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# A novel analytical evaluation of the laboratory-measured mechanical properties of lightweight concrete

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**Abstract.** Urbanization and industrialization have significantly increased the amount of solid waste produced in recent decades, posing considerable disposal problems and environmental burdens. The practice of waste utilization in concrete has gained popularity among construction practitioners and researchers for the efficient use of resources and the transition to the circular economy in construction. This study employed Lytag aggregate, an environmentally friendly pulverized fuel ash-based lightweight aggregate, as a substitute for natural coarse aggregate. At the same time, fly ash, an industrial by-product, was used as a partial substitute for cement. Concrete mix M20 was experimented with using fly ash and Lytag lightweight aggregate. The percentages of fly ash that make up the replacements were 5%, 10%, 15%, 20%, and 25%. The Compressive Strength (CS), Split Tensile Strength (STS), and deflection were discovered at these percentages after 56 days of testing. The concrete cube, cylinder, and beam specimens were examined in the explorations, as mentioned earlier. The results indicate that a 10% substitution of cement with fly ash and a replacement of coarse aggregate with Lytag lightweight aggregate produced concrete that performed well in terms of mechanical properties and deflection. The cementitious composites have varying characteristics as the environment changes. Therefore, understanding their mechanical properties are crucial for safety reasons. CS, STS, and deflection are the essential property of concrete. Machine learning (ML) approaches have been necessary to predict the CS of concrete. The Artificial Fish Swarm Optimization (AFSO), Particle Swarm Optimization (PSO), and Harmony Search (HS) algorithms were investigated for the prediction of outcomes. This work deftly explains the tremendous AFSO technique, which achieves the precise ideal values of the weights in the model to crown the mathematical modeling technique. This has been proved by the minimum, maximum, and sample median, and the first and third quartiles were used as the basis for a boxplot through the standardized method of showing the dataset. It graphically displays the quantitative value distribution of a field. The correlation matrix and confidence interval were represented graphically using the corrupt method.

**Keywords:** box plot; corrplot; deflection; Lytag lightweight aggregate; mathematical modeling; optimization algorithms

## 1. Introduction

The most widely used construction material in the world, concrete plays a crucial role in creating a nation's infrastructure (Hosan *et al.* 2016). The major drawback of the current construction practice is the excessive consumption of virgin natural resources (Prakash *et al.* 2021). One of the reasons influencing the sector, especially the manufacturing of cement and concrete, is the high demand for these natural resources and the absence of regulation and motivation to manage their over-exploitation (Prakash *et al.* 2019). Its manufacture uses a tremendous quantity of natural resources and generates a lot of $CO_2$ emissions (Prakash *et al.* 2022). There have been initiatives to expand the novel techniques for intensifying concrete for decades. Fly ash is essential to the operation of such a device. In the building sector, the utilization of fly ash as a cement substitute has been observed as the majority of attention. As an additional measure to decrease the self-weight of the concrete, Lytag lightweight aggregate has been utilized in place of coarse aggregate. The mix proportions, moisture content, and aggregate grading influence concrete density. With light coarse particles, the concrete mixture was created. Typically, sintered fly ash aggregate that has been burned in a rotary kiln to generate a porous character is utilized as the light aggregate in this structural concrete (Divyah *et al.* 2023)

Machine learning techniques can now be used to tackle engineering challenges, and their applications can serve as ideal examples of domains that have been investigated with a range of assumptions and practical outcomes (Zhang *et al.* 2023, El-Mir *et al.* 2023). Researchers used mathematical modeling with optimization techniques to predict concrete parameters (Sivakumar and Kameshwari, 2016, Li *et al.*

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