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# The Mechanics Properties of Foam Concrete Blockwork with Tire Waste Powder Additive

**Bukalendhi Tharmanesan, Veddhesh Kanapathy, Veemal Suresh, Salman Salim***

[1] *Department of Civil Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub,84600, Pagoh, Johor, MALAYSIA*

*Corresponding Author: salman@uthm.edu.my
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**Abstract**

The development in civil industry worldwide have made way for the production of foam concrete blockwork. It is getting popular in current market but it lacks some significant mechanical properties such as compressive strength. The integration of tire powder into foam concrete improves its strength and workability while addressing tire waste, creating a sustainable and efficient construction material. This paper assesses the mechanical of foam concrete blockwork by incorporating tire powder as an additive, addressing both construction performance and environmental concerns. Various percentages of tire powder (0%, 5%, 10 %, 15%, 20%) were added to foam concrete mixes, which were then cast into blocks and cured for 7 and 28 days. Testing revealed that as the percentage of tire powder increases, the compressive strength will also increase as the foam concrete blockwork with 20% tire waste powder records the highest reading for average compressive strength for 7 and 28 days with the reading of 18.6 and 22.6 $N/mm^2$. Besides, foam concrete with 20% tire waste powder also achieced a lesser water absorption with 1.3% after being in water bath for 24 hours. This approach demonstrates a novel use of recycled tire waste, contributing to sustainable construction and waste management. The findings support further exploration of optimized mix designs and practical aplplications in the construction industry. The contribution of foam concrete blockwork in terms of engineering to the society is its reduced structural load, which allows for cost savings in the design and construction of foundations and structural supports.

## 1. Introduction

Concrete, a composite material of cement, aggregate, and water, is fundamental in construction. [1] Foam concrete, comprising water, cement, and foam, is particularly popular due to its low density and versatility. It is used in walls, void filling, roof insulation, bridge abutments, repairs, and trench reinstatements. Its low density reduces structural weight and construction costs, while its texture and microstructure enhance sound absorption and thermal and fire insulation.

Foam concrete's cellular structure makes it lightweight and thermally efficient. Adding tire powder could enhance its strength and workability by filling voids. [2] Foam concrete's popularity has grown due to its cost-effectiveness and reduced environmental impact, aligning with sustainable building practices. Incorporating tire powder could reduce carbon emissions and improve concrete properties.[2] This study explores the feasibility of using tire powder to create a more sustainable and robust foam concrete. [3]

## 1.1 Foam Concrete Blockwork

Concrete is a composite material that consists of binding medium in which are embedded particles or fragments of aggregates. Plain concrete or typical concrete usually made up of cement, aggregate and water [1]. One of the most favourable concrete blocks in current construction industry by a lot of civil engineers is foam concrete block. It is basically consisting of water, cement and foam. Sand can be added to strengthen the end product of foam concrete block.

Foam concrete block is widely being used for several purposes such as for panels and block for walls, planned and emergency void filling, roof insulation, bridge abutments and repairs, and trench reinstatements. The low-density property of this foamed concrete increased its popularity in the construction field as its helps in reducing the self-weight and size of structures, reducing cement usage and thus reducing overall construction material cost. [5] In addition, foamed concrete texture surface accompanied by its microstructural elements improved some properties of concrete such as sound absorption, fire and thermal insulation.

## 1.2 Production of Foam Concrete Blockwork with Tire Waste Powder Additive

Used tires will act as coarse aggregates which provides maximum amount of strength to the concrete blockwork.[6]The use of tire powder will enhance the strength by filling the voids in foam concrete. Based on an experiment conducted by researcher named Imtiaz Ali Bhatti, the workability of foam concrete is decreasing as the percentage of rubber powder increasing. However, strength of the foam concrete will increase 5% of rubber powder into the foam concrete was ideal which significantly showed increase of 1.97 MPa in strength.

### 1.2.1 Materials

The materials needed for the production of foam concrete with tire powder as additive were cement, water, tire powder with size of 1-3mm according to Fig. 1 (a), foam concrete machine (b), sand (c), mould, shovel, curing tank, compressive machine and concrete.

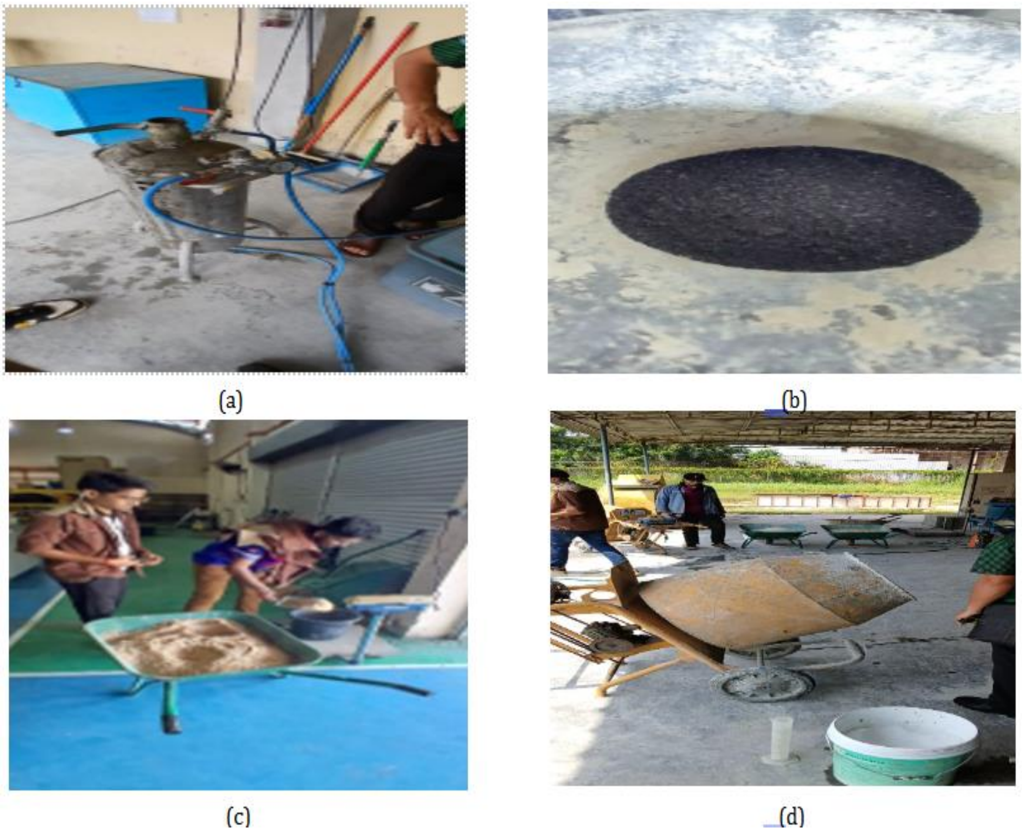


**Fig. 1** *(a) Foam Concrete Machine, (b) Waste Tire Powder 1-3 mm, (c) Sand, (D) Concrete Mixer*

## 2. Methodology

There's a pressing vital issue with an abundance of waste that's posing a serious threat to the environment. Consequently, there's a significant necessity to discover practical uses and solutions for these waste materials. This includes comprehensive information on the methodology, sample preparation, design mix, and the quantity of samples. Additionally, it has detailed specific tests conducted on foam concrete, like the inverted slump cone test, compression tests, and splitting tensile tests.

The sample preparation began by determining the overall quantity of materials required for this study, including cement, sand, water, foaming agent and tire powder. For the compressive strength test, cube shaped molds measuring 100mm x 100mm x 100mm (length, width, and height) were used, while cylindrical molds sized at 150mm x 300mm (diameter and height) were used for maintaining a water-cement ratio of 0.40 [7]. The density of foam concrete achieved was 1600kg/m$^3$. Table 1 shows the concrete mix design for foamed concrete with water cement ratio of 0.4 and wastage of material is added 5%.

**Table 1** *Mix Design for Foam Concrete*

| Ratio | Cement (kg) | Sand (kg) | $H_2O$ (kg) | Rubber content (kg) |
|---|---|---|---|---|
| 1:2 | 0.5 | 1.0 | 0.2 | 0 (0%) |
| 1:2 | 0.5 | 1.0 | 0.2 | 0.05 (5%) |
| 1:2 | 0.5 | 1.0 | 0.2 | 0.10 (10%) |
| 1:2 | 0.5 | 1.0 | 0.2 | 0.15 (15%) |
| 1:2 | 0.5 | 1.0 | 0.2 | 0.20 (20%) |

## 3. Results and Discussion

To measure the dimensions of each specimen accurately, begin by recording their mass. Wipe the surfaces of the specimens to remove any loose particles. Ensure the testing machine is calibrated and ready for use. Place each specimen in the testing machine, ensuring it is centered. Apply the load continuously until failure, and record the maximum load applied to each specimen. In a study on foam concrete with tire powder, medium-density foam concrete (1600 kg/m$^3$) showed varying compressive strengths with different tire powder contents according to Table 2.

**Table 2** *Final Results of Compression Test of Foam Concrete after 7 days*

| Amount of tire powder in foam concrete | 0% | 5% | 10% | 15% | 20% |
|---|---|---|---|---|---|
| Average Mass (g) | 1516.5 | 1599.79 | 1450.65 | 1352.81 | 1543.99 |
| Average Compressive strength (N/mm$^2$) | 8 | 9.1 | 10.1 | 11.4 | 18.6 |

The highest strength (18.6 N/mm$^2$) was achieved with 20% tire powder, while the lowest (8 N/mm$^2$) was recorded with no tire powder. This suggests that tire powder enhances compressive strength. However, excessive tire powder can lead to increased porosity, workability issues, and thermal expansion problems, potentially reducing durability. Thus, while adding tire powder improves strength and offers a sustainable recycling solution, optimal amounts must be used to avoid adverse effects, according to Table 3.

**Table 3** *Final Results of Compression Test after 28 Days*

| Amount of tire powder in foam concrete | 0% | 5% | 10% | 15% | 20% |
|---|---|---|---|---|---|
| Average Mass (g) | 1520.89 | 1611.76 | 1537.65 | 1549.44 | 1572.35 |

| | | | | | |
|---|---|---|---|---|---|
| Average Compressive strength (N/mm²) | 9 | 10.5 | 11.1 | 12.6 | 22.6 |

A study on foam concrete with tire powder, air-cured for 28 days, shows that the addition of tire powder impacts both mass and compressive strength according to Table 4. The mass fluctuates non-linearly with different tire powder percentages, while the compressive strength consistently increases with higher tire powder content. The sample with 20% tire powder achieves the highest compressive strength of 22.6 N/mm$^2$, compared to 9 N/mm$^2$ for the baseline with no tire powder according to Fig.3 and Fig. 4. These results indicate that tire powder significantly enhances foam concrete strength, making it a beneficial and eco-friendly additive.

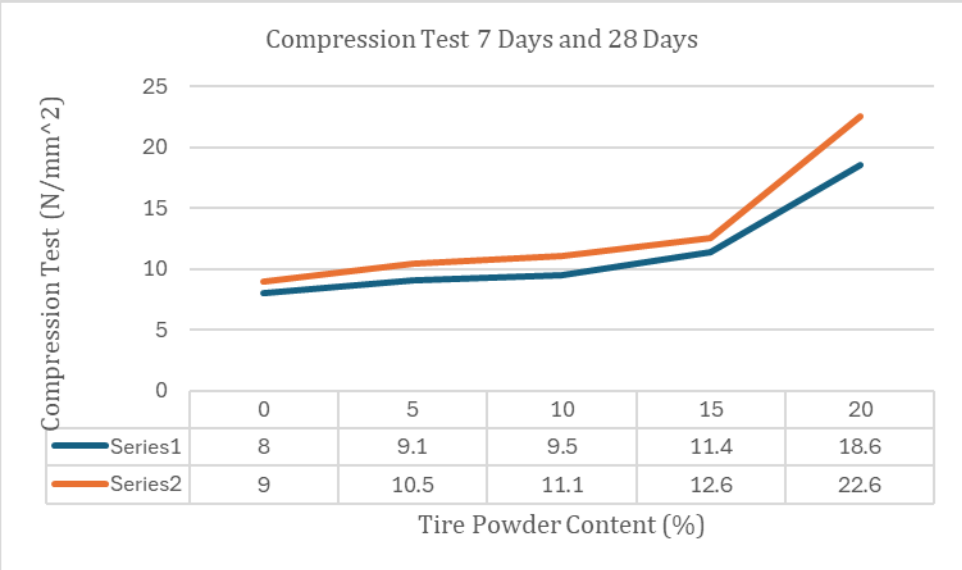


**Fig.2** Compressive strength after 7 and 28 days

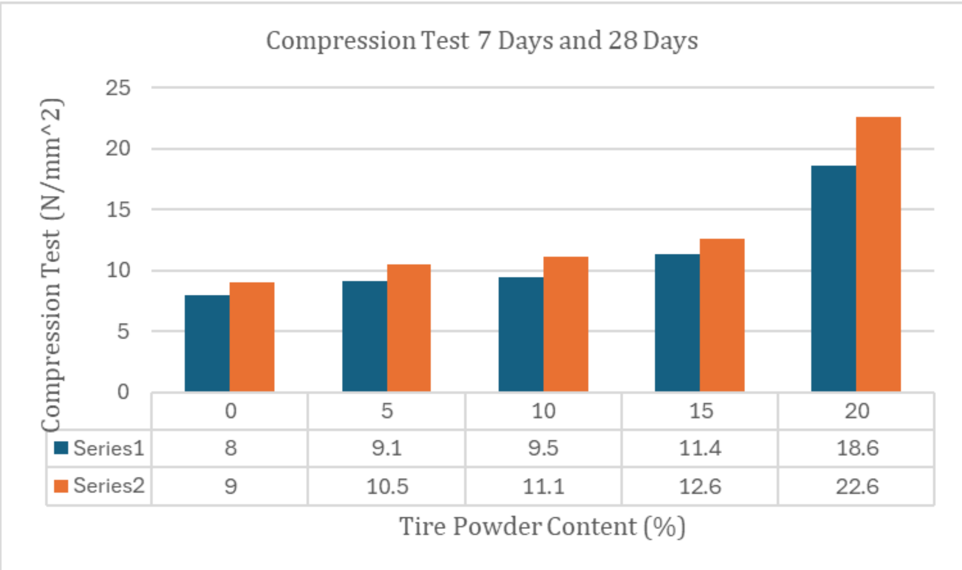


**Fig.3** Comparison between compression test of foam concrete in 7 and 28 days

**Table 4** Water absorption of foam concrete with tire waste additive

| Percentage of tire powder in foam concrete (%) | 0 | 5 | 10 | 15 | 20 |
|---|---|---|---|---|---|
| Mass before water bath, Md (g) | 1501.48 | 1383.13 | 1468.67 | 1183.31 | 1581.98 |
| Mass after water bath (g) | 1584.06 | 1438.46 | 1515.67 | 1215.26 | 1602.55 |
| Water absorption (%) | 5.5 | 4 | 3.2 | 2.7 | 1.3 |

Weigh each dried sample and record the mass. Immerse the samples in water, ensuring they are completely submerged, and leave them immersed for 24 hours. After 24 hours, remove the samples from the water and surface-dry them with a damp cloth to remove any surface water. Weigh each surface-dried sample and record the mass. Calculate the water absorption based on the formula (1).

$$\text{Water Absorption (\%)} = (Ms - Md) \div Md \times 100 \quad (1)$$

Md = Mass before water bath (g)
Ms = Mass after water bath for 24 hours (g)

A study on foam concrete with tire powder, air-cured for 28 days, shows that the addition of tire powder impacts in less water absorption. The amount of water absorption consistently decreases with higher tire powder content compared to ability of water absorption by normal concrete cubes. The sample with 20% tire powder achieves the lowest water absorption in percentage, which is 1.3 %. This is a huge positive because foam concrete with no tire powder in it recorded 5.5% of water absorption in percentage. These results indicate that tire powder significantly enhances foam concrete strength, making it a beneficial and eco-friendly additive.

## 5. Conclusion

The present study effectively showcases the possibility of using tire powder into foam concrete blockwork to improve its mechanical characteristics and mitigate environmental issues related to the disposal of scrap tires. Numerous significant discoveries were made by including different amounts of tire powder (0%, 5%, 10%, 15%, and 20%) into foam concrete mixtures and evaluating the 40 foam concrete blockworks after seven and twenty-eight days of curing. The compressive strength of foam concrete is greatly increased by the inclusion of tire powder. The solution including 20% tire powder yielded the maximum strength, demonstrating an astounding 18.6 N/mm$^2$ after 7 days and 22.6 N/mm$^2$ after 28 days. In comparison, the baseline (0% tire powder) showed 8 N/mm$^2$ and 9 N/mm$^2$, respectively. Furthermore, the use of tire powder lowers the water absorption of foam concrete which is only 1.3% in foam concrete blockwork with tire powder of 20% out of total sand in it compared to 5.5% in foam concrete with tire powder of 0% out of total sand in it. In conclusion, tire waste powder in a foam concrete blockwork has improved its mechanical properties such as lesser water absorption and also greater compressive strength. The amount of waste tires in this world also can be reduced as per our objective.[6]

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## Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

## Author Contribution

*The authors confirm contribution to the paper as follows:* ***study conception and design, data collection, analysis and interpretation of results, draft manuscript preparation:*** *Bukalendhi Tharmanesan, Veddhesh Kanapathy, Veemal Suresh, Salman Salim. All authors reviewed the results and approved the final version of the manuscript.*

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