An Experimental Study On Compressive Strength of Concrete by Blending of Fly ash, Artificial Sand and Over Brunt Brick

[1] **Swati Ramrao Jadhav , [2]S.P Sharma, [3]L.S Mahajan**

[1]MTech Student, [2,3]Assistant Professor,
[1] Department of Civil Engineering,
[1] Shreeyash College of Engineering & Technology, Chh. Sambhajinagar, India

Abstract : The rapid growth of the construction industry has significantly increased the demand for cement, natural river sand, and coarse aggregates, leading to the depletion of natural resources and environmental degradation. To address these challenges, the present study investigates the compressive strength of sustainable concrete by incorporating fly ash, artificial sand, and over-burnt brick aggregate as partial replacements for conventional concrete materials. Ordinary Portland Cement (OPC 53 Grade) was partially replaced with fly ash, natural river sand with artificial sand, and natural coarse aggregate with over-burnt brick aggregate at different replacement levels. Four concrete mixes, including a control mix, were prepared for M20 grade concrete following IS 10262:2019 guidelines. Standard concrete cube specimens (150 mm × 150 mm × 150 mm) were cast, water-cured for 7, 14, and 28 days, and tested for compressive strength using a Compression Testing Machine (CTM) in accordance with IS 516.

The experimental results revealed that the concrete mix containing 20% fly ash, 40% artificial sand, and 40% over-burnt brick aggregate achieved the highest 28-day compressive strength of 44.69 MPa, compared to 42.81 MPa for conventional concrete. Moderate replacement levels enhanced the compressive strength owing to improved particle packing and the pozzolanic reaction of fly ash, whereas higher replacement levels reduced strength because of increased porosity and water absorption. The findings demonstrate that the combined use of fly ash, artificial sand, and over-burnt brick aggregate is a feasible and sustainable alternative for concrete production. This approach promotes the utilization of industrial and construction waste, conserves natural resources, reduces environmental impact, and supports the development of eco-friendly and durable concrete for future construction applications.

Keywords: Fly Ash, Artificial Sand, Over-Burnt Brick Aggregate, Sustainable Concrete, Compressive Strength, M20 Grade Concrete.

I. INTRODUCTION

Concrete is the most widely used construction material due to its high compressive strength, durability, versatility, and cost-effectiveness. It is an essential component of modern infrastructure, including residential buildings, bridges, highways, dams, and industrial structures. However, the rapid growth of the construction industry has significantly increased the demand for cement, natural river sand, and coarse aggregates. Excessive consumption of these natural resources has resulted in environmental problems such as depletion of riverbeds, ecological imbalance, and increased carbon dioxide (CO_2) emissions from cement manufacturing. Therefore, the development of sustainable concrete using industrial by-products and recycled materials has become an important area of research.

Fly ash, a by-product generated from coal-fired thermal power plants, is widely used as a supplementary cementitious material in concrete. Its pozzolanic properties improve long-term strength, durability, and resistance to chemical attack while reducing cement consumption and greenhouse gas emissions. Similarly, artificial sand (manufactured sand) has emerged as a suitable replacement for natural river sand because of its consistent grading, better particle shape, and easy availability. The use of artificial sand also minimizes the environmental impact caused by excessive river sand mining.

Over-burnt bricks are another valuable waste material generated during brick manufacturing. These bricks are unsuitable for masonry work but can be crushed and used as partial replacements for conventional coarse aggregates. Their utilization not only reduces construction waste but also conserves natural stone resources and supports sustainable construction practices. However, the performance of concrete depends on the optimum replacement level of these materials, as excessive replacement may adversely affect strength and workability.

Several researchers have independently investigated the effects of fly ash, artificial sand, and recycled brick aggregates on concrete properties. Most studies have reported improvements in strength and durability at moderate replacement levels. However, limited research has focused on the combined use of these three sustainable materials in a single concrete mix. Therefore, further investigation is required to determine the optimum replacement proportions that provide enhanced mechanical performance while ensuring environmental sustainability.

The present study experimentally investigates the compressive strength of M20 grade concrete prepared by partially replacing cement with fly ash, fine aggregate with artificial sand, and coarse aggregate with over-burnt brick aggregate. Concrete specimens were tested after 7, 14, and 28 days of curing. The experimental results demonstrated that the mix containing 20% fly ash, 40% artificial sand, and 40% over-burnt brick aggregate achieved the highest compressive strength. The findings indicate that sustainable concrete produced using these replacement materials can reduce dependence on natural resources, promote waste utilization, and provide an eco-friendly alternative for future construction projects.

NEED OF THE STUDY.

The increasing demand for concrete has led to excessive consumption of cement, natural river sand, and coarse aggregates, causing environmental degradation and depletion of natural resources. Simultaneously, large quantities of industrial by-products such as fly ash and construction waste like over-burnt bricks are generated, creating disposal challenges. This study is needed to evaluate the effective utilization of these waste materials along with artificial sand in concrete production. The research aims to develop sustainable concrete with improved compressive strength, reduced environmental impact, and lower material costs while promoting resource conservation and eco-friendly construction practices for future infrastructure development.

II. LITERATURE REVIEW

Several researchers have investigated the use of sustainable materials in concrete to reduce environmental impacts and improve performance. Mehta and Monteiro (2014) reported that fly ash enhances the durability and long-term strength of concrete through its pozzolanic reaction. Neville (2012) emphasized that the quality of aggregates and proper mix design significantly influence the strength and durability of concrete.

Marthong and Agrawal (2012) observed that replacing cement with up to 20% fly ash improves workability and long-term compressive strength. Jatale et al. (2013) concluded that optimum fly ash replacement enhances concrete strength, whereas excessive replacement decreases mechanical performance. Similarly, Upadhyaya and Chandak (2014) reported that fly ash concrete achieves satisfactory strength while reducing cement consumption.

Studies on artificial sand have shown that it can effectively replace natural river sand because of its better grading and particle interlocking characteristics. Research on over-burnt brick aggregate indicates that moderate replacement of conventional coarse aggregate provides acceptable compressive strength while promoting construction waste utilization.

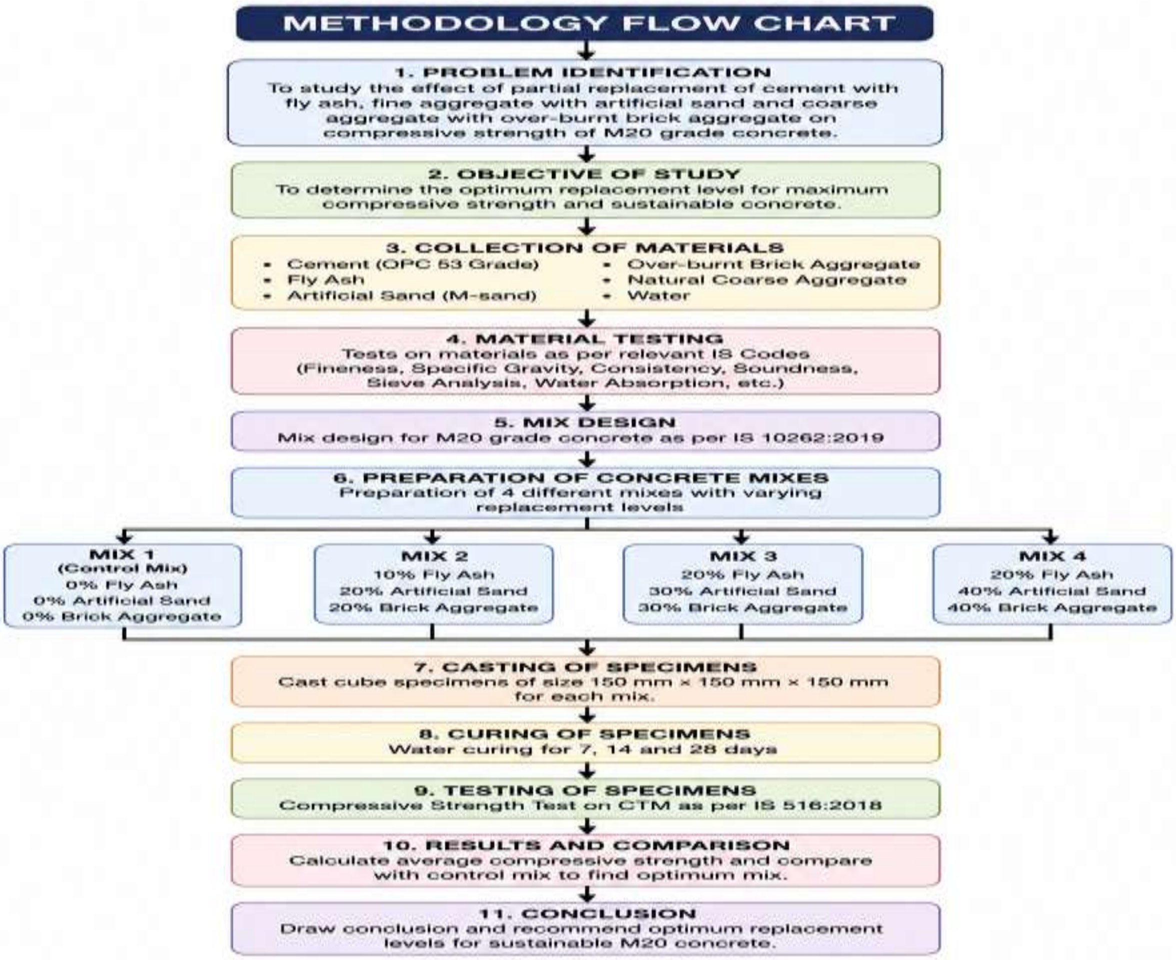
Although previous studies have examined the individual use of fly ash, artificial sand, and recycled brick aggregates, limited research has focused on their combined application in concrete. Therefore, the present study investigates the combined effect of these sustainable materials on the compressive strength of M20 grade concrete to identify the optimum replacement levels for practical construction applications.

Research Gap

Previous studies have extensively investigated the individual use of fly ash, artificial sand, and recycled brick aggregates in concrete. However, limited research has examined the combined effect of these three sustainable materials on the compressive strength of M20 grade concrete. Additionally, there is insufficient information regarding the optimum replacement proportions that provide improved strength while maintaining sustainability and cost-effectiveness. Therefore, this study aims to bridge this gap by evaluating the combined utilization of fly ash, artificial sand, and over-burnt brick aggregate to develop an eco-friendly and high-performance concrete mix.

I. MATERIALS AND METHODOLOGY

The experimental study was conducted to evaluate the compressive strength of M20 grade concrete by partially replacing conventional concrete materials with sustainable alternatives. Ordinary Portland Cement (OPC 53 Grade) was used as the binding material. Fly ash was used as a partial replacement for cement, artificial sand (manufactured sand) was used as a partial replacement for natural river sand, and crushed over-burnt brick aggregate was used as a partial replacement for conventional coarse aggregate. Potable water was used for mixing and curing the concrete.Four concrete mixes were prepared with different replacement levels. The control mix contained conventional materials, while the other mixes incorporated varying percentages of fly ash, artificial sand, and over-burnt brick aggregate. Concrete cube specimens of 150 mm × 150 mm × 150 mm were cast according to the mix design specified in IS 10262:2019 and cured in water for 7, 14, and 28 days.After curing, the specimens were tested for compressive strength using a Compression Testing Machine (CTM) in accordance with IS 516. The average compressive strength of three specimens was recorded for each mix and compared with the control mix to determine the optimum replacement level. The experimental results were analyzed to evaluate the effect of sustainable materials on the strength and performance of concrete.



IV. RESULTS AND DISCUSSION

A Results of Descriptive Statics of Study

The compressive strength of concrete cubes was determined after curing periods of 7, 14, and 28 days. Four concrete mixes were investigated: conventional concrete (control mix) and three sustainable concrete mixes prepared by partially replacing cement with fly ash, fine aggregate with artificial sand, and coarse aggregate with over-burnt brick aggregate.

Table 1. Average Compressive Strength of Concrete Table

Mix	Fly Ash (%)	Artificial Sand (%)	Over-Burnt Brick (%)	7Days (MPa)	14Days (MPa)	28Days (MPa)
Control Mix	0	0	0	20.50	37.34	42.81
Mix 1	10	20	20	23.67	38.44	42.81
Mix 2	20	40	40	25.90	38.55	44.69
Mix 3	30	60	60	17.93	23.71	29.55

The experimental results indicate that the compressive strength of concrete is significantly influenced by the replacement percentages of fly ash, artificial sand, and over-burnt brick aggregate.

1 Seven-Day Compressive Strength

The control concrete achieved an average compressive strength of 20.50 MPa after seven days of curing. Mix 1 (10% fly ash, 20% artificial sand, and 20% over-burnt brick aggregate) exhibited an average strength of 23.67 MPa, representing an improvement of approximately 15.46% compared with the control mix.

The highest seven-day strength (25.90 MPa) was observed for Mix 2 containing 20% fly ash, 40% artificial sand, and 40% over-burnt brick aggregate, corresponding to an increase of approximately 26.34% over conventional concrete. This improvement may be attributed to better particle packing and the pozzolanic reaction of fly ash, which contributes to the formation of additional calcium silicate hydrate (C-S-H) gel.

However, increasing the replacement levels to 30% fly ash, 60% artificial sand, and 60% over-burnt brick aggregate reduced the compressive strength to 17.93 MPa. The reduction is mainly associated with increased water absorption of brick aggregates, higher porosity, and weaker aggregate–paste bonding

2 Fourteen-Day Compressive Strength

At fourteen days, the control concrete developed an average compressive strength of 37.34 MPa. Mix 1 and Mix 2 achieved strengths of 38.44 MPa and 38.55 MPa, respectively, indicating marginal improvements over conventional concrete.

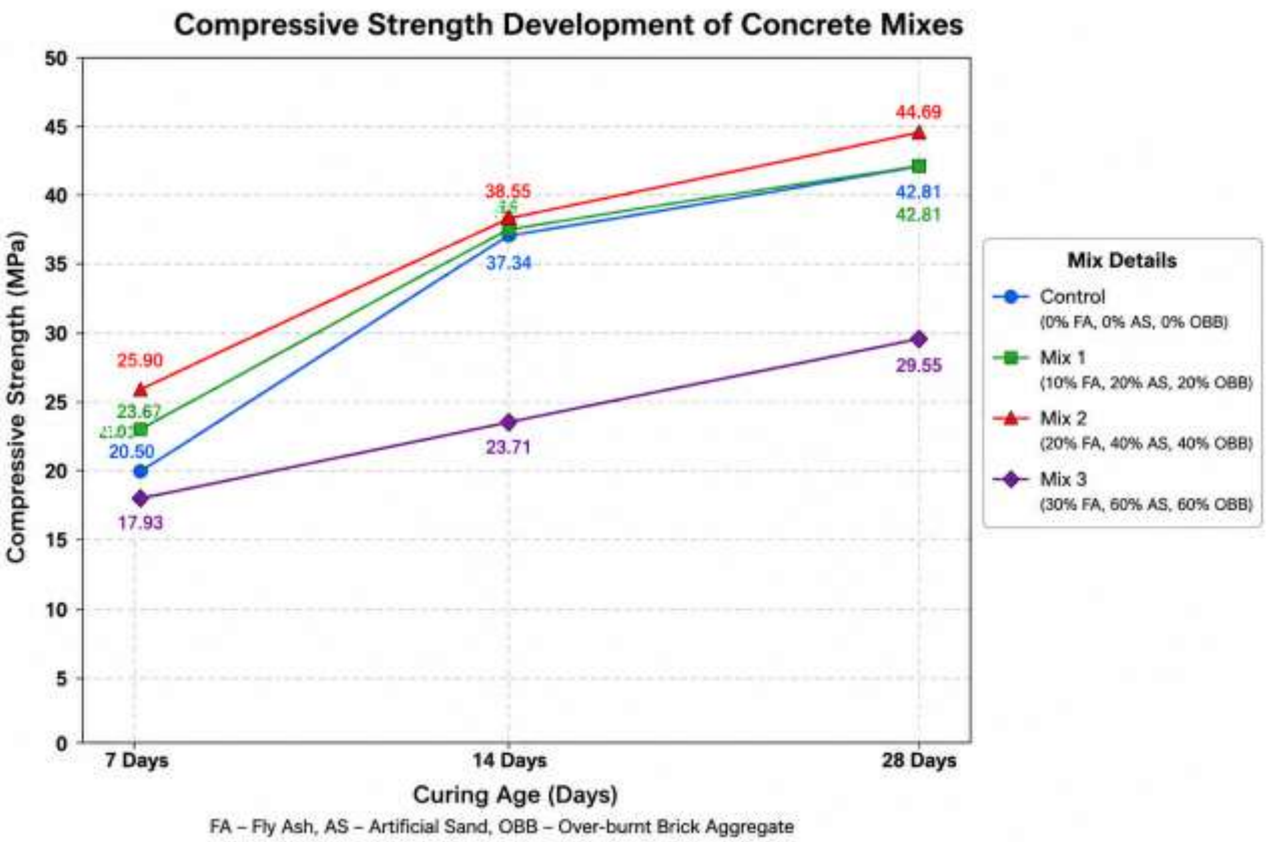
Mix 2 again exhibited the highest strength among all replacement levels, confirming that moderate replacement percentages enhance strength development during curing. In contrast, Mix 3 recorded only 23.71 MPa, demonstrating that excessive replacement adversely affects hydration and internal concrete structure.

3 Twenty-Eight-Day Compressive Strength

After twenty-eight days of curing, the control mix attained a compressive strength of 42.81 MPa. Mix 1 produced an identical average strength of 42.81 MPa, indicating that 10% fly ash with 20% replacement of aggregates can effectively substitute conventional materials without reducing strength.

The maximum compressive strength of 44.69 MPa was achieved by Mix 2. This represents an increase of approximately 4.39% over the control concrete, demonstrating that the combination of 20% fly ash, 40% artificial sand, and 40% over-burnt brick aggregate provides the optimum replacement level for M20 grade concrete.

Conversely, Mix 3 exhibited a compressive strength of only 29.55 MPa, indicating a significant reduction due to excessive replacement. Higher proportions of over-burnt brick aggregate increase water absorption and internal voids, while excessive fly ash delays hydration, collectively reducing mechanical performance.



B. Conclusion

The experimental investigation demonstrates that moderate replacement levels improve concrete performance by enhancing particle packing, optimizing the microstructure, and promoting secondary hydration through the pozzolanic reaction of fly ash. Artificial sand contributes to improved inter-particle contact because of its angular shape, while over-burnt brick aggregate effectively utilizes construction waste without compromising strength when used within optimum limits.

The optimum mix proportion identified in the present study consists of 20% fly ash, 40% artificial sand, and 40% over-burnt brick aggregate, which achieved the highest compressive strength at all curing ages. Beyond these replacement levels, the mechanical properties deteriorated because of increased porosity, higher water demand, and weaker aggregate–cement paste bonding.

The findings are consistent with previously published research on sustainable concrete, which reports that moderate incorporation of supplementary cementitious materials and recycled aggregates can produce environmentally friendly concrete with satisfactory structural performance.

Overall, the study confirms that the combined use of fly ash, artificial sand, and over-burnt brick aggregate is a technically feasible and environmentally sustainable approach for the production of M20 grade concrete. The proposed mix not only conserves natural resources but also supports waste utilization and reduces the environmental footprint of concrete production.

REFERENCES

1. Mehta, P. K., & Monteiro, P. J. M. (2014). *Concrete: Microstructure, Properties, and Materials* (4th ed.). McGraw-Hill Education.
2. Neville, A. M. (2012). *Properties of Concrete* (5th ed.). Pearson Education.
3. Siddique, R. (2008). *Waste Materials and By-products in Concrete*. Springer.
4. Thomas, M. (2013). *Supplementary Cementing Materials in Concrete*. CRC Press.
5. Marthong, C., & Agrawal, T. P. (2012). Effect of Fly Ash Additive on Concrete Properties. *International Journal of Engineering Research and Applications*, 2(4), 1986–1991.
6. Jatale, A., Tiwari, K., & Khandelwal, S. (2013). Effects on Compressive Strength when Cement is Partially Replaced by Fly Ash. *IOSR Journal of Mechanical and Civil Engineering*, 5(4), 34–43.
7. Upadhyaya, S., & Chandak, R. (2014). Effect of Fly Ash on Compressive Strength of M20 Concrete. *International Journal of Advancement in Research & Technology*, 3(9).
8. Kumar, D. N., Abhilash, P. P., Singh, R., Kumar, R., & Kumar, V. (2022). Fly Ash for Sustainable Construction: A Review of Fly Ash Concrete and Its Beneficial Use Case Studies. *Cleaner Materials*, 6, 100143.
9. Yao, Z., Ji, X., Sarker, P. K., et al. (2018). Characteristics and Applications of Fly Ash as a Sustainable Construction Material: A State-of-the-Art Review. *Resources, Conservation and Recycling*, 136, 95–109.
10. Islam, M. N., Noaman, M. A., Islam, K. S., & Hanif, M. A. (2024). Mechanical Properties and Microstructure of Brick Aggregate Concrete with Raw Fly Ash as a Partial Replacement of Cement. *Heliyon*, 10(7), e28904.
11. IS 456:2000. *Plain and Reinforced Concrete – Code of Practice*. Bureau of Indian Standards, New Delhi.
12. IS 10262:2019. *Concrete Mix Proportioning – Guidelines*. Bureau of Indian Standards, New Delhi.