PROGRESS IN ENGINEERING APPLICATION AND TECHNOLOGY
e-ISSN: 2773-5303

PEAT

Vol. 7 No. 1 (2026) 133-140
https://publisher.uthm.edu.my/periodicals/index.php/peat

Concrete Paver Blocks using Particles Replacement Expanded Polystyrene Beads and Addition of Coir Fibre

Muhammad Firdaus Nabhan[1], Abd Sukor Sarif[1]*

[1] *Department of Civil Engineering Technology, Faculty of Engineering Technology Universiti Tun Hussein Onn, 84600 Pagoh, Johor, MALAYSIA*

*Corresponding Author: sukor@uthm.edu.my
DOI: https://doi.org/10.30880/peat.2026.07.01.017

Article Info

Received: 12 January 2026
Accepted: 20 February 2026
Available online: 25 May 2026

Keywords

Expanded Polystyrene Beads, Coir Fiber, interlocking concrete paver blocks, compressive strength, density, water absorption, sustainable material

Abstract

This study evaluates the incorporation of Expanded Polystyrene Beads (EPS) and Coir Fiber (CF) in the production of interlocking concrete paver blocks. Four mix designs were developed, 0%, 10%, 20% and 30% EPS replacing coarse aggregate by weight while addition of, 0%, 1%, 2% and 3% CF. Compressive strength, water absorption and density were assessed at 7 and 28 days. The results show diminish in early strength with higher EPS, though long-term curing improved durability. Appropriate performance was observed in the 10%-20% EPS and 1%-2% CF range. These findings support the development of making sustainable interlocking concrete paver blocks materials using natural and industrial waste.

1. Introduction

Concrete is the predominant construction material in the building and infrastructure industry. In the building sector, a new era of building technology is developing due to the incorporation of industrial waste in manufacturing various types of building materials [15]. Millions weight tons waste of polystyrenes and coir fiber are certainly produced all over the world. It will lead to pollution in the end and is detrimental to natural. To solve the problem, a new material from polystyrene and coir fiber has been created to be used in building industry [3]. EPS is a popular material that is used by the different area of engineering field for having unique characteristic, such as very-low density, squeegee capacity structure crash worthiness and Insulation value (low thermal transmission coefficient, negligible water absorption). One of the natural fibers is coir fiber almost use in building materials [7]. Therefore, the purpose of this study aims to evaluate the performance of concrete paver blocks made with coir fiber as reinforcement and EPS beads as a partial substitute for coarse aggregate. The specific goals are to: (i) evaluate how EPS and coir fiber affect density, water absorption, and compressive strength; and (ii) determine appropriate replacement levels for possible uses in low-load paver block usage.

Table 1 *Classification strength of types paver blocks*

Grade	Classification	Strength (MPa)		Wear Resistant		Absorption (%)
		Average	Minimal	Average	Minimal	Maximum average
A	Road	40	35	0.090	0.103	3
B	Parking	20	17	0.130	0.149	6
C	Walkway	15	12.5	0.160	0.184	8
D	Garden and Playground	10	8.5	0.219	0.251	10

2. Materials and Methods

2.1 Materials

This study used Ordinary Portland Cement (OPC), Expanded Polystyrene Beads (EPS), Coir Fiber (CF), gravel (Coarse aggregate), Sand (Fine aggregate) and clean water. The EPS beads were used to partially replace coarse aggregate by weight. Coir fibre was added as a percentage of cement content.

(a) **(b)** **(c)**

Fig. 1 *Concrete materials (a) Expanded Polystyrene Beads; (b) Coir fibre; (c) Ordinary Portland Cement.*

(a) **(b)** **(c)**

Fig. 2 *Concrete materials (a) Natural sand; (b) Gravel; (c) Water.*

2.2 Mix proportions and Specimen Preparation

According to table 1 and table 2 showed the EPS replacement levels of 0%, 10%, 20%, and 30% of coarse aggregate were used in the preparation of four concrete mix designs. At 0%, 1%, 2%, and 3%, coir fibre was added. For every mix, the water-to-binder ratio was kept constant. For testing, concrete cubes measuring 100 mm by 100 mm by 100 mm were cast. Before testing, the specimens were demoulded 24 hours after casting and allowed to cure for 7 and 28 days at room temperature in water.

Table 2 *Concrete Mix Design Proportion m3 EPS beads for 1 cube.*

Code Sample	EPS (kg)	CCF (kg)	Cement (kg)	Fine aggregates (kg)	Coarse aggregates (kg)	Water (kg)
0% (Control)	0	0	0.35	0.7	1.40	0.175
EPS 10% CF 1%	0.000634	0.0035	0.35	0.7	1.26	0.175
EPS 20% CF	0.001269	0.007	0.35	0.7	1.12	0.175

2%						
EPS 30% CF 3%	0.001903	0.0105	0.35	0.7	0.98	0.175

Table 3 *Concrete Mix Design Proportion m3 EPS beads for 24 cubes.*

Code Sample	EPS (kg)	CCF (kg)	Cement (kg)	Fine aggregates (kg)	Coarse aggregates (kg)	Water (kg)	7 days samples	28 days samples
0% (Control)	0	0	2.1	4.2	8.4	1.05	3	3
EPS 10% CF 1%	0.003804	0.021	2.1	4.2	7.56	1.05	3	3
EPS 20% CF 2%	0.007607	0.042	2.1	4.2	6.72	1.05	3	3
EPS 30% CF 3%	0.011418	0.063	2.1	4.2	5.88	1.05	3	3
						Total	12	12

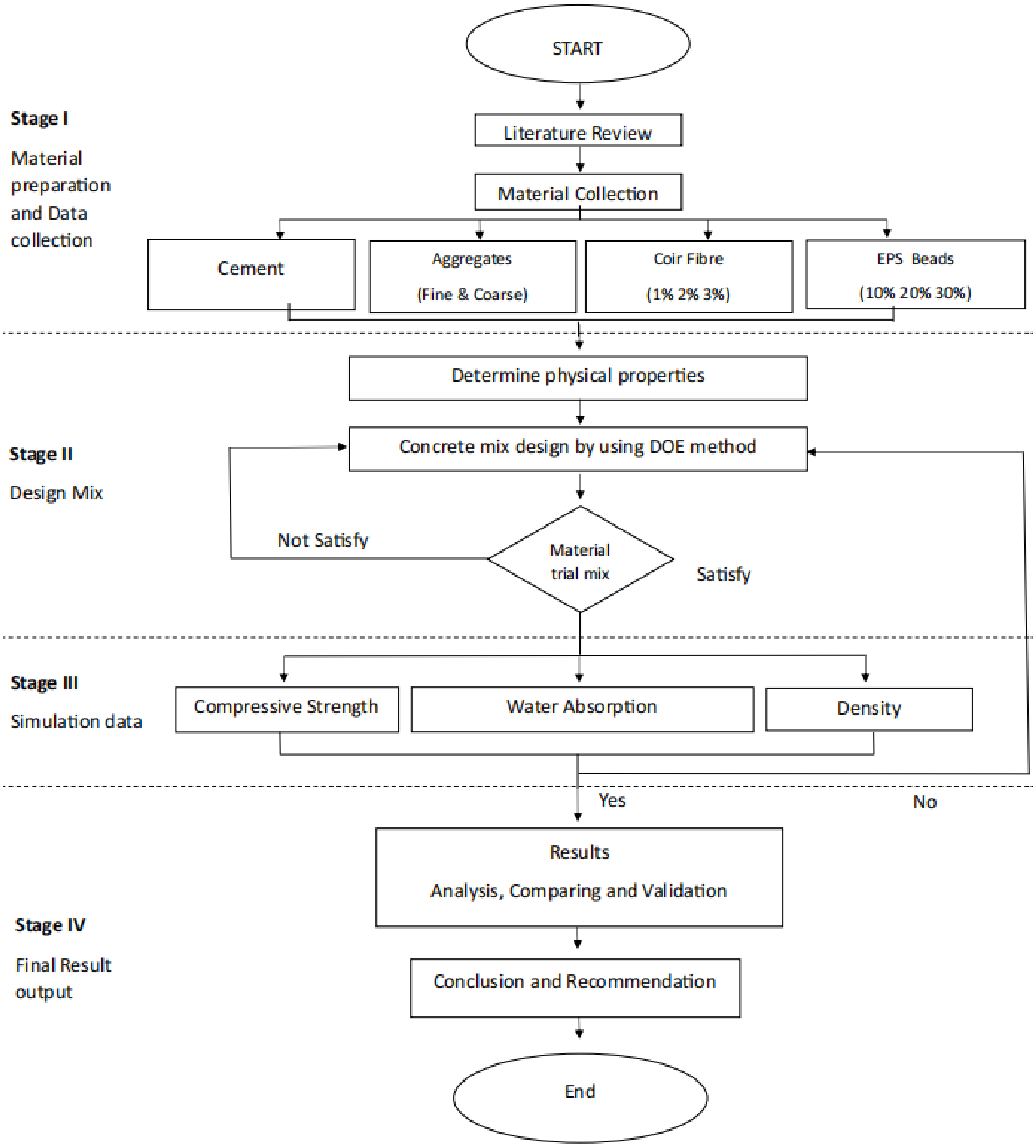

Fig. 3 *Concrete samples preparation and testing flowchart.*

2.3 Testing method

The Fig. 4 showed the tests for compressive strength were carried out in compliance with ASTM C39. Density was computed using the mass and volume of hardened concrete specimens, and water absorption was measured in accordance with ASTM C642 [1]. Every test was conducted between 7 and 28 days after curing.

(a) (b) (c)

Fig. 4 *Concrete samples test; (a) Compressive strength; (b) Water absorption; (c) Density.*

3. Results and Discussion

The test results of concrete cubes from laboratory tests carried out with different contents of Expanded Polystyrene Beads (EPS) and Coir Fibre (CF) in the mix are presented and analysed. Compressive strength, water absorption and density were evaluated as the functional performance indicators on days 7 and 28 of concrete age. Presentation and interpretation of test results on fresh state, hardened and mechanical properties tests were showed in this chapter. The influence of EPS on concrete mixture properties compared to the control mixture without EPS was presented [2].

3.1 Compressive Strength

According to Fig.5, the compressive strength decreased as the EPS content increased. When 10% EPS and 1% CF are applied, the strength reduction of 16.72 MPa at 7 days and 19.56 MPa at 28 days. With the increase in EPS percentage, the compressive strength decreases, was 13.48 MPa and 16.80 MPa for 20% EPS + 2% CF mixes at 7 days and 28 days. The strength developed by 30% EPS + 3% CF combination with the strength of 9.27 MPa and 13.30 at 7 day and 28 days. This decrease can be attributed to the very low stiffness and ultralight weight of EPS beads, which weakened the interfacial bonding between cement paste and beads. The progressive compressive strength reduction, on whole, increasing the replacement percent of EPS and adding fibre create lighter albeit weaker concrete.

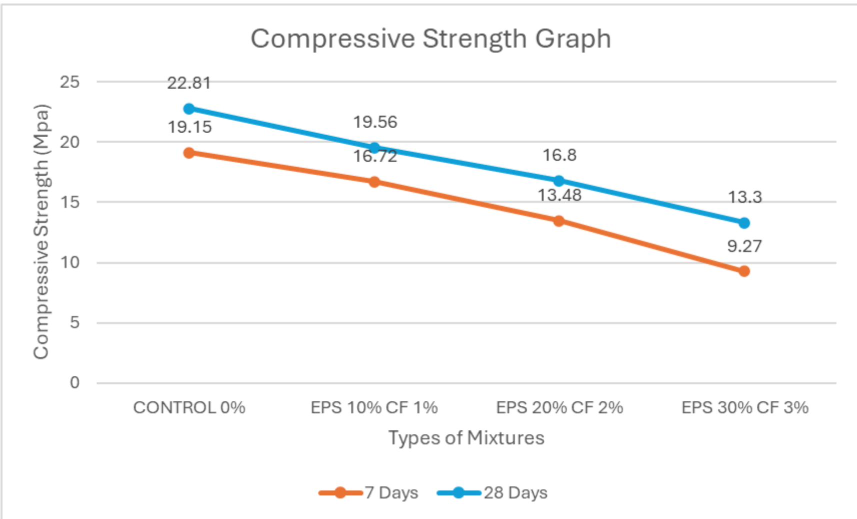

Fig. 5 *Line chart showing the Compressive strength results after 7 and 28 days of curing*

3.2 Water Absorption

According to the Fig. 6, water absorption increased when coir fibre is introduced 10% EPS, 1% CF, a rapid increase in water absorption can be observed, reaching to 2.71% at 7 days and 1.53% after 28 days of curing. On the mixture 20% EPS + 2% CF demonstrates a water absorption inversely increasing with values of 3.70%, at end of seven days, and 1.88%, at end of 28-days. The mixture of 30% EPS + 3% CF presents water absorption slightly lower 3.13% at 7 days and 2.23% at 28 days. Although the EPS beads are hydrophobic, it can provide void spaces around the interface which then enables water to move into concrete. This is the reason of the fact that with increasing voids water absorption increases: more voids, penetrates more water into the matrix causing a decrease in its resistance. Coir fibre is an absorbent material, which allows the concrete to be more porous and water-retaining and likely due to improved compaction or different fibre distribution.

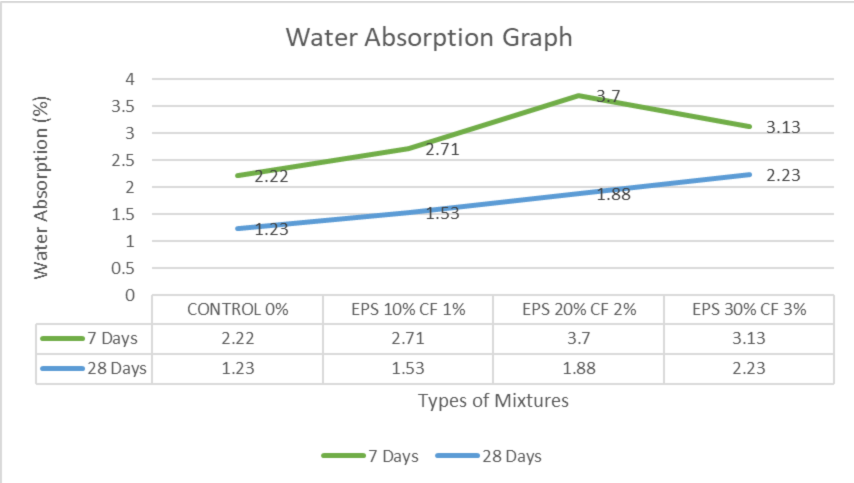

Fig. 6 *Line chart showing show the water absorption of concrete mix with different percentages of EPS and CF at 7 and 28-days*

3.3 Density

According to Fig. 7, density declined when 1% CF is incorporated with 10% EPS, density significantly reduces to 2140.67 kg/m^3 at 7 days and 2225 kg/m^3 at 28 days, it demonstrates that fibres as organic very low-mass material lessens the total mass of concrete. At 20% EPS substitution and 2% CF inclusion, the density decreased to 2016.33 kg/m^3 at 7 days and 2047 kg/m^3 at 28 days. EPS beads are highly light and replace the coarse aggregates; such a reduction in weight though does not reduce the volume of concrete brings down its mass. Mixture with 20% EPS and 2% CF: The following density values are recorded at 2070.67 kg/m^3 at 7 days and 2034.33 kg/m^3 at 28 days, indicating that even if the compaction differs slightly, the density readings obtained may mildly fluctuate. The lowest density is obtained for 30% EPS and 3% CF, which decreases to hovering around 1850 kg/m^3 at 7 d and shows an increasing trend at 28 days. The Increasing density in the figure reflects that when the RHA loading increases, lighter EPS material was replaced by heavy aggregate.

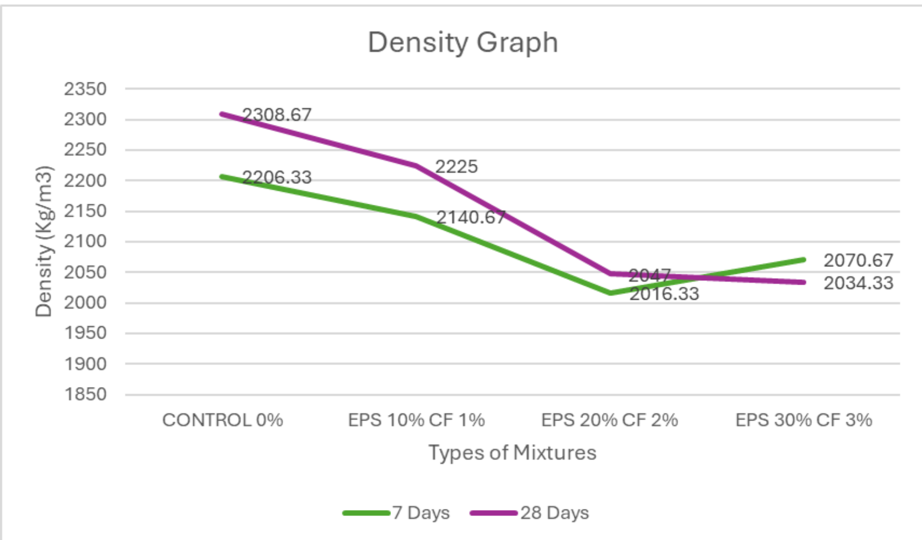

Fig. 7 *Line chart showing the Density (%) of concrete mixes with different percentages of EPS and CF.*

Progress in Engineering Application and Technology Vol. 7 No.1 (2026) p. 133-140

Concrete mixes containing 10–20% EPS and 1–2% coir fibre provide a balanced performance in terms of strength, density, and water absorption, according to the experimental findings. These mixtures are thought to be appropriate for low-load uses like garden paths, walkways, and landscaping.

4. Conclusion

The effects of adding coir fiber and expanded polystyrene beads to concrete paver blocks were examined in this study. The findings show that while EPS beads successfully lower concrete density, they also increase water absorption and decrease compressive strength. When added at higher contents, coir fiber increases porosity but offers only modest reinforcement benefits. For lightweight, low-load paver block applications, an ideal range of 10–20% EPS replacement with 1-2% coir fiber was found to be appropriate. Utilizing EPS and coir fiber helps reduce waste and promotes the creation of more environmentally friendly building materials.

Future Research

Optimizing the proportion of EPS and coir fiber in mix. Consequently, application of lower or moderate replacement levels like 5–10% EPS and 0.5–1% CF can achieve equilibrium between concrete property and sufficient strength [7]. The time to cure the concrete must likewise be increased to allow it to gain greater strength and develop a more compact microstructure. The curing is continued up to 48 days or 56 days, the strength of concrete will increase for long period. Addition of chemicals or pozzolanic supplements like the silica fume and fly ash materials can be employed to optimize the pore structure and limit water absorption. A better and reliable paver block can be produced by adding admixtures with optimized mix proportions combing together [10].

Acknowledgement

The author would like to express their appreciation to University Tun Hussein Onn Malaysia (UTHM) for the facilities and assistance they received during this study. We would especially like to thank the UTHM Publishing Office for helping with research communication.

Conflict of Interest

The author also declares that there is no conflict of interest related to the publication of this paper.

Author Contribution

The authors confirm contribution to the paper as follows: study conception and design: Muhammad Firdaus Nabhan, Abd Sukor Sarif; data collection: Muhammad Firdaus Nabhan; analysis and interpretation of results: Muhammad Firdaus Nabhan, Abd Sukor Sarif; manuscript preparation: Muhammad Firdaus Nabhan, Abd Sukor Sarif. All authors reviewed the results and approved the final version of the manuscript.

References

[1] ASTM C39/C39M- 18. (2018). Standard Test Method for Compressive Strength of Concrete Specimens. ASTM International.

[2] ASTM C642- 13. (2013). Standard Test Method for Density, Absorption, and Voids in Hardened Concrete. ASTM International.

[3] Bilir, T., Aygun, B. F., Shi, J., Gencel, O., & Ozbakkaloglu, T. (2022). Influence of different types of wastes on mechanical and durability properties of interlocking concrete block paving (ICBP): a review. Sustainability, 14(7), 3733. https://doi.org/10.3390/su14073733

[4] Development of Paving Blocks using Waste Materials. (2019). In International Journal of Innovative Technology and Exploring Engineering (IJITEE) (Vol. 8, Issue 9S3, pp. 1329–1330) [Journal-article]

[5] Gamage, S., Palitha, S., Meddage, D. P. P., Mendis, S., Azamathulla, H. M., & Rathnayake, U. (2022). Influence of crumb rubber and coconut coir on strength and durability characteristics of interlocking paving blocks. Buildings, 12(7), 1001. https://doi.org/10.3390/buildings12071001

[6] Kore, S. D. (2021). Sustainable Production of Concrete using Coir Fibres. IOP Conference Series Earth and Environmental Science, 795(1), 012006. https://doi.org/10.1088/1755-1315/795/1/012006

[7] Kumar, C., Arun, E., & Bhaskar, B. (2021). Light weight concrete using EPS (Expanded polystyrene) beads. In Holy Mary Institute of technology and Science, International Journal of Research Publication and Reviews (Vols. 2–2, Issue 8, pp. 1591–1598) [Journal-article]. Retrieved from https://ijrpr.com/uploads/V2ISSUE8/IJRPR1178.pdf

[8] Mudiyono, R., & Sudarno, S. (2019). The Influence of Coconut Fiber on the Compressive and Flexural Strength of Paving Blocks. Engineering, Technology & Applied Science Research, 9(5), 4702–4705.

[9] Ni, X. (2022). Evaluation of Interlocking Concrete Block Pavement with Recycled Materials Based on Experimental and Finite Element Analysis. In McMaster University, McMaster University [Thesis].

[10] Omidi, M. (2021). Development of a new and innovative concrete paver. In S. L. Tighe, M. Luckhardt, S. Yin, V. Henderson, B. Annable, H. K. Al-Bayati, R. Oyediji, E. Melese, J. Achebe, & A. Nahidi (Eds.), University of Waterloo. https://uwspace.uwaterloo.ca/bitstream/handle/10012/17161/Omidi_Mahshad.pdf?sequence=1

[11] Ranjitham, M., Mohanraj, S., Ajithpandi, K., Akileswaran, S., & Sree, S. D. (2019, July). Strength properties of coconut fibre reinforced concrete. In AIP Conference Proceedings (Vol. 2128, No. 1, p. 020005). AIP Publishing LLC. https://doi.org/10.1063/1.5117917

[12] Ru, S., Zhao, C., & Yang, S. (2022). Multi-Objective Optimization and Analysis of Mechanical Properties of Coir Fiber from Coconut Forest Waste. Forests, 13(12), 2033. https://doi.org/10.3390/f13122033

[13] Silva, W., Picado-Santos, L., Barroso, S., Cabral, A. E., & Stefanutti, R. (2023). Assessment of Interlocking Concrete Block Pavement with By-Products and Comparison with an Asphalt Pavement: A Review. In Norhazilan Md Noor (Ed.), Appl. Sci. (Vol. 13, p. 5846) [Journal-article]. https://doi.org/10.3390/app13105846

[14] Thienel, K.-C., Haller, T., Beuntner, N., & Institute for Construction Materials, Universität der Bundeswehr München. (2020). Lightweight Concrete—From Basics to Innovations. Materials, 13, 1120–1120. https://doi.org/10.3390/ma13051120

[15] Vieira, F., Santana, H. E. P., Jesus, M., Santos, J., Pires, P., Vaz-Velho, M., Silva, D. P., & Ruzene, D. S. (2024). Coconut Waste: Discovering Sustainable approaches to advance a circular economy. Sustainability, 16, 3066. https://doi.org/10.3390/su16073066