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Investigating The Combined Effects of Replacing Cement with Sugarcane Bagasse Ash and Coarse Aggregate with Ceramic Tile Waste in Concrete Production

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Abstract: In pursuit of sustainable and innovative construction practices, this study investigates the combined effects of sugarcane bagasse ash (SCBA) and ceramic tile waste (CTW) as subsititue to aggregates on concrete properties, aiming to optimize their usage as eco-friendly alternatives. However, SCBA is a waste product of sugar industry. As a result of increasing recognition and understanding of sustainability and recycling in academia and industry over the past several decades, sustainability and recycling have become increasingly significant. It is also important to note that recycling construction waste and debris is one of the opportunities available for reducing construction waste. To optimize the amount of cement replaced by SCBA, the cement was partially replaced by SCBA and the ceramic waste was replaced at different dosages of 10%, 20%, and 30% by weight of coarse aggregates. Different properties such as workability and compressive strength have been evaluated during 7 and 28 days following replacement by SCBA and CTW. The results further revealed that the workability decreased with the inclusion of SCBA and CTW due to water absorption by the CTW and SCBA particles. However, the compressive strength of concrete mix was relatively higher at 10% replacement of cement by SCBA and 10% replacement of CTW, after which it decreased beyond 10% replacement. The maximum compressive strength was observed as 29.31 MPa with 10% SCBA and 10% CTW at the age of 28 days which is around 9.7% higher than the control mix concrete. It was deduced from the results of this study that 10% SCBA and 10% CTW replacement by the cement and coarse aggregates respectively, could be considered as optimum replacement.

Keywords: Sugarcane bagasse ash, ceramic tile waste, workability, compressive strength

1. Introduction

Agricultural residue presents a significant opportunity for integration into concrete manufacturing. In Pakistan, sugarcane holds a predominant agricultural status, yielding sugar and leaving residual byproducts such as sugarcane bagasse and bagasse ash. This residual bagasse emerges as a byproduct of the sugar industry, exhibiting promising potential as additional cementitious material in concrete, as highlighted by (Bahurudeen et al., 2014; Jha et al., 2021). The residual bagasse is repurposed as fuel to generate steam via boilers for electricity production, ultimately giving rise to ash, as indicated by (Alves et al., 2015; Arif et al., 2016). According to the Pakistan Sugar Mills Association's 2018-2019 report, sugarcane production reached 83.3 million tons, with 65.6 million tons processed in mills, culminating in an annual generation of around 0.26 million tons of sugarcane bagasse ash (SCBA) through the industrial combustion process (PSMA annual report 2018). This data underscores the abundant availability of SCBA in Pakistan. Regrettably, its utilization remains restricted, possibly due to insufficient comprehension or a shortage of technical information.

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Moreover, ceramics have served practical roles in households for an extended duration, particularly in applications like sanitary ware. Furthermore, ceramics have established themselves as integral components in construction, exemplified by their use in ceramic floor and wall tiles, as indicated by (Adekunle et al., 2017). The culmination of construction activities often leads to a surplus of ceramic tile waste, which conventionally finds its way to open landfills, contributing to environmental degradation. Integrating discarded ceramic waste into concrete presents economic advantages and addresses disposal challenges. Within the ceramic industry, 30% of production is rendered as waste, an untapped resource until now. Notably, ceramic waste exhibits robustness, hardness, and exceptional resistance to a range of degrading influences, be they chemical, biological, or physical, as emphasized by (Bommisetty et al., 2019). As the stockpile of ceramic waste steadily grows, the ceramic industry faces mounting pressure to devise disposal solutions. Handling ceramic tile waste emerging from construction and demolition sites poses a primary concern for contractors, amplifying societal predicaments. The allocation of landfill space to ceramic tile waste exacerbates the strain on landfill sites. In light of environmental and social ramifications, exploring the utilization of ceramic tile waste becomes a compelling avenue for researchers.The application of crushed ceramic waste as an aggregate holds promise for lightweight concrete production without compromising strength, an insight outlined by (Mangi et al., 2022). In the current investigation, crushed ceramic tile waste assumes the role of coarse aggregate, consequently examining the fresh and hardened attributes of concrete in which sugarcane bagasse and ceramic tile waste collaboratively contribute to the production process.

2. Materials and Methodology

This study used ordinary Portland Cement (OPC) Type-I of brand DG cement as the main binding agent. Hill sand was used as fine aggregate passed through 4.75 mm sieve with the specific gravity as 2.70. The crushed lime stone was used as coarse aggregates passed through 19.5 mm and retained on 4.75 mm sieve with the specific gravity as 2.65. The sugarcane bagasse shown in Fig. 1 (a) was collected from local sugar industry and burns it into open drum to make it ash as shown in Fig. 1 (b). The ash was then ground in a ball mill (Los Angeles machine) for 1 hour to obtain finer particles after grounding the ash was passed through 45-micron sieve as recommended by ASTM C618. However, the ceramic tiles waste (CTW) was collected from the local construction sites as shown in Fig. 2 (a). The collected CTW was crushed by hand hammering as per previous guidelines provided by Singh & Singla (2015) to be used as a substitute for coarse aggregates, as shown in Fig. 2 (b). Initially the physical parameters were evaluated and it was noticed that the shape of CTW was flaky, the specific gravity of CTW was recorded as 2.24 and water absorption was noted as 15%. This study considered M20 grade concrete (1:1.5:3 ratio) for preparing concrete mix with 0.50 water to cement ratio. The details of the concrete mix proportion are provided in Table 1.

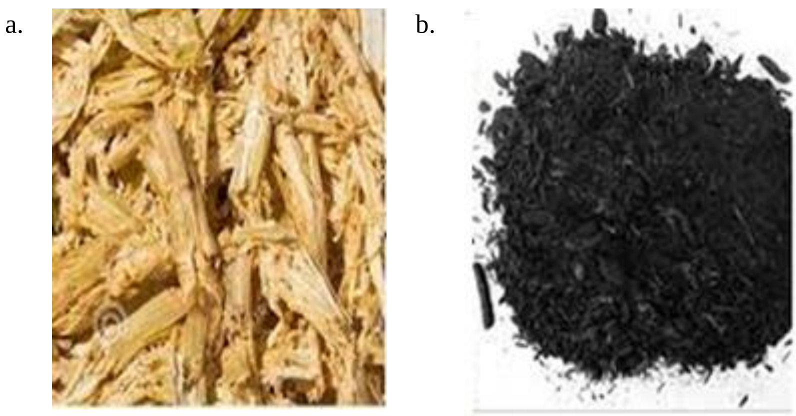

Fig. 1 - (a) Sugarcane bagasse; (b) sugarcane bagasse ash

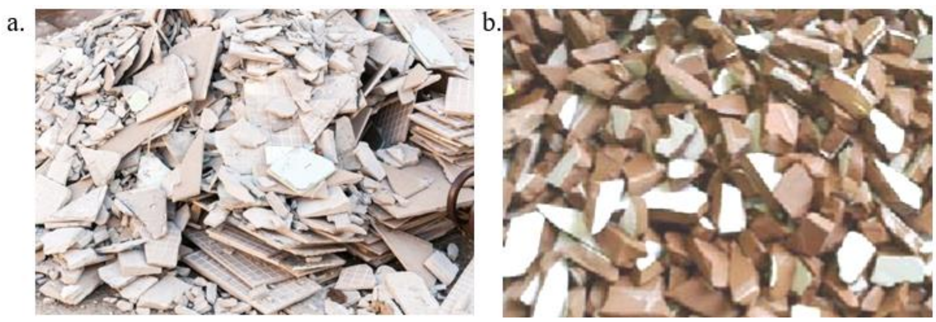

Fig. 2 - (a) ceramic tiles waste on site; (b) ceramic tiles waste after crushing

Table 1 - Detail of concrete mix proportion

Code	Binder Partial Replacement		F.A (%)	C.A (%)	CTW (%)	w/c ratio
	Cement (%)	SCBA (%)				
CM	100	0	100	100	0	0.5
SCBA10CTW0	90	10	100	100	0	0.5
SCBA10CTW10	90	10	100	90	10	0.5
SCBA10CTW20	90	10	100	80	20	0.5
SCBA10CTW30	90	10	100	70	30	0.5

**SCBA: Sugarcane Bagasse Ash, CTW: Ceramic Tile Waste, F.A: Fine Aggregate, C.A: Coarse Aggregate.*

3. Results and Discussions

3.1 Workability

Fig. 3 shows the slump results noted during the laboratory tests. It was observed that with the inclusion of SCBA, the workability of the concrete was increased due to higher water absorption by the SCBA particles. Besides that, inclusion of CTW also affects the workability performance of fresh mix concrete. The control mix concrete gives the slump as 80mm, while the addition of 10% SCBA gives the 75 mm slump value 6% lower than the control mix concrete. As the dosage of CTW increased, the workability was decreased due to the additional water absorption. However, the compatible slump value was achieved with 10% SCBA replacement i.e. 75 mm.

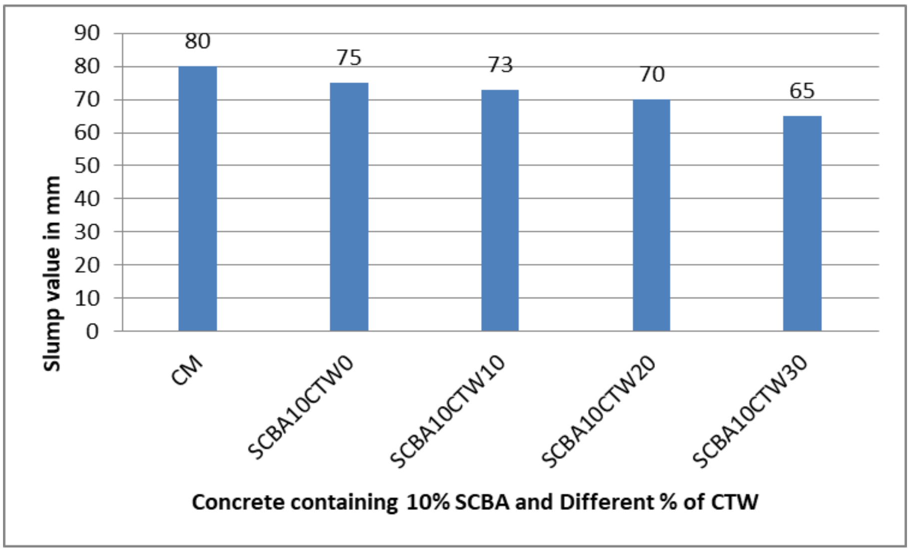

Fig. 3 - Workability of concrete containing 10% SCBA and different % of CTW

3.2 Compressive Strength

Fig. 4 shows the average compressive strength values for concrete containing 10% SCBA and concrete containing different amounts of CTW at 7 and 28 days. The compressive strength of concrete containing SCBA and CTW was observed to increase from 0% to 10% with the inclusion of both materials and then decreased again.

The maximum compressive strength of 24 MPa at 7days was obtained when 0% SCBA and 10% CTW were added to the concrete's weight of cement and coarse aggregate, respectively. There was an increment of 8.8% more than control mix at 7 days curing. The compressive strength of concrete containing SCBA and CTW was improved with inclusion of both the materials from 0% to 10% after then it was decreased. The maximum compressive strength of 29.31 MPa was obtained by adding 10% SCBA and 10% CTW by cement and coarse aggregate weight respectively in concrete. There is an increase of 9.70% higher than the control mix at 28 days of curing.

Based on the experimental results this study found that 10% replacement of SCBA with cement and 10% replacement of CTW with coarse aggregates by weight of concrete is optimum.

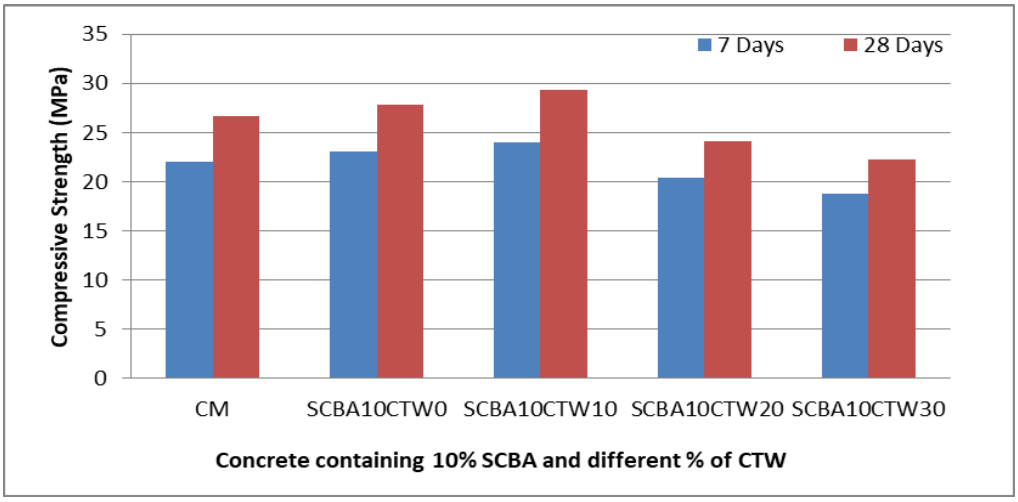

Fig. 4 - Compressive strength of concrete containing 10% SCBA and different % of CTW

4. Conclusion and Recommendations

- As the quantity of SCBA and ceramic tile waste (CTW) increased, the slump value was decreased. The control mix concrete gives the slump as 80mm, while adding 10% SCBA gives the 75 mm slump value 6% lower than the control mix concrete. The compatible slump value was achieved with 10% SCBA replacement i.e. 75 mm.
- The compressive strength of concrete containing SCBA and CTW improved by including both materials from 0% to 10% after it decreased. The maximum compressive strength of 24 MPa is achieved at 10% SCBA and 10% CTW replacement by cement and coarse aggregate weight, respectively in concrete. There was a rise of 8.8%, more than the control mix at 7 days of curing.
- The compressive strength of concrete containing SCBA and CTW is improved with the inclusion of both materials from (0% to 10%) after then it decreased. The maximum compressive strength of 29.31 MPa is achieved at 10% SCBA and 10% CTW addition by cement and coarse aggregate weight, respectively in concrete. There is an increase of 9.7% which is more than the control mix at 28 days of curing.
- Based on conducted research 10% replacement of SCBA with cement and 10% replacement of CTW with coarse aggregates by weight of concrete is optimum.

For the future study it is recommended to investigate other mechanical properties such as splitting tensile strength and flexural strength of concrete may be carried out with SCBA as cement replacement and CTW as coarse aggregate replacement.

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References

Adekunle, A. A., Abimbola, K. R., & Familusi, A. O. (2017). Utilization of Construction Waste Tiles as a Replacement for Fine Aggregates in Concrete. Engineering, Technology & Applied Science Research, 7(5), 1930–1933. https://doi.org/10.48084/etasr.1071

Alves, M., Ponce, G. H. S. F., Silva, M. A., & Ensinas, A. V. (2015). Surplus electricity production in sugarcane mills using residual bagasse and straw as fuel. Energy, 91, 751–757. https://doi.org/10.1016/j.energy.2015.08.101

Arif, E., Clark, M. W., & Lake, N. (2016). Sugar cane bagasse ash from a high efficiency co-generation boiler: Applications in cement and mortar production. Construction and Building Materials, 128, 287–297. https://doi.org/10.1016/j.conbuildmat.2016.10.091

Bahurudeen, A., Marckson, A. V, Kishore, A., & Santhanam, M. (2014). Development of sugarcane bagasse ash based Portland pozzolana cement and evaluation of compatibility with superplasticizers. Construction and Building Materials, 68, 465–475.

Bommisetty, J., Keertan, T. S., Ravitheja, A., & Mahendra, K. (2019). Effect of waste ceramic tiles as a partial replacement of aggregates in concrete. Materials Today: Proceedings, 19, 875–877. https://doi.org/10.1016/j.matpr.2019.08.230

Jha, P., Sachan, A. K., & Singh, R. P. (2021). Agro-waste sugarcane bagasse ash (ScBA) as partial replacement of binder material in concrete. Materials Today: Proceedings, 44, 419–427. https://doi.org/10.1016/j.matpr.2020.09.751

Mangi, S. A., Raza, M. S., Khahro, S. H., Qureshi, A. S., & Kumar, R. (2022). Recycling of ceramic tiles waste and marble waste in sustainable production of concrete: a review. Environmental Science and Pollution Research, 29(13), 18311–18332. https://doi.org/10.1007/s11356-021-18105-x

PSMA Annual Report (2018). Pakistan Sugar Mills Association Islamabad.

Singh, P., & Singla, R. K. (2015). Utilization of waste ceramic tiles as coarse aggregate in concrete. Journal of Multidisciplinary Engineering Science and Technology (JMEST), 2, 3294–3300.