Momentum Int. J. Civ. Eng, Vol 2, No 2, July 2026
e-ISSN: 3090-6571

Performance Evaluation of Concrete Incorporating Roof Tile Waste as Coarse Aggregate Replacement and Fosroc Conplast WP421 Admixture

Agyanata Tua Munthe[1*], Romadhon[2], Syafwandi[3]
[1,3]Department of Civil Engineering, Mercu Buana University, Jakarta, Indonesia
[2]Undergraduate Student, Department of Civil Engineering, Mercu Buana University, Jakarta, Indonesia
*Corresponding author, e-mail: agyanata_tua@mercubuana.ac.id

Abstract— The increasing demand for concrete in construction has encouraged the exploration of sustainable materials to reduce the consumption of natural resources and utilize construction waste. Roof tile waste has potential as a partial substitute for coarse aggregate, while chemical admixtures such as Fosroc Conplast WP421 can improve concrete workability and performance. This study aimed to evaluate the effects of roof tile waste and Fosroc Conplast WP421 on the workability and compressive strength of concrete. An experimental laboratory method was employed using cylindrical concrete specimens with a diameter of 150 mm and a height of 300 mm. Fosroc Conplast WP421 was added at 1.3% of cement weight, while roof tile waste was used as a 30% replacement for coarse aggregate. Slump tests and compressive strength tests were conducted at curing ages of 7, 14, and 28 days. The results indicated that the addition of Fosroc Conplast WP421 increased the slump value from 13.5 cm in normal concrete to 18.0 cm in concrete containing 30% roof tile waste. The highest compressive strength at 28 days was obtained by concrete containing 1.3% Fosroc Conplast WP421 without roof tile waste, reaching 39.65 MPa, while the mixture with 30% roof tile waste achieved 37.73 MPa. It can be concluded that Fosroc Conplast WP421 improved concrete workability and maintained satisfactory compressive strength. Further studies are recommended to investigate different replacement ratios and long-term durability performance. The findings contribute to the development of more sustainable concrete materials through waste utilization.

Keywords: concrete; roof tile waste; Fosroc Conplast WP421; compressive strength.

1. Introduction

Concrete is the most widely used construction material in the construction industry due to its strength, durability, and versatility. However, increasing demand for natural aggregates and cement has led to serious environmental issues such as resource depletion and high carbon emissions. Therefore, sustainable construction materials have become a critical focus in modern civil engineering research.

One of the most widely explored solutions is the utilization of ceramic-based waste materials, especially roof tile waste, as partial replacement of natural aggregates. Ogawa et al. [1] reported that porous ceramic roof tile waste aggregate significantly affects strength development and durability performance of concrete. Similarly, Sua-iam and Jamnam [2] demonstrated that porcelain tile waste can be effectively

Received: 10 June 2026, Revised: 3 July 2026, Accepted for publication: 3 July 2026
https://doi.org/10.64123/mijce.v2.i1.4

used as coarse aggregate in green self-compacting concrete while maintaining acceptable mechanical performance.

Further studies have expanded the application of ceramic waste in various construction materials. Sivakumar et al. [3] and Mohammed and Ahmed [4] found that waste ceramic tiles used as partial replacement of fine and coarse aggregates can still produce concrete with satisfactory compressive strength. Muthusamy et al. [5] also confirmed that roof tile waste as partial fine aggregate replacement influences compressive strength development.

In addition, ceramic waste has been widely studied in advanced concrete systems. Amin et al. [6] reported that the combination of mineral admixtures and ceramic waste improves the performance of ultrahigh-performance concrete. Shareef et al. [7] and Bayraktar et al. [8] demonstrated the feasibility of using ceramic waste in foam concrete and lightweight construction applications, supporting sustainable material development in civil engineering.

Roof tile waste has also been utilized in the production and development of sustainable roofing systems. Patrisia et al. [9] developed advanced manufacturing of waste-integrated concrete roof tiles, while Poyyamozhi et al. [10] highlighted the use of municipal solid waste in eco-friendly roof tile production. De Silva et al. [11] further confirmed that ceramic sludge and waste materials improve microstructure and engineering properties of sustainable roof tiles. Mourou et al. [12] also explored ceramic-coated roof systems for cool roof applications.

Beyond structural applications, ceramic waste has also been applied in mortar and cement-based systems. Archana and Ponmalar [13] investigated ceramic tile waste in nano-silica blended mortar, while Gautam et al. [14] confirmed its effectiveness in self-compacting concrete. Maryoto et al. [15] found that finer ceramic roof tile waste powder significantly influences mortar properties when used as cement substitution. Wibowo et al. [16] also reported that ceramic roof tile waste powder affects slump loss and water content in concrete mixtures.

Additional studies have explored alternative waste materials in concrete systems. Etefa and Mosisa [17] investigated waste rubber tires as partial coarse aggregate replacement in concrete tile production. Manikandan et al. [18] studied partial replacement of aggregate with ceramic tiles in concrete. Supar et al. [19] provided a review of waste material utilization in concrete roof tile applications, while Kızıltepe and Şahin [20] evaluated travertine waste as alternative concrete aggregate.

Despite extensive research, most previous studies focus separately on either ceramic waste as aggregate replacement or cement substitution. Limited research has investigated the combined effect of roof tile waste as coarse aggregate replacement together with chemical admixtures in conventional concrete systems, particularly using Fosroc Conplast WP421.

Therefore, this study aims to evaluate the effect of roof tile waste as coarse aggregate substitution combined with Fosroc Conplast WP421 as a chemical admixture on concrete performance. The study focuses on workability, compressive strength at different curing ages, density, and water absorption. The findings are expected to contribute to sustainable concrete development by optimizing waste utilization while maintaining structural performance.

2. Method

This research was conducted using an experimental method in the concrete laboratory of PT. Pionir Beton, Bandung, Indonesia. The study focused on evaluating the effect of roof tile waste as a partial replacement of coarse aggregate and Fosroc Conplast WP421 as a chemical admixture on concrete performance. The experimental workflow of this study is presented in Figure 1, which illustrates the sequence of activities starting from material preparation, mix design, specimen casting, curing, to laboratory testing and data analysis.

The materials used in this study included Portland cement, fine aggregate, coarse aggregate, crushed roof tile waste, water, and Fosroc Conplast WP421 as a superplasticizer admixture. Roof tile waste was used as a coarse aggregate substitute at a proportion of 30%, while Fosroc Conplast WP421 was added at 1.3% of cement weight.

The composition of concrete mixtures for each variation is summarized in Table 1, which describes the proportion of normal concrete, concrete with admixture only, and concrete with combined admixture and roof tile waste substitution.

A total of 36 cylindrical specimens with dimensions of 150 mm diameter and 300 mm height were prepared. The specimens were divided equally for testing at curing ages of 7, 14, and 28 days. All specimens were cured in water under standard laboratory conditions until the testing age was reached.

Workability was assessed using the slump test in accordance with standard procedures. Hardened concrete properties were evaluated through compressive strength testing using a compression testing machine. Additional measurements of density and water absorption were conducted on hardened concrete specimens at 28 days.

All experimental data were obtained directly from laboratory testing and were analyzed by comparing the performance of each concrete mixture to evaluate the influence of roof tile waste and Fosroc Conplast WP421 on concrete behavior.

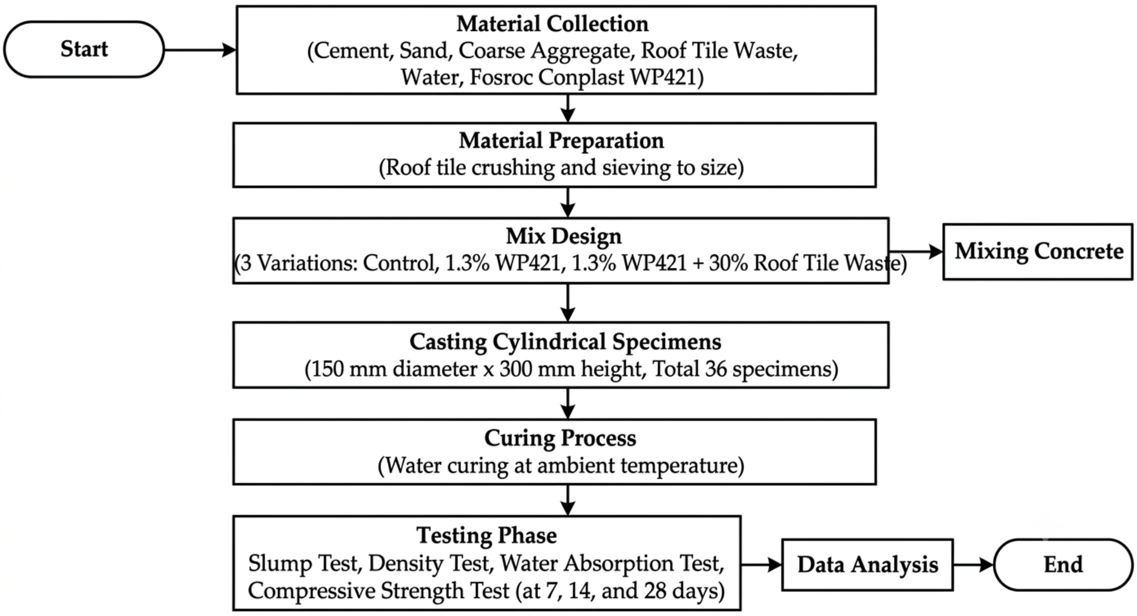

Figure 1. Experimental flow diagram of the research methodology

Table 1. Concrete mix variations used in this study.

Mix ID	Fosroc Conplast WP421 (% of cement)	Roof Tile Waste Replacement (%)	Description
M0	0%	0%	Normal concrete (control mix)
M1	1.30%	0%	Concrete with chemical admixture only
M2	1.30%	30%	Concrete with admixture and roof tile waste substitution

3. Results and Discussion

The experimental results of this study evaluate the effect of roof tile waste as coarse aggregate substitution and Fosroc Conplast WP421 as a chemical admixture on concrete performance, including workability, compressive strength, density, and water absorption.

The workability performance of fresh concrete is presented in Table 2, which shows the slump values for each concrete mixture variation. The results indicate that the use of Fosroc Conplast WP421 significantly improves the workability of concrete compared to the normal mix. The increase in slump is associated with the dispersing effect of the superplasticizer, which reduces water demand and improves particle lubrication within the concrete mixture.

Table 2. Slump Test Results

Mix ID	Slump (cm)
M0	13.5
M1	16
M2	18

The compressive strength development at 7 days is shown in Table 3. At this early curing age, the control mix exhibits slightly higher strength compared to mixtures containing roof tile waste. This condition indicates that the presence of ceramic-based waste material initially slows down hydration bonding due to its lower reactivity compared to natural coarse aggregate.

Table 3. Compressive Strength at 7 Days

Mix ID	7 Days (MPa)
M0	25.99
M1	25.83
M2	24.35

The compressive strength results at 14 days are presented in Table 4. At this stage, concrete containing 1.3% WP421 without roof tile waste shows the highest strength value. This improvement is attributed to better particle dispersion and improved hydration efficiency due to the admixture effect.

Table 4. Compressive Strength at 14 Days

Mix ID	14 Days (MPa)
M0	32.15
M1	33.88
M2	32.72

The 28-day compressive strength results are shown in Table 5. The highest strength is achieved by concrete containing 1.3% WP421 without roof tile waste, indicating that the admixture has a dominant effect on strength development compared to aggregate substitution. Meanwhile, the inclusion of 30% roof tile waste results in slightly lower strength due to reduced aggregate quality and higher porosity.

Table 5. Compressive Strength at 28 Days

Mix ID	28 Days (MPa)
M0	39.27
M1	39.65
M2	37.73

A comparison of compressive strength development across all curing ages is summarized in Table 6, which illustrates the overall trend of strength gain. The data show that all mixtures experience continuous strength development with curing time, where 28-day strength is significantly higher than 7-day and 14-day results.

Table 6. Summary of Compressive Strength Development

Mix ID	7 Days	14 Days	28 Days
M0	25.99	32.15	39.27
M1	25.83	33.88	39.65
M2	24.35	32.72	37.73

In general, the use of Fosroc Conplast WP421 improves both workability and strength performance of concrete. However, the replacement of coarse aggregate with roof tile waste tends to slightly reduce compressive strength while still maintaining acceptable structural performance. This suggests that roof tile waste can be used as a sustainable alternative material with proper mix optimization.

Overall, the results demonstrate that the combination of chemical admixture and recycled ceramic waste provides a balanced performance between sustainability and mechanical properties, making it suitable for eco-friendly concrete applications.

4. Conclusion

This study investigated the effect of roof tile waste as a coarse aggregate replacement and Fosroc Conplast WP421 as a chemical admixture on concrete performance. Based on the experimental results, several conclusions can be drawn.

First, the use of Fosroc Conplast WP421 significantly improves the workability of concrete, as indicated by an increase in slump value from 13.5 cm in normal concrete to 18.0 cm in concrete containing both admixture and roof tile waste. This demonstrates that the admixture effectively enhances particle dispersion and reduces internal friction in the concrete mix.

Second, in terms of compressive strength, the highest strength at 7 days was achieved by normal concrete, while at 14 days and 28 days, the mixture containing 1.3% Fosroc Conplast WP421 without roof tile waste showed the highest performance. The incorporation of roof tile waste as a 30% coarse aggregate substitute resulted in slightly lower compressive strength compared to mixes without substitution, although the values remained within acceptable structural ranges.

Third, density and water absorption results indicate that all concrete mixtures maintained relatively stable physical properties, suggesting that roof tile waste can still be considered as a potential alternative material in concrete production.

Overall, the combination of Fosroc Conplast WP421 and roof tile waste demonstrates a balance between improved workability and sustainable material utilization, although excessive substitution of natural aggregates may reduce compressive strength.

For future research, it is recommended to investigate different percentages of roof tile waste, optimize mix design proportions, and evaluate long-term durability properties such as shrinkage, permeability, and resistance to environmental exposure. These findings contribute to the development of sustainable and environmentally friendly concrete materials in the construction industry.

References

[1] Y. Ogawa, P. T. Bui, K. Kawai, and R. Sato, “Effects of porous ceramic roof tile waste aggregate on strength development and carbonation resistance of steam-cured fly ash concrete,” *Construction and Building Materials*, vol. 236, p. 117462, 2020.

[2] G. Sua-iam and S. Jamnam, “Influence of calcium carbonate on green self-compacting concrete incorporating porcelain tile waste as coarse aggregate replacement,” *Case Studies in Construction Materials*, vol. 19, p. e02366, 2023.

[3] A. Sivakumar, S. Srividhya, V. Sathiyamoorthy, M. Seenivasan, and M. R. Subbarayan, “Impact of waste ceramic tiles as partial replacement of fine and coarse aggregate in concrete,” *Materials Today: Proceedings*, vol. 61, pp. 224–231, 2022.

[4] H. Mohammed and S. Ahmed, “Mechanical performance evaluation of concrete with waste coarse ceramic aggregate,” in *Smart Cities—Opportunities and Challenges: Select Proceedings of ICSC 2019*, Springer, 2020, pp. 593–605.

[5] K. Muthusamy, M. I. Hassan, R. Othman, M. A. Sulaiman, and H. N. Ruslan, “Compressive strength of concrete containing roof tile waste as partial fine aggregate replacement,” *Key Engineering Materials*, vol. 942, pp. 95–101, 2023.

[6] M. Amin, B. A. Tayeh, and I. S. Agwa, “Effect of using mineral admixtures and ceramic wastes as coarse aggregates on properties of ultrahigh-performance concrete,” *Journal of Cleaner Production*, vol. 273, p. 123073, 2020.

[7] Z. A. Shareef, S. Y. Ahmed, and O. M. Abdulkareem, “Potential use of wastes of thermostone blocks and ceramic tiles as recycled aggregates in production of foam concrete,” *Civil Engineering and Architecture*, vol. 11, no. 3, pp. 1280–1296, 2023.

[8] O. Y. Bayraktar et al., “Feasibility of foam concrete using recycled brick and roof tile fine aggregates,” *European Journal of Environmental and Civil Engineering*, vol. 29, no. 3, pp. 548–566, 2025.

[9] Y. Patrisia et al., “Advanced manufacturing of waste-integrated concrete roof tiles: scaling up to TRL 6,” *Sustainable Materials and Technologies*, vol. 45, p. e01461, 2025.

[10] M. Poyyamozhi et al., “Elevating thermal comfort with eco-friendly concrete roof tiles crafted from municipal solid waste,” *Journal of Building Engineering*, vol. 88, p. 109222, 2024.

[11] G. S. De Silva et al., “Engineering properties and microstructure of a sustainable roof tile manufactured with waste rice husk ash and ceramic sludge addition,” *Case Studies in Construction Materials*, vol. 17, p. e01470, 2022.

[12] C. Mourou et al., “Characterization of ceramic tiles coated with recycled waste glass particles to be used for cool roof applications,” *Construction and Building Materials*, vol. 398, p. 132489, 2023.

[13] K. Archana and V. Ponmalar, “Performance evaluation of ceramic tile waste aggregate in nano-silica blended mortar,” *Ceramics International*, 2026.

[14] L. Gautam, J. K. Jain, T. Alomayri, N. Meena, and P. Kalla, “Performance evaluation of self-compacting concrete comprising ceramic waste powder as fine aggregate,” *Materials Today: Proceedings*, vol. 61, pp. 204–211, 2022.

[15] A. Maryoto, N. I. S. Hermanto, and V. Oktaviani, “Influence of finer ceramic roof-tile waste powder as a cement substitute on mortar properties,” *Materials*, vol. 19, no. 10, p. 2124, 2026.

[16] I. Wibowo, N. I. S. Hermanto, and A. Maryoto, “Influence of ceramic roof tile waste powder fineness on slump loss and water content of concrete with cement substitution,” *Jurnal Ilmiah Dinamika Rekayasa*, vol. 22, no. 1, pp. 86–93, 2026.

[17] G. Etefa and A. Mosisa, “Waste rubber tires: a partial replacement for coarse aggregate in concrete floor tile production,” *American Journal of Civil Engineering*, vol. 8, no. 3, pp. 57–63, 2020.

[18] K. P. Manikandan et al., “Partial replacement of aggregate with ceramic tile in concrete,” *Materials Today: Proceedings*, 2023.

[19] K. Supar, F. A. A. Rani, N. L. Mazlan, and M. K. Musa, “Partial replacement of fine aggregate using waste materials in concrete as roof tile: a review,” in *IOP Conference Series: Materials Science and Engineering*, vol. 1200, no. 1, p. 012008, 2021.

[20] U. Kızıltepe and Y. Şahin, “Performance assessment of travertine waste as alternative concrete aggregate,” *European Journal of Environmental and Civil Engineering*, vol. 26, no. 14, pp. 7155–7176, 2022.