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Comprehensive Analysis of Perlite as a Replacement for Aggregates in Light Weight Concrete

[1]Mo jahid, [2]Mithun Kumar Rana, [3]Pushpendra Kumar Kushwaha

[1]M. Tech. Research Scholar, Civil Department, RKDF College of Engineering, Bhopal (M. P.), 402026, India
[2,3]Assistant Professor, Civil Department, RKDF College of Engineering, Bhopal (M. P.), 402026, India

***Abstract* - Structural Low Density Aggregate Concrete has an ability to reduce the self-weight of the structure as well as reduces the risk of earthquake damages to a structure because earthquake forces are proportional to mass of the structure. For structural application of lightweight concrete, the density is more important than the strength. A low density for the same strength level reduces the self-weight, foundation size and construction costs. In this study, structural lightweight aggregate concrete was designed with natural Perlite aggregate that will provide an advantage of reducing dead weight of structure also compared the strength of normal concrete with perlite concrete by fully replacing coarse aggregate with perlite by varying the water cement ratio in perlite concrete.**

This thesis investigates the development and performance evaluation of perlite lightweight concrete, targeting its mechanical strength and durability for structural use. The research comprises three comprehensive phases aimed at enhancing various aspects of lightweight concrete formulations and structural behaviour., focuses on the design of concrete mixtures with varying proportions of perlite replacement (ranging from 10% to 50%) for three different grades (M30, and M40).

Keywords: Low density concrete, Perlite aggregate, Self – weight reduction, Compressive strength analysis, Tensile strength analysis.

I. INTRODUCTION

Lightweight concrete is a type of concrete with a lower density than standard concrete, achieved by using lighter aggregates. It is often used to reduce the overall weight of structures, improve thermal and acoustic insulation, and increase fire resistance. The lower density results in reduced structural load, which can be beneficial for large buildings, bridges, and other structures where weight is a significant factor.

Types of Lightweight Concrete

1. Lightweight Aggregate Concrete: Made with lightweight aggregates like expanded clay, shale, or pumice, which have a porous structure. This is common for structural uses due to its strength and durability.
2. Foamed or Aerated Concrete: Created by introducing air bubbles into the mix, usually through a foaming agent, which leads to an even lighter material. Often used in non-structural applications like insulation panels and roof decks.
3. No-Fines Concrete: Uses only coarse aggregate and cement without any fine materials (like sand), resulting in a porous and lightweight material.

Advantages of Lightweight Concrete

- Reduced Structural Weight: Ideal for multi-story buildings or load-sensitive structures.
- Improved Insulation: Good for thermal and sound insulation.
- Enhanced Fire Resistance: Due to its lower thermal conductivity and higher heat tolerance.

II. LITERATURE SURVEY & BACKGROUND

Shukla, A. K., and Patel, D. H. (2020). Experimental Study of Lightweight Concrete's Properties Using Various Lightweight Aggregates. Proceedings of Materials Today, 33(2), 707-713. By combining different lightweight aggregates, Patel and Shukla explore the qualities of lightweight concrete in their study work. The effectiveness of lightweight concrete using expanded clay, expanded shale, and pumice aggregates is evaluated through a comparative analysis conducted in this study. It examines important characteristics including density, water absorption, and compressive strength in order to determine if certain lightweight aggregates are suitable for making concrete.

Murat Kurt et al. (2016) conducted a comprehensive empirical investigation to investigate the effects of pumice aggregates, various water-to-(cement + mineral additive) ratios, and the presence of pumice powder on the mechanical and physical properties of self-compacting lightweight aggregate concrete. Pumice is a lightweight material utilised in aggregates, according to their thorough literature review. Density, flow capacity, V-funnel duration, L-box evaluations, compressive strength at 7, 28, 90, and 180 days, splitting

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tensile strength at 28 days, dry density, water absorption, thermal conductance, and ultrasonic pulse velocity assessments were among the basic characteristics of self-compacting lightweight concrete with pumice aggregates that were covered in the study. They meticulously constructed 24 sets of concrete samples in order to achieve these goals, then divided them into two groups.

III. OBJECTIVE

Design of concrete mix of various proportions and then compare the mechanical and durability performance of perlite light weight concrete at 10%, 20%, 30%, 40% and 50% replacement levels for three different grades (M25, M30) so as to determine the most effective or viable part to consider for replacement level in concrete mix proportioning.

IV. RESULT

4.1 Slum test value

The slump test is a widely used method to assess the workability or consistency of fresh concrete. It provides an indication of how easily concrete can be mixed, transported, placed, and compacted without segregation.

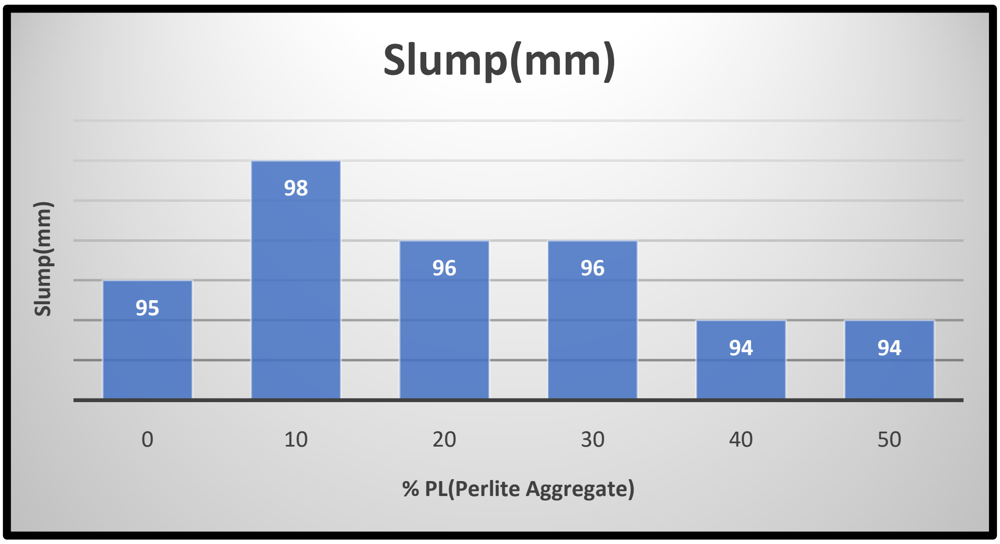

Figure 1: Slump value for M30 concrete

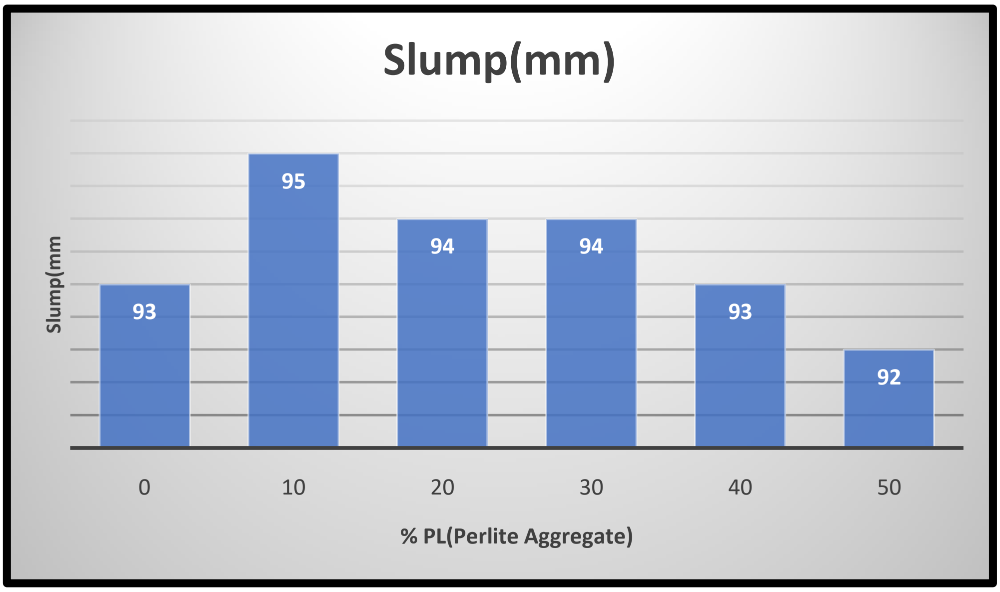

Figure 2: Slump value for M30 concrete

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4.2 Compressive strength

Compressive strength is the ratio of the maximum load applied to a sample to the cross-sectional area of the cube, expressed in units like megapascals (MPa) or pounds per square inch (psi).

Table 1: Compressive strength N/mm² For M25

SN	mix id	% PL (Perlite Aggregate)	Compressive strength N/mm²			
			7 days	21 Day	28 day	56 day
1	NC	0	18.2	24.24	28.13	30.25
2	Mix-1	10	22.21	24	28.56	29.23
3	Mix-2	20	18.5	20	22.23	25.21
4	Mix-3	30	18.1	19	20.21	22.1
5	Mix-4	40	16	17	18.32	20.21
6	Mix-5	50	14.12	15.5	17.23	19.21

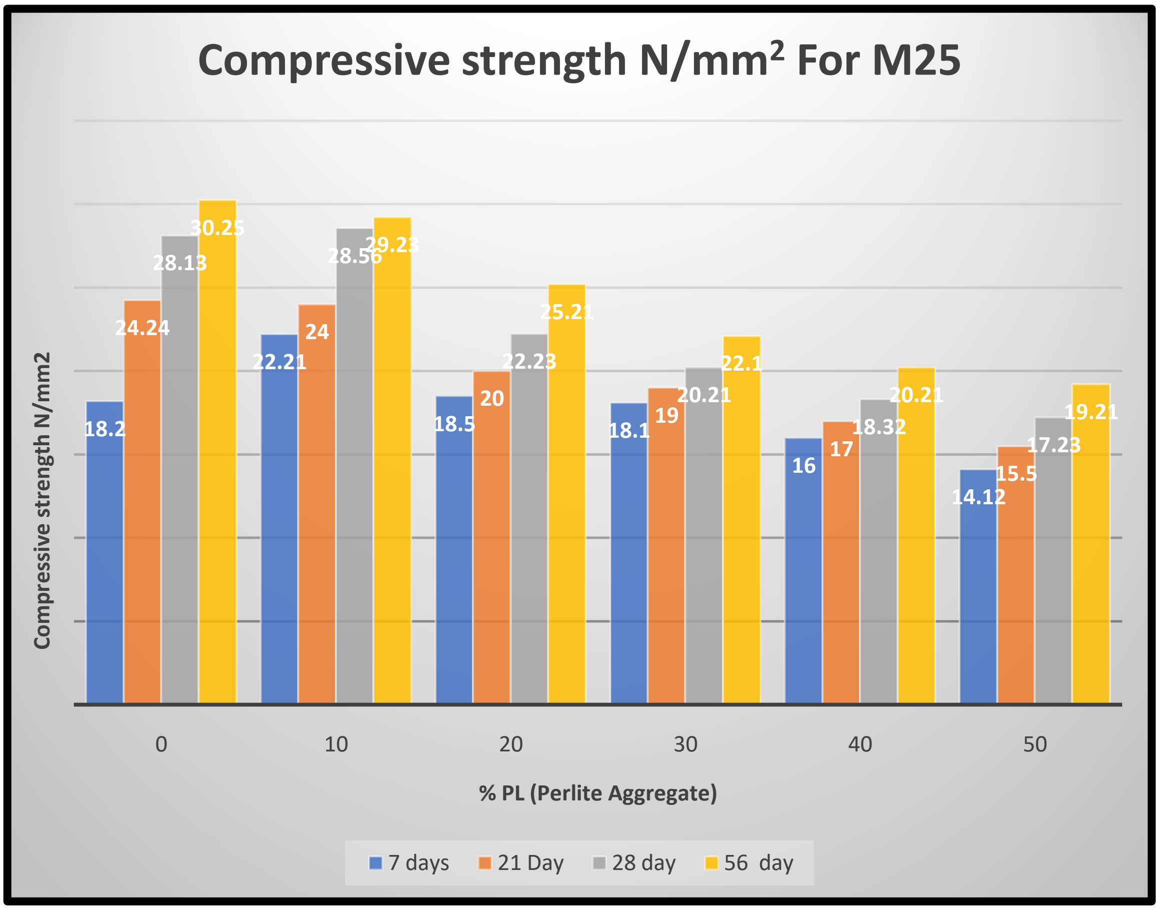

Figure 3: Variation in compressive strength for M25 grade Perlite Concrete at 7, 21, 28, 56 Days

According to the results of the experiments, the compressive strength increased noticeably by 12.91% after seven days when coarse aggregate was replaced with perlite aggregate at different percentages (10%, 20%, 30%, 40%, and 50%). But over a longer period of time, a slight decrease of 2.84% was noted at 56 days. By contrast, the compressive strength of the standard M25 grade concrete varied from 19.2 MPa at 37 days to 30.25 MPa at 56 days.

At 28 days, the compressive strength decreased by 14.26% (Mix 2), 22.42% (Mix 3), 30.58% (Mi4), and 32.24% (Mix 5) compared to standard concrete, showing a linear connection with the substitution percentages.

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Table 2: Showing variation in long term compressive strength for M30 grade Perlite Concrete

SN	mix id	% PL (Perlite Aggregate)	Compressive strength N/mm^2			
			7 days	21 Day	28 day	56 day
1	NC	0	19.2	29.32	32.34	36.56
2	Mix-1	10	24.23	27.23	31.76	35.21
3	Mix-2	20	22.34	26	30	32.12
4	Mix-3	30	21	22	26	29
5	Mix-4	40	20	21	25	28.01
6	Mix-5	50	19.1	20	24.12	27.1

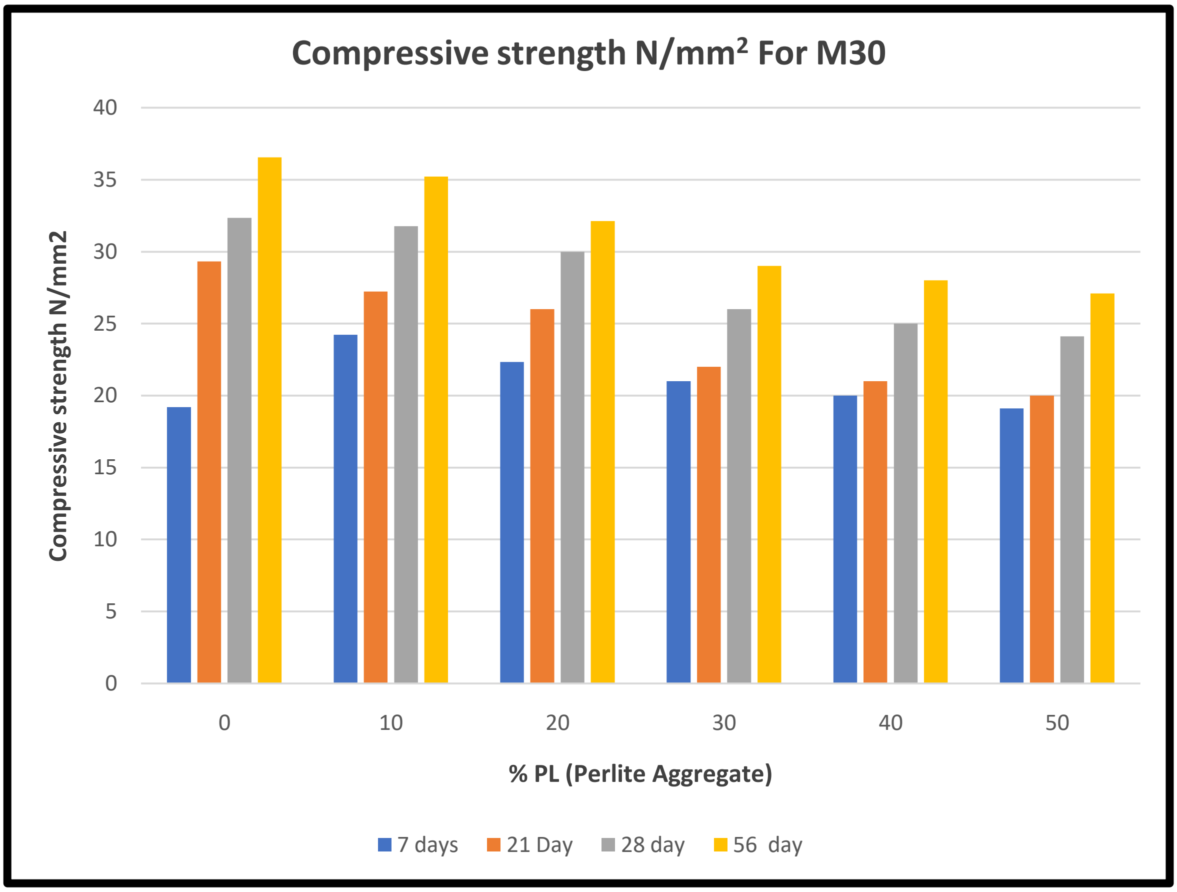

Figure 4: Compressive strength N/mm^2 For M30

For conventional M30 grade concrete, as shown in the figure, the compressive strength increased from 19.2 MPa to 36.56 MPa after 7 and 56 days of tenure. In contrast, the concrete made with perlite aggregates as the coarse aggregate increased from 19.2 MPa to 24.233 MPa after 7 days, 31.25 MPa after 28 days, and 35.21 MPa after 56 days.

V. CONCLUSION

- Experimental results show that the M25, M30, and M40 grades of control concrete's compressive are nearly identical to those of the concrete in which 10% perlite aggregates are used to partially replace the coarse aggregate.
- It is observed that, with regard to 56-day long-term compressive, , the objective strength was almost reached by partially substituting 10% perlite aggregate for coarse aggregate. Nonetheless, 20%, 30%, 40%, and 50% perlite aggregates offer adequate results that can be modified for small-scale projects.
- According to the results of the experiments, the compressive strength increased noticeably by 12.91% after seven days when coarse aggregate was replaced with perlite aggregate at different percentages (10%, 20%, 30%, 40%, and 50%).

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