6th Conference on Sustainability in Civil Engineering (CSCE'24)
Department of Civil Engineering
Capital University of Science and Technology, Islamabad Pakistan

UTILIZATION OF INDUSTRIAL WASTES IN BRICKS AND TUFF TILES

[a] Khawaja Adeel Tariq*, [b]Zeshan Ahmad

*a: Civil Engineering Department, University of Engineering and Technology, Lahore, Narowal Campus, Pakistan.
khawaja.adeel@uet.edu.pk
b: Civil Engineering Department, University of Engineering and Technology, Lahore, Narowal Campus, Pakistan.
zeshanashraf464@gmail.com

Abstract- This study aims to address the problem of pollution caused by carbon dioxide emissions from cement production in Pakistan by investigating the feasibility of using waste to produce tuff tiles. The utilization of industrial wastes in clay bricks is also explored. A variety of organic and inorganic wastes are considered potential substitutes for traditional building materials. This study explored different ways to integrate these waste materials into the manufacturing process while maintaining a strong and durable design. The resulting product are carefully evaluated for their overall mechanical performance. The results show that replacing part of the cement in the tuff tiles with waste materials, especially glass powder and marble powder, up to 5%, can achieve good results. Optimum replacement percentage of clay with rice rusk ash in brick is found as 6%.

Keywords- Sustainable construction materials, tuff tiles, wastes, bricks

1 Introduction

In Pakistan, clay bricks and tuff tiles are fundamental components of construction. However, the burning of clay bricks uses coal, and tuff tiles have a component which is cement; both are linked to considerable negative effects on the surrounding ecosystem, including carbon dioxide (CO_2) emissions, which is also one of the major causes of ozone depletion, affecting human health and the environment for other living beings.

Researchers have investigated the use of waste materials on the mechanical properties, energy efficiency, and environmental impact of the bricks. Results indicate that incorporating these waste materials into clay bricks can lead to a reduction in energy consumption during firing, improved mechanical strength, and decreased environmental footprint, making them eco-friendly and economical alternatives to conventional clay bricks [1].

Over the past decade, several researchers have explored novel construction techniques to develop efficient and affordable solutions for sustainable tuff tiles. Mortar with waste rice husk ash showed improved strength activity index and reduced bulk density with waste Rice hush ask (RHA). RHA because of its fine size can be used in improving the mechanical behavior of soil. Researchers have found beneficial usage of rice husk ash for the purpose of ground improvement. is also used as a soil improvement agent with cement. The experiment on use of rice husk ash as a partial replacement of cement to be used in deep soil mixing has shown promising results [2].

Ceramic Wastes Powder (CWP) is also used in brick kiln industries as a partial replacement of clay in bricks. The findings indicated that incorporating CWP led to enhanced durability of the bricks. It's used is found beneficial in improving the efflorescence and also resistance against acid attacks. Moreover, the bricks displayed reduced porosity and a compact microstructure [3]. Plastic paver blocks were created from plastic bag waste. The results are compared with concrete paver block. It was concluded that plastic paver block is not only sustainable but also exhibit similar strength properties [4].

Dust waste generated during the sizing of volcanic tuff stones are used as an alternative raw material for industrial floor tile manufacturing. Comparing the properties of tiles before and after firing, it was found that incorporating 5 wt. % tuff waste into the industrial formulation yielded the highest green strength (9.83 MPa) and fired strength (26.77 MPa) values, along with the lowest water absorption rate (5.77) [5]. Glass powder and marble powder have been used by the researchers in enhancing the durability and mechanical behavior of concrete and bricks. Optimum usage of marble powder and glass powder was observed as 10% [6] and 15% [7] respectively.

The issue of producing various unutilized byproducts from industries and agriculture sectors, such as inorganic wastes of plastic, glass, marble, stones, etc. are causing environmental concerns in Pakistan as shown in following Figure 1 [8]. The major sources of waste generation in Pakistan are from food, yard, and construction. Waste from Waste generation estimates of Urban and Rural areas of Punjab are shown in Table 1 [9]. The efficiency of our mechanism for controlling waste generation and disposal is minimal.

Table 1: Waste Generation Estimates (reproduced)

Typology	Waste Generated (kg per capita)	Waste Generated (Metric Ton per year)	Collection (% of generated)	Disposal (% of collected)
Large Cities	0.55	9.44	80	0
Mid and small sized cites	0.42	4.44	50-70	0
Rural communities	0.33	13.72	<20	0

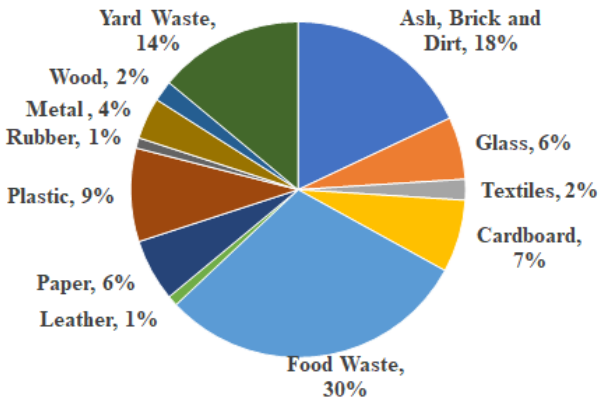


Figure 1: Composition of waste generation in Pakistan (reproduced)

Most of the industries are using conventional techniques in the production of tuff tiles i.e. without employing any compaction pressure. Whereas, some industries are now shifted to automated process of manufacturing with compaction to ensure durable tuff tiles.

The purpose of this research study is to explore the possibilities of utilization of industrial wastes in bricks and tuff tiles. Eco-friendly tuff tiles and bricks are more than just construction materials; they represent our commitment towards a better sustainable future. It will offers a durable, aesthetically pleasing solutions that seamlessly blend into our surroundings, making our cities more livable and eco-conscious.

2 Materials and Methods

2.1 Materials

Cement, sand, aggregate are used in conventional tuff tiles. Waste materials (plastic, marble powder and glass powder) were used as a partial replacement of cement and clay in bricks. Sargodha crush and Chenab sand was used in the production of tuff tiles. Tuff tiles are available in market in numerous designs with commonly used thickness of 60 mm. The dimension of casted tuff tiles was 200(L) x 100(W) x 60(T) mm. The strength of control specimen of tuff tiles and

brick was 28 MPa and 3.0 MPa respectively. After preliminary investigation, marble powder, glass and plastic was decided to be used as partial replacement of cement in the tuff tiles, and rice husk ash and baggase ash as partial replacement of clay in the bricks.

2.2 Methods

In order to access the actual situation of the tuff tiles and brick industries of Gujranwala Division, industries were visited. Samples from various industries were collected and tested in laboratory for density, water absorption and compression test. It is observed that compressive strength of some of the collected specimens are below the target strength as advertised by the manufactures. The ratios of replacement of cement and clay is selected as 5%, 10% and 15% by weight. These ratios are decided based on previous studies in similar research areas [6,7].

3 Results and Discussions

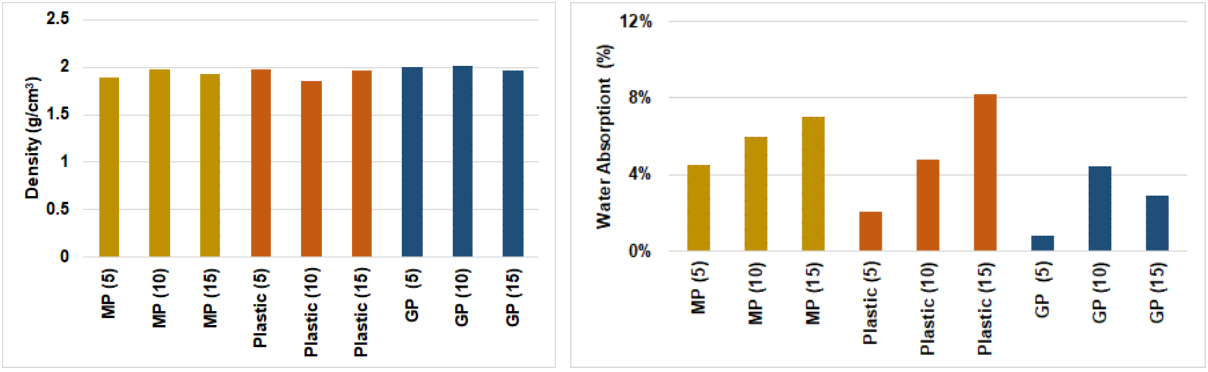
Water absorption and compression tests were performed on the collected and casted specimens.

3.1 Density

It was observed that the average density of the collected brick and tuff tiles specimens was about 2.0 g/cm^3 and 2.25 g/cm^3 respectively. The casted bricks and tuff tiles optimum density with replacement of selected wastes was about 1.7 and 2.0 g/cm^3 respectively. Figure 2(a), shows the effect on density of tuff tiles for various wastes replacement levels. It was observed that effect on density was minimum for various replacement levels. The lower density was likely due to non-compaction/vibration of casted tuff tiles specimens.

3.2 Water absorption test

It was observed that the average water absorption of the collected tuff tiles and bricks was about 6 to 8% and 8 to 12% for bricks respectively. The casted bricks and tuff tiles optimum water absorption with replacement of selected waste was about 16 to 18 % and 4 to 6% respectively. Figure 2(b), shows the effect on water absorption of tuff tiles for various wastes replacement levels. It was observed that water absorption increases with the increase in replacement level of wastes. The lower values were observed in marble and glass powder. It was due to its fine content that results in a better interlocking of the fine aggregates and thereby improving the composite matrix.



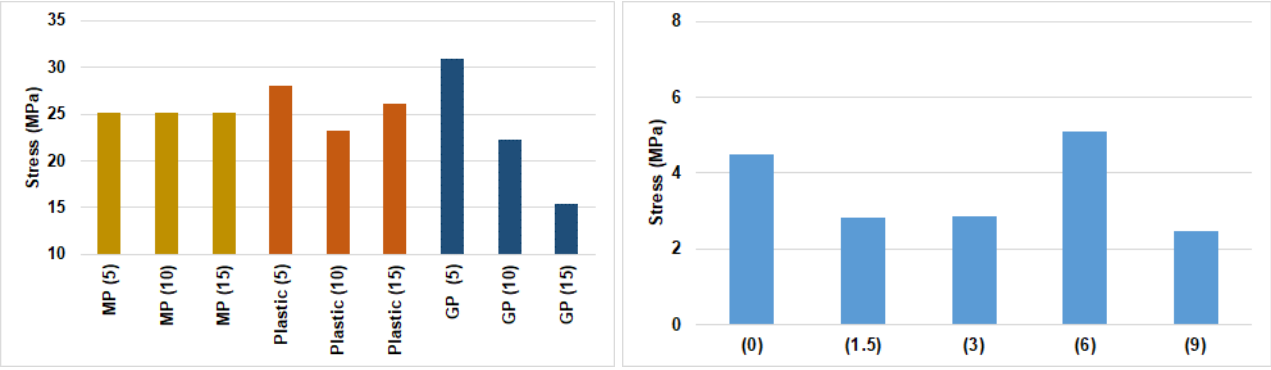
a) *b)*

Figure 2: Variations with addition of Marble powder (MP), Plastic and Glass powder (GP) in a. density and, b. water absorption (Replacement percentages are mentioned in brackets).

3.3 Unconfined Compression test

Uniaxial compression test was performed on controlled (5.0 MPa and 28 MPa for bricks and tuff tiles respectively) and tuff tiles and brick specimens prepared from various wastes. Optimum result in compressive strength was observed for tuff tiles having Plastic and Glass powder as partial replacement of cement, and rice rusk ash for bricks as shown in Figure 3.

Glass powder is finer as compared with plastic used for tuff tiles preparation, whereas rice husk ash imparts pozzolanic effect in the bricks.



a) *b)*

Figure 3: Variations in unconfined compressive strength with addition of a. Marble powder (MP), Plastic and Glass powder (GP) in tuff tiles and, b. Rice husk ash in brick (Replacement percentages are mentioned in brackets).

4 Practical Implementation

Brick and Tuff tiles are most commonly used building material. Millions of tons of solid waste is generated in Pakistan. By utilizing the waste in bricks and tuff tiles, can results not only economically friendly bricks but also a sustainable solution for developing countries like Pakistan.

5 Conclusion

It is observed from experimentation that the waste used is beneficial in producing sustainable bricks and tuff tiles. However, with increase of replacement percentage effects the durability of the products. The optimum percentage of replacement was found as 5 to 10% for bricks and tuff tiles using rice husk ash and glass powder; marble powder respectively.

Acknowledgment

The research is financially supported by Higher Education Commission Pakistan through National Research Grant Program for Universities (NRPU-16783) and by Pakistan Engineering Council Award for Final Year Design Projects.

References

[1] R.D.A. Hafez, B. A. Tayeh and R.O. Al Ftah, "Development and evaluation of green fired clay bricks using industrial and agricultural wastes," Case Studies in Construction Materials, vol. 17, pp. 1-20, 2022.
[2] S.S. Hossain, L. Mathur and P.K. Roy, "Rice husk/rice husk ash as an alternative source of silica in ceramics: A review," Journal of Asian Ceramic Societies, vol. 6, pp. 299-313, 2018.
[3] M.H. Riaz, A. Khitab, S. Ahmad, W. Anwar and M.T. Arshad, "Use of ceramic waste powder for manufacturing durable," Asian Journal of Civil Engineering, vol. 21, pp. 243-252, 2019.
[4] J. Ghuge, S. Surale, B.M. Patil and S.B. Bhutekar, "Utilization of waste plastic in manufacturing of paver blocks," International research journal of engineering and technology, vol. 6(4), pp.1967-1970, 2019.
[5] S. Akpınar and S. T. Anli, "Using volcanic tuff wastes instead of feldspar in ceramic tile production," Journal of Material Cycles and Waste Management, vol. 25, pp. 2159-2170, 2023.
[6] K. Khan, W. Ahmad, M.N. Amin, A. Ahamd, S. Nazar, A.A. Alabdullah and A.M.A. Arab, "Exploring the use of waste marble powder in concrete and predicting its strength with different advanced algorithms," Materials, vol. 15(12), pp. 1-28.
[7] K.L. Jain, G. Sancheti and L.K. Gupta, "Durability performance of waste granite and glass powder added concrete," Construction and Building Materials, vol. 252, pp. 1-11, 2020.
[8] United Nations Environment Programme, report on waste management in Pakistan (https://www.trade.gov/country-commercial-guides/pakistan-waste-management#).
[9] Center for peace and development intitaives, "Punjab's waste woes: a look at solid waste management, sanitation, and water supply", 2022.