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# Innovative Use of Volcanic Rocks to Improve Compressive Strength in Ventilation Blocks

**N. Vattanaprateep[1,*], P. Wongthong[1], P. Peerapong[2] and W. Ponloa[1]**

***[1]Department of Civil Engineering,***
***[2]Department of Aerospace Engineering,***
***Faculty Engineering, Bangkokthonburi University, Bangkok, Thailand***

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**ABSTRACT**

This work investigates the improvement of mechanical properties, specifically compressive strength and density, of ventilation blocks through the incorporation of volcanic rocks. The study focuses on optimizing the mixture of volcanic rocks with the aim of enhancing the performance of these blocks. The experimental approach involved utilizing a Universal Testing Machine (UTM-CY-6040A12) for compressive strength analysis. Results indicate that the introduction of volcanic rocks into the ventilation block composition led to notable improvements in compressive strength. The blocks achieved their highest compressive strength at 380 KN when incorporating 5% by weight of mixed rough volcanic rock. Additionally, blocks incorporating 4% by weight of mixed fine-grained volcanic rock demonstrated a compressive strength of 268 KN. It was observed that an increase in the percentage of volcanic rock in the mixture resulted in a decrease in compressive strength. Furthermore, the study explored the impact on block density due to the addition of volcanic rocks. Blocks with a 4% by weight mixture of volcanic rock exhibited the lowest density at 2.180 g/cm$^3$, showcasing a significant decrease compared to traditional ventilation blocks. Importantly, all blocks incorporating volcanic rocks experienced a reduction in density compared to standard ventilation blocks. The successful outcomes of this research have practical implications for the production of ventilation blocks in collaboration with commercial block factories. These findings offer insights into the optimal mixtures of volcanic rocks, providing a pathway for enhancing both the compressive strength and reducing the density of ventilation blocks for improved overall performance in construction applications.

***Key word:*** *Ventilation block, Volcanic rocks, Compressive strength, Density, Mechanical properties*

## Introduction

Ventilation blocks play a crucial role in modern construction, serving as essential elements for ensuring proper air circulation within buildings. These blocks, often used in walls and facades, allow for natural ventilation, which is vital for maintaining indoor air quality and reducing the reliance on mechanical ventilation systems. As a result, the structural integrity and mechanical performance of these blocks are of paramount importance in ensuring both the safety and comfort of building occupants.

The mechanical properties of ventilation blocks, particularly their compressive strength and density, are key factors that determine their suitability for various construction applications. Compressive strength, the ability of a material to withstand axial loads, is a critical parameter that affects the durability and load-bearing capacity of ventilation blocks. On the other hand, density influences not only the weight of the blocks but also their thermal and acoustic insulation properties. Achieving an optimal balance between these properties is essential for producing ventilation blocks that are both strong and lightweight, making them easier to handle and install while also contributing to energy efficiency in buildings.

Traditional ventilation blocks are typically made from materials such as concrete, clay, or other cementitious materials. While these materials provide satisfactory performance, they often fall short of the increasing demands for enhanced strength and reduced weight in modern construction. The quest for improved performance has led researchers and manufacturers to explore alternative materials and innovative mixture designs that can offer superior mechanical properties without significantly increasing production costs.

In recent years, there has been growing interest in the use of natural materials, particularly those with unique geological properties, to enhance the performance of construction materials. Among these, volcanic rocks have emerged as a promising candidate due to their inherent strength, durability, and availability in many regions around the world. Volcanic rocks, formed from the cooling and solidification of magma, possess a range of physical and chemical properties that make them suitable for various construction applications. These rocks are typically characterized by high compressive strength, low porosity, and resistance to weathering, making them an attractive option for incorporation into building materials.

Despite the potential advantages of using volcanic rocks in construction, there has been limited research on their specific application in ventilation blocks. Most studies on volcanic rocks have focused on their use in concrete or asphalt mixtures, where they have been shown to improve strength and durability. However, the effects of volcanic rocks on the compressive strength and density of ventilation blocks remain largely unexplored. This research aims to fill this gap by systematically investigating the impact of volcanic rock mixtures on the mechanical properties of ventilation blocks.

The primary objective of this study is to determine the optimal mixture of volcanic rocks that can enhance the compressive strength of ventilation blocks while also considering the effects on density. The research focuses on two types of volcanic rock mixtures: rough volcanic rock and fine-grained volcanic rock, each incorporated into the block composition at varying percentages by weight. By analyzing the compressive strength and density of the resulting blocks, the study seeks to identify the mixture that provides the best balance of properties for use in construction.

The significance of this research extends beyond the laboratory, with practical implications for the construction industry. The successful integration of volcanic rocks into ventilation block production could lead to the development of more efficient, durable, and cost-effective building materials. Such advancements would be particularly beneficial in regions where volcanic rocks are readily available, offering a sustainable and locally sourced alternative to traditional materials. Furthermore, the findings of this study could pave the way for further exploration of other natural materials in construction, contributing to the broader goal of creating more sustainable and resilient buildings.

In conclusion, this research seeks to explore the untapped potential of volcanic rocks as a means of improving the mechanical properties of ventilation blocks. By optimizing the mixture proportions and analyzing the resulting performance, the study aims to provide valuable insights that could influence the future of construction material development. The outcomes of this research are expected to contribute to the ongoing efforts to enhance building efficiency, safety, and sustainability, ultimately benefiting both the construction industry and society at large.

## Materials and Methods

### Materials

The materials used in this study include cement, sand, and volcanic rocks. The volcanic rocks were sourced and prepared in two different forms: coarse-grained and fine-grained. The coarse-grained volcanic rocks were used to create a rough mixture, while the fine-grained volcanic rocks were used to produce a more refined powder. These materials were combined in various proportions to create the test samples, with the aim of determining the optimal mixture for enhancing the compressive strength and reducing the density of the ventilation blocks. The design mix ratios for the ventilation block samples are summarized in Table 1.

### Methods

The experimental approach centers around the assessment of compressive strength, a fundamental mechanical property crucial for evaluating the structural integrity of ventilation blocks. Compressive strength tests were conducted using the Universal Testing Machine (UTM-CY-6040A12), which allows for precise and standardized measurements of the load-bearing capacity of the samples.

Each sample was carefully prepared by mixing the designated proportions of cement, sand, and volcanic rocks according to the ratios specified in Table 1. After mixing, the samples were molded into standard block shapes and allowed to set for a specified duration before testing.

**Table 1.** Design mix ratio for ventilation block sample with volcanic rocks

| No. | Sample | Weight (kg) | | |
|---|---|---|---|---|
| | | Cement | Sand | Volcanic Rocks |
| 1 | N | 9.0 | 36.9 | - |
| 2 | C | 9.0 | 36.9 | 2.5 |
| 3 | F1 | 9.0 | 36.9 | 2 |
| 4 | F2 | 9.0 | 36.9 | 4 |
| 5 | F3 | 9.0 | 36.9 | 8 |

**N**: Represents the standard ventilation block without the addition of volcanic rocks.
**C**: Uses 5% by weight of coarse-grained volcanic rock (2.5 kg), which is a size No. 02.
**F1**: Uses 4% by weight of fine-grained volcanic rock (2.0 kg), which is a size No. 00.
**F2**: Uses 6% by weight of fine-grained volcanic rock (4.0 kg), which is a size No. 00.
**F3**: Uses 8% by weight of fine-grained volcanic rock (8.0 kg), which is a size No. 00.

To ensure the reliability and accuracy of the test results, the specimens underwent a controlled curing process under standardized environmental conditions. The curing process was carried out at a consistent temperature and humidity level to prevent any external factors from affecting the strength development of the blocks. The curing period lasted for 28 days, which is a critical industry standard for assessing the long-term strength and durability of concrete-based materials. This duration allows the hydration process to reach a sufficient level of completion, ensuring that the compressive strength measured is representative of the block's potential performance in real-world applications.

After the 28-day curing period, the samples were subjected to compressive strength testing using the UTM-CY-6040A12. The machine applies a gradually increasing load to the samples until failure occurs, at which point the maximum load is recorded as the compressive strength of the block. The results were then analyzed to determine the effect of the volcanic rock content on the compressive strength and density of the ventilation blocks.

This methodical approach ensures that the findings of this study are both accurate and applicable to real-world construction scenarios, providing valuable insights into the potential benefits of incorporating volcanic rocks into ventilation block production.

## Results and Discussion

The experimental results detailing the density and compressive strength of the various ventilation block samples are summarized in Table 2.

### Density analysis

The density of the ventilation blocks was significantly influenced by the incorporation of volcanic rocks. As shown in Table 2 and Figure 2, the standard block sample without volcanic rocks (Sample N) exhibited the highest density at 2.512 g/cm³. This is expected, as traditional materials like cement and sand typically produce denser blocks.

Upon introducing volcanic rocks into the mixture, a noticeable reduction in density was observed across all samples. This reduction is attributed to the inherent properties of volcanic rocks, which generally have lower densities compared to conventional construction materials like sand and cement. The sample with 5% by weight of coarse-grained volcanic rock (Sample C) showed a considerable decrease in density to 2.229 g/cm³, which is approximately an 11% reduction compared to the standard block. This suggests that even a small percentage of volcanic rock can effectively reduce the overall density of the block.

**Table 2.** The density and compressive strength of the ventilation block sample

| No. | Sample | %Volcanic Rocks Weight | Density (g/cm³) | Compressive Strength (KN) |
|---|---|---|---|---|
| 1 | N | - | 2.512 | 166 |
| 2 | C | 5% | 2.229 | 380 |
| 3 | F1 | 4% | 2.180 | 268 |
| 4 | F2 | 6% | 2.248 | 180 |
| 5 | F3 | 8% | 2.198 | 175 |

Further reductions in density were observed in samples containing fine-grained volcanic rocks. Sample F1, with 4% by weight of fine-grained volcanic rock, exhibited the lowest density among all samples at 2.180 g/cm³. This represents a 13% decrease in density compared to the standard block. This significant reduction can be attributed to the finer particle size of the volcanic rock, which may lead to a more uniform distribution within the matrix, thereby reducing the overall mass of the block.

Interestingly, increasing the proportion of fine-grained volcanic rock beyond 4% did not result in a consistent trend in density reduction. Sample F2, with 6% volcanic rock, had a density of 2.248 g/cm³, slightly higher than Sample F1 but still lower than the standard block. Sample F3, with 8% volcanic rock, had a density of 2.198 g/cm³, which is lower than F2 but not as low as F1. These variations could be due to the balance between the amount of volcanic rock and the cement-sand matrix, where excessive volcanic rock content might lead to less effective binding and compaction, thus affecting the density.

Overall, the addition of volcanic rocks to the ventilation block mixture consistently reduced the density of the blocks. The most significant reduction was observed with the inclusion of 4% fine-grained volcanic rock, indicating that this proportion may offer the optimal balance between reducing density and maintaining the structural integrity of the block. The findings suggest that volcanic rocks can be effectively utilized to produce lighter ventilation blocks, which could be advantageous in applications where reduced weight is a critical factor, such as in high-rise construction or structures requiring minimal load on the foundation.

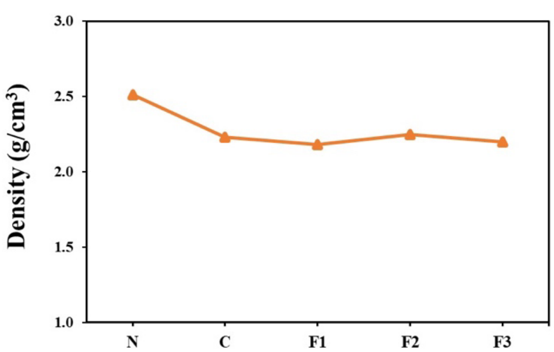


**Fig. 2.** Density of the ventilation blocks with volcanic rocks

**Compressive Strength analysis**

The compressive strength of the ventilation block samples was assessed to determine the impact of volcanic rock content on the structural performance of the blocks. The results are presented in Table 2 and visually depicted in Figure 3.

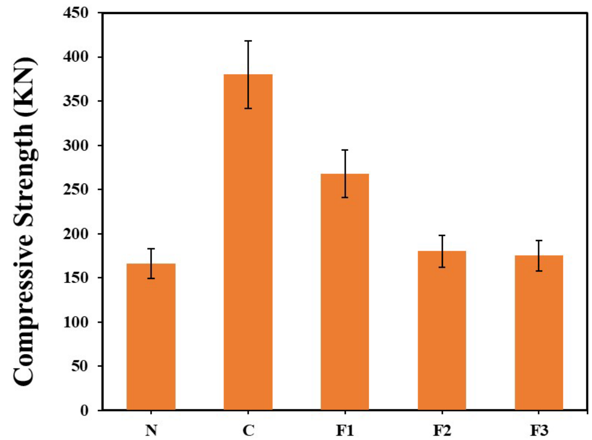


**Fig. 3.** Compressive strength of the ventilation blocks with volcanic rocks

The data in Table 2 indicates that the addition of volcanic rocks significantly influenced the compressive strength of the ventilation blocks. The standard block sample without volcanic rocks (Sample N) exhibited a compressive strength of 166 KN, serving as the baseline for comparison.

Introducing volcanic rocks into the mixture resulted in a notable improvement in compressive strength for certain samples. Sample C, which contained 5% by weight of coarse-grained volcanic rock, demonstrated the highest compressive strength at 380 KN. This represents a substantial increase of approximately 129% compared to the standard block. The coarse-grained volcanic rocks appear to enhance the block's ability to withstand compressive loads, likely due to the increased bonding and mechanical interlock provided by the larger rock particles within the cement matrix.

Sample F1, which contained 4% by weight of fine-grained volcanic rock, also showed an improvement in compressive strength, reaching 268 KN. This is a 61% increase compared to the standard block. The fine-grained volcanic rock particles may have contributed to a denser and more compact structure, improving the block's load-bearing capacity. However, the compressive strength of Sample F1 was lower than that of Sample C, suggesting that coarse-grained volcanic rocks might be more effective in enhancing strength when used in appropriate proportions.

However, increasing the volcanic rock content beyond certain levels resulted in a decrease in compressive strength. Sample F2, with 6% by weight of fine-grained volcanic rock, exhibited a compressive strength of 180 KN, which is only slightly higher than the standard block. Sample F3, with 8% by weight of fine-grained volcanic rock, showed a further decrease in compressive strength to 175 KN. This decline in strength could be attributed to the excessive presence of volcanic rock, which might disrupt the cement matrix and reduce the overall cohesion within the block. As the volcanic rock content increases, the balance between the binder (cement) and the aggregates (volcanic rock and sand) may be compromised, leading to weaker structural integrity.

The results suggest that there is an optimal range for the incorporation of volcanic rocks into ventilation blocks to enhance compressive strength. The best performance was observed with a 5% inclusion of coarse-grained volcanic rock, which significantly improved strength without compromising other mechanical properties. Fine-grained volcanic rocks also improved compressive strength, but the effects diminished as their content increased beyond 4%.

These findings have practical implications for the construction industry. The use of volcanic rocks in ventilation blocks can significantly enhance compressive strength when properly optimized, offering a potential pathway for producing stronger and more durable blocks. However, careful consideration of the proportion and type of volcanic rock used is essential to achieve the desired mechanical properties without compromising the overall performance of the blocks.

## Conclusion

This study investigated the effects of incorporating volcanic rocks into ventilation block mixtures, focusing on the resulting changes in density and compressive strength. The findings indicate that volcanic rocks can significantly enhance the mechanical properties of ventilation blocks, with varying outcomes depending on the type and proportion of volcanic rock used.

The addition of volcanic rocks consistently reduced the density of the ventilation blocks. The most substantial reduction was observed with 4% fine-grained volcanic rock, which achieved the lowest density at 2.180 $g/cm^3$. This reduction in density suggests that volcanic rocks can be effectively utilized to produce lighter blocks, which could be advantageous in applications requiring reduced material weight without compromising structural integrity.

In terms of compressive strength, the results revealed that volcanic rocks could substantially enhance the load-bearing capacity of the blocks when used in optimal proportions. The sample containing 5% by weight of coarse-grained volcanic rock exhibited the highest compressive strength at 380 KN, representing a significant improvement over the standard block. However, increasing the volcanic rock content beyond certain levels led to a decline in compressive strength, indicating the importance of optimizing the mixture to balance strength and durability.

Overall, the study demonstrates that volcanic rocks hold significant potential as an additive in the production of ventilation blocks, offering a pathway to creating stronger, lighter, and potentially more cost-effective building materials. These findings provide valuable insights for the construction industry, particularly in regions where volcanic rocks are readily available. By carefully selecting the type and proportion of volcanic rock, manufacturers can enhance the performance of ventilation blocks, contributing to more sustainable and efficient building practices.

Future research could explore the long-term durability of these blocks under various environmental conditions, as well as the potential benefits of combining volcanic rocks with other innovative materials to further improve the properties of construction materials.

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**Conflict of Interest**- None

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