 | 11.5 | 4 | 18 | 46 | 12210 | 265.43 | 26 | | |

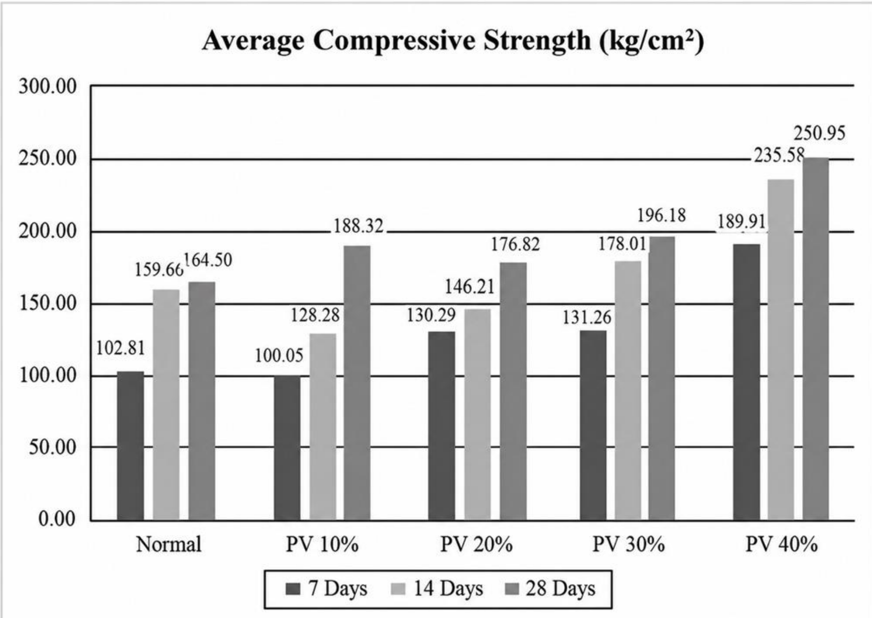


Figure 1. Compressive Strength of Normal Bricks and Volcanic Sand Bricks

1. The compressive strength test results show that standard concrete blocks and those made with volcanic sand have a significant effect on compressive strength, as shown in Figure 4.3. The highest compressive strength was recorded in blocks with 40% volcanic sand, namely 189.91 kg/cm² at 7 days, increasing to 235.58 kg/cm² at 14 days, and reaching 250.95 kg/cm² at 28 days. These results indicate that the use of volcanic sand has a significant effect on increasing compressive strength.

**Water Absorption**

The absorption test aims to measure the extent to which the addition of volcanic sand affects the amount of water absorbed by the concrete blocks. This test was conducted on 28-day-old concrete blocks, with the test subjects including standard concrete blocks and variations containing 10%, 20%, 30%, and 40% volcanic sand. The objective is to determine the water absorption rate of the concrete blocks at intervals of 1 minute, 5 minutes, 10 minutes, 30 minutes, 60 minutes, and up to 24 hours. The results of this test, shown in Figure 3.3 and Figure 3.4, indicate that the highest water absorption occurs in standard concrete blocks and those with 20% volcanic sand added. These water absorption values indicate the presence of sufficiently large voids or pores, so the amount of absorption is influenced by the size of the voids or pores in the concrete blocks.

Table 8. Water Absorption of Standard Concrete Blocks

| Min | Time | | Weight (g) Sample | | Average I | Average Weight (AW) | Water Absorption (WA) | % |
|---|---|---|---|---|---|---|---|---|
| | (s) | (s^1/2) | 1 | 2 | | | | |
| | 0 | 0 | 9890.000 | 9355.000 | 737.64322 | 9622.500 | 0.0 | 0.00% |
| 1 MIN | 60 | 7.745967 | 9930.000 | 9395.000 | 742.57723 | 9662.500 | 1269.8 | 0.42% |
| 5 MIN | 300 | 17.32051 | 9935.000 | 9410.000 | 743.81073 | 9672.500 | 1587.3 | 0.52% |
| 10 MIN | 600 | 24.49490 | 9940.000 | 9415.000 | 744.42748 | 9677.500 | 1746.0 | 0.57% |
| 30 MIN | 1800 | 42.42641 | 9950.000 | 9420.000 | 745.35261 | 9685.000 | 1984.1 | 0.65% |
| 60 MIN | 3600 | 60.00000 | 9965.000 | 9435.000 | 747.20286 | 9700.000 | 2460.3 | 0.81% |
| 24 HOURS | 7200 | 84.85281 | 10030.000 | 9465.000 | 753.06199 | 9747.500 | 3968.3 | 1.30% |

Table 9. Water Absorption of P.V 10% Bricks

| Min | Time | | Weight (g) Sample | | Average I | Average Weight (AW) | Water Absorption (WA) | % |
|---|---|---|---|---|---|---|---|---|
| | (s) | (s^1/2) | 1 | 2 | | | | |
| Initial | 0 | 0.00000 | 9800.000 | 9555.000 | 744.42748 | 9677.500 | 0.00 | 0.00 |
| 1 min | 60 | 7.74597 | 9825.000 | 9590.000 | 748.12799 | 9707.500 | 952.38 | 0.31 |
| 5 min | 300 | 17.32051 | 9830.000 | 9595.000 | 748.74474 | 9712.500 | 158.73 | 0.36 |
| 10 min | 600 | 24.49490 | 9840.000 | 9615.000 | 750.59499 | 9727.500 | 476.19 | 0.52 |
| 30 min | 1800 | 42.42641 | 9845.000 | 9620.000 | 751.21174 | 9732.500 | 158.73 | 0.57 |
| 60 min | 3600 | 60.00000 | 9850.000 | 9625.000 | 751.82849 | 9737.500 | 158.73 | 0.62 |
| 24 h | 7200 | 84.85281 | 9880.000 | 9645.000 | 754.91225 | 9762.500 | 793.65 | 0.88 |

Table 10. Absorption of 20% P.V. Concrete Bricks

| Min | Time | | Weight (g) Sample | | Average I | Average Weight (AW) | Water Absorption (WA) | % |
|---|---|---|---|---|---|---|---|---|
| | (s) | (s^1/2) | 1 | 2 | | | | |
| Initial | 0 | 0.00000 | 9975.000 | 9775.000 | 768.78914 | 9875.000 | 0.0 | 0.00 |
| 1 min | 60 | 7.74597 | 10025.000 | 9825.000 | 774.95665 | 9925.000 | 1587.3 | 0.51 |
| 5 min | 300 | 17.32051 | 10030.000 | 9830.000 | 775.57340 | 9930.000 | 1746.0 | 0.56 |
| 10 min | 600 | 24.49490 | 10035.000 | 9840.000 | 776.49853 | 9937.500 | 1984.1 | 0.63 |
| 30 min | 1800 | 42.42641 | 10040.000 | 9845.000 | 777.11528 | 9942.500 | 2142.9 | 0.68 |
| 60 min | 3600 | 60.00000 | 10060.000 | 9850.000 | 778.65716 | 9955.000 | 2539.7 | 0.81 |
| 24 h | 7200 | 84.85281 | 10095.000 | 9885.000 | 782.97442 | 9990.000 | 3650.8 | 1.16 |

Table 11. Absorption of P.V 30% Concrete Brick

| Min | Time | | Weight (g) Sample | | Average I | Average Weight (AW) | Water Absorption (WA) | % |
|---|---|---|---|---|---|---|---|---|
| | (s) | (s^1/2) | 1 | 2 | | | | |
| Initial | 0 | 0.00000 | 9825.000 | 9640.000 | 751.21174 | 9732.500 | 0.0 | 0.00 |
| 1 min | 60 | 7.74597 | 9845.000 | 9675.000 | 754.60387 | 9760.000 | 873.02 | 0.28 |
| 5 min | 300 | 17.32051 | 9850.000 | 9680.000 | 755.22062 | 9765.000 | 1031.7 | 0.33 |
| 10 min | 600 | 24.49490 | 9855.000 | 9685.000 | 755.83737 | 9770.000 | 1190.5 | 0.39 |
| 30 min | 1800 | 42.42641 | 9860.000 | 9690.000 | 756.45413 | 9775.000 | 1349.2 | 0.44 |
| 60 min | 3600 | 60.00000 | 9865.000 | 9695.000 | 757.07088 | 9780.000 | 1507.9 | 0.49 |
| 24 h | 7200 | 84.85281 | 9885.000 | 9735.000 | 760.77138 | 9810.000 | 2460.3 | 0.80 |

Table 12. Absorption of P.V 40% Concrete Bricks

| Min | Time | | Weight (g) Sample | | Average I | Average Weight (AW) | Water Absorption (WA) | % |
|---|---|---|---|---|---|---|---|---|
| | (s) | (s^1/2) | 1 | 2 | | | | |
| Initial | 0 | 0.00000 | 10105.000 | 10015.000 | 791.60893 | 10060.000 | 0.0 | 0.00 |
| 1 min | 60 | 7.74597 | 10125.000 | 10030.000 | 793.76756 | 10077.500 | 555.56 | 0.17 |
| 5 min | 300 | 17.32051 | 10130.000 | 10035.000 | 794.38431 | 10082.500 | 714.29 | 0.22 |
| 10 min | 600 | 24.49490 | 10135.000 | 10040.000 | 795.00106 | 10087.500 | 873.02 | 0.27 |
| 30 min | 1800 | 42.42641 | 10140.000 | 10045.000 | 795.61781 | 10092.500 | 1031.70 | 0.32 |
| 60 min | 3600 | 60.00000 | 10150.000 | 10060.000 | 797.15969 | 10105.000 | 1428.60 | 0.45 |
| 24 h | 7200 | 84.85281 | 10180.000 | 10090.000 | 800.86019 | 10135.000 | 2381.00 | 0.75 |

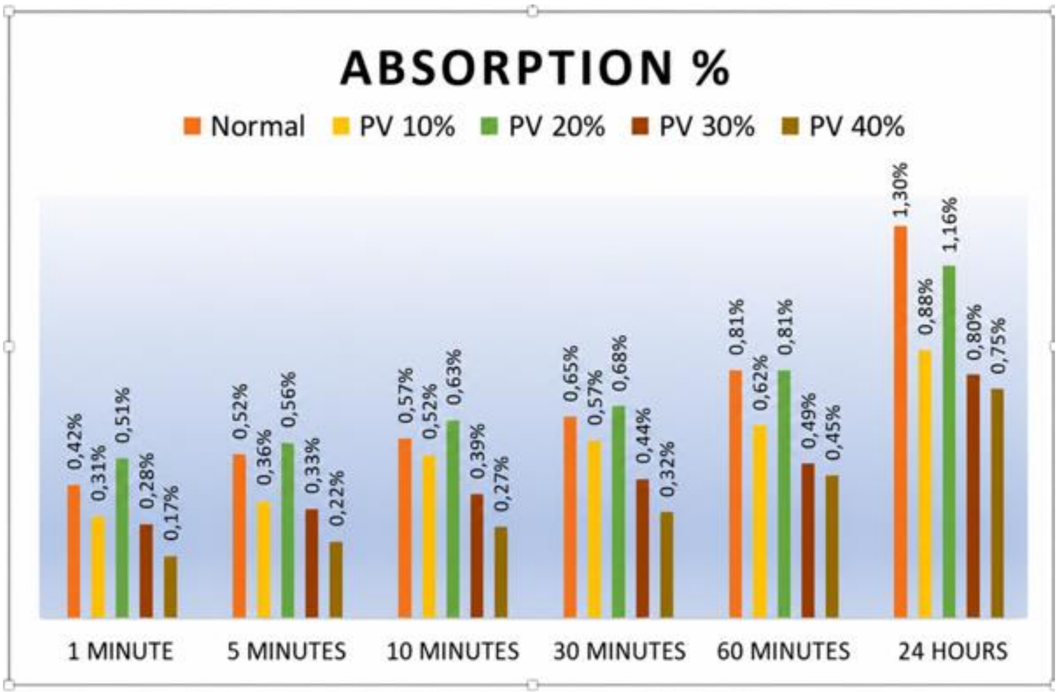

Figure 2. Percentage of Absorption of Normal Brick and Variation of Volcanic Sand

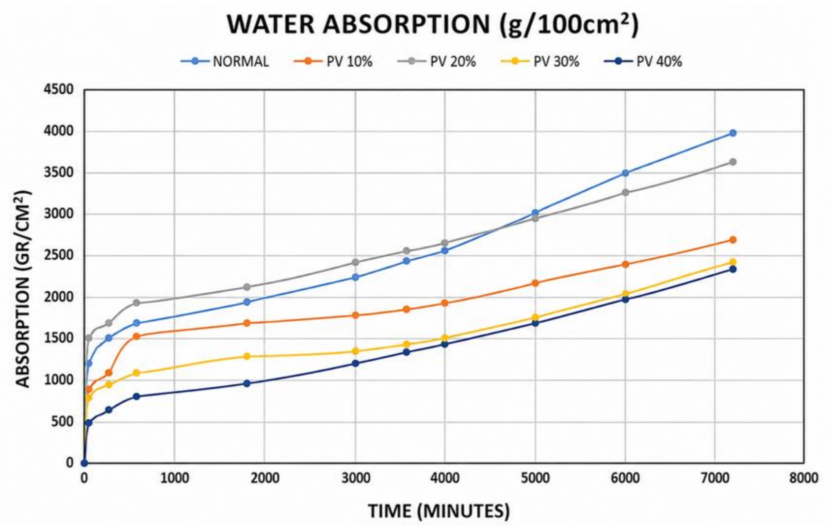

Figure 3. Test Results of Normal Bricks and Volcanic Sand Bricks

**Application of Concrete Blocks**

1. Absorption test results show that the highest water absorption values were found in standard concrete blocks and those with a 20% volcanic sand content, due to their larger pore size. Conversely, the lowest water absorption was found in the 30% and 40% volcanic sand variations, where the blocks have smaller pores. From this, it can be concluded that standard blocks and the 20% volcanic sand variation are highly suitable for use in interior construction (such as roofs). Meanwhile, blocks with 30% and 40% variations, which have low absorption values, are more suitable for non-load-bearing construction in areas not exposed to rain or direct sunlight, provided that the wall surfaces are not plastered.

Test results show that the highest compressive strength was found in concrete blocks containing

40% volcanic sand, which fall under Quality Grade II. These blocks can be used as load-bearing concrete blocks, but should preferably be used only in areas protected from the weather, such as under a roof. Meanwhile, concrete blocks with 10%, 20%, and 30% volcanic sand fall under Quality Grade III, meaning they are not suitable for load-bearing applications. Additionally, these blocks must be placed in areas not exposed to rain or direct sunlight, their wall surfaces must not be plastered, and they must be installed under a roof

## CONCLUSION

Based on the results of tests conducted on the effect of using volcanic sand from Mount Soputan as a substitute for fine aggregate in the production of concrete blocks, the following conclusions can be drawn:

1. Based on the water absorption test results at 28 days, high water absorption was observed during immersion periods of 1, 5, 10, 30, 60 minutes, and 24 hours. The highest absorption value was found in standard concrete blocks at 1.30%, while the addition of 20% volcanic sand resulted in 1.16%. The high water absorption is due to the blocks having larger pores than the other variations. Meanwhile, the lowest water absorption was found in the 30% PV variation at 0.80% and the 40% PV variation at 0.75%.
2. Based on the compressive strength test results, the highest compressive strength was found in the PV 40% brick mixture at 28 days, with a value of 73.29 kgf/cm², while the lowest compressive strength at 28 days was found in the 30% mixture, with a value of 51.99 kgf/cm². Therefore, it can be concluded that the use of volcanic sand in the production of these bricks significantly affects the compressive strength of the bricks.

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