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Assessment of Limestone Dust and Chips as Eco-friendly Alternatives in Concrete Production

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ABSTRACT

During Recent days as there is seen an expandable rise in Construction Works the use of River Sand is also increasing significantly at a rapid rate and due to its fixed amount of availability there is a need to find the replacement of River Sand or Fine Aggregates. So here we are partially replacing the River Sand with Limestone Chips and Ordinary Portland Cement with Limestone Dust to see its properties. The study is done to determine the Compressive Strength Test. The use of Ordinary Portland Cement of 43 grade has been made. The samples of concrete (Cubes) were made for two different Grade i.e. M20 and M25 with variable mix Percentages of Limestone Chips (i.e.10%,20%,30% and 40%) while the Limestone Dust is replaced by 10% of OPC for every mix prepared. The different Design Mixes were Prepared. The results after tests were compared to that of Conventional Concrete and determination of the concrete mixes were made if they are suitable to use for structural members of buildings and related structures.

Keywords: Cement, OPC, Limestone, Dust, Fine Aggregates

I. INTRODUCTION

Irregularities are inherent in the construction of buildings [1]. This paper focuses on examining the structural characteristics of concrete mixes using various combinations of limestone dust with cement and limestone chips as fine aggregates. Limestone, a sedimentary rock formed from the remains of shells or skeletons over an extensive period [2], is primarily composed of calcium carbonate and may also contain magnesium, iron, or manganese, influencing its whiteness and hardness [3-4]. The chemical composition of limestone collected from Nandini Mines, Jamul, Bhilai, reveals SiO2 at 12.45%, CaO at 45.15%, and MgO at 0.46% [5]. While widely used in the construction industry, limestone also finds numerous applications in everyday life.

Comparative analysis with normal concrete, maintaining the same water/cement ratio and cement types, suggests that concrete with a higher content of limestone powder and a considerable particle size distribution generally exhibits improved characteristic strengths [6]. Concrete incorporating limestone dust as a partial replacement of Ordinary Portland Cement (OPC) can tolerate up to 10% without adversely affecting concrete strength [7]. Similarly, concrete utilizing limestone dust as a partial replacement of cement can accommodate up to 20% without compromising strength [8-9].

Furthermore, employing various combinations of limestone chips and limestone dust as replacements for OPC and river sand, different design mixes were explored to achieve higher compressive and tensile strengths, as well as improved workability for M20 and M25 mix proportions [10-12]. Specifically, compressive strength ranging between 21.06 - 35.2 N/mm2 for concrete mixtures was considered. Multiple mixes were prepared to partially replace river sand with limestone chips at percentages of 10%, 20%, 30%, and 40%, while limestone dust replaced ordinary Portland cement at 10%, and the results were compared with those of conventional concrete.

The utilization of alternative materials in construction processes has become increasingly imperative to address environmental concerns and meet the escalating demands of the construction industry. Limestone, a readily available natural resource, has garnered attention as a potential substitute in concrete production. This paper explores the utilization of limestone dust as a partial replacement of cement and limestone chips for fine aggregates in concrete mixtures. By harnessing these waste materials from crusher mines, the study aims to assess their efficacy in enhancing the mechanical properties of concrete while promoting sustainable construction practices. Through comprehensive experimentation and analysis, this research seeks to provide valuable insights into the feasibility and potential benefits of incorporating limestone dust and chips in concrete formulations

II. SIGNIFICANCE OF THE WORK

With the Construction Industry expanding rapidly, there is a corresponding surge in demand for construction materials, necessitating the exploration of new materials to meet evolving objectives [13]. Studies have indicated that replacing a portion of river sand (fine aggregate) with limestone chips and ordinary Portland cement with limestone powder yields comparable compressive strength properties. The primary objective of this study is to reduce reliance on river sand and cement while striving to enhance environmental sustainability for future prospects.

Figure 1. Used Materials

III. EXPERIMENTAL WORK

In this study, limestone chips and limestone dust are sourced as waste materials from crusher mines. Limestone dust is substituted for 10% of the quantity of ordinary Portland cement in each mix prepared, while limestone chips are replaced at varying percentages of 10%, 20%, 30%, and 40%. These mixes were formulated for M20 and M25 grades of concrete. Three samples were prepared for each type of mix, and nominal mixes were also formulated for both grades for comparison. In total, 60 samples were prepared and subjected to compressive strength tests at 7 and 28 days.

- Cement – Ordinary Portland Cement (Ultratech OPC) was used. Different tests were performed like Initial setting time, Final setting time, Consistency test and Soundness test.
- Coarse Aggregate – Normal Crusher Stones passing 20mm Sieve were taken into account for the study.
- Fine Aggregates – (A). River Sand was taken for the study passing 4.75 mm Sieve and tests like specific gravity using Picnometer and Sieve Analysis were done. (B). Limestone Dust was collected from the Baloda-Bazar District of Chhatisgarh and Sieve Analysis is performed. The Limestone Dust passing 90 micron Sieve were taken for replacement with Cement.
- Water – Water plays a vital role in making concrete as it the reason behind Chemical reaction between the materials. Water having PH-7 is used for mixing and curing purposes.

IV. METHODOLOGY

The Cubes were casted for M20 and M25 grade of Concrete for which Mix Designs were done and the ratio for M20 is (1:2:3.64) and for M25 it is (1:1.73:3.27). Then after calculating the weight of materials.

1. Take the weighted materials i.e. Fine Aggregate and Coarse Aggregate along with the Limestone Chips for which it has to be replaced and Cement replaced with Limestone Dust in a Pan.
2. Dry mix the materials thoroughly.
3. Mix all the materials side by side and by turning it over each other and then make a hollow at the centre.
4. Add Appropiate quantity of water by measuring and mix the dry mixture thoroughly.
5. Now put the mixture in oil polished Cube Moulds for 1/3 part.
6. Now after temping 25 times fill the 2/3 of the mould and repeat the process.
7. Now completely fill the mould and level it then put on Table Vibrator then keep for 24 hours.
8. After 24 hours take the specimen out of the mould and keep for Curing in curing tanks.
9. After 7 & 28 Days the specimens will be taken out of curing tanks and Compressive Strength tests will be performed.

V. RESULTS AND DISCUSSION

Replacing limestone dust in all mixes by 10% of the cement content and limestone chips by 10%, 20%, 30%, and 40% of river sand resulted in varying increments in 7-day compressive strength. For M20 grade, the increments ranged between 16% to 50%, while for M25 grade, it ranged from 0% to 6%. Similarly, for 28-day compressive strength, the increments for M20 grade were between 0% to 12%, and for M25 grade, they ranged from 0% to 8%. It was observed that the highest compressive strength for all grades was achieved when river sand was replaced by 30% limestone chips and cement by 10% limestone dust.

Table 1. Experiment Investigation on Compressive Strength of M20 of M20 Concrete with different % Mix

% age Mix (Cement partially replaced by Limestone Dust)	% age Mix (River Sand partially replaced by Limestone Chips)	7 Days Compressive Strength (MPa)	28 Days Compressive Strength (MPa)
0%	0%	13.23	21.67
10%	10%	15.45	19.01
10%	20%	15.90	22.56
10%	30%	19.90	24.34
10%	40%	18.32	22.76

Table 2. Experiment Investigation on Compressive Strength of M25 Concrete with different % Mix

% age Mix (Cement	% age Mix (River	7 Days Compressive Strength	28 Days Compressive Strength

partially replaced by Limestone Dust)	Sand partially replaced by Limestone Chips)	(MPa)	(MPa)
0%	0%	20.48	25.67
10%	10%	21.23	27.45
10%	20%	19.90	23.67
10%	30%	21.67	26.56
10%	40%	18.76	22.32

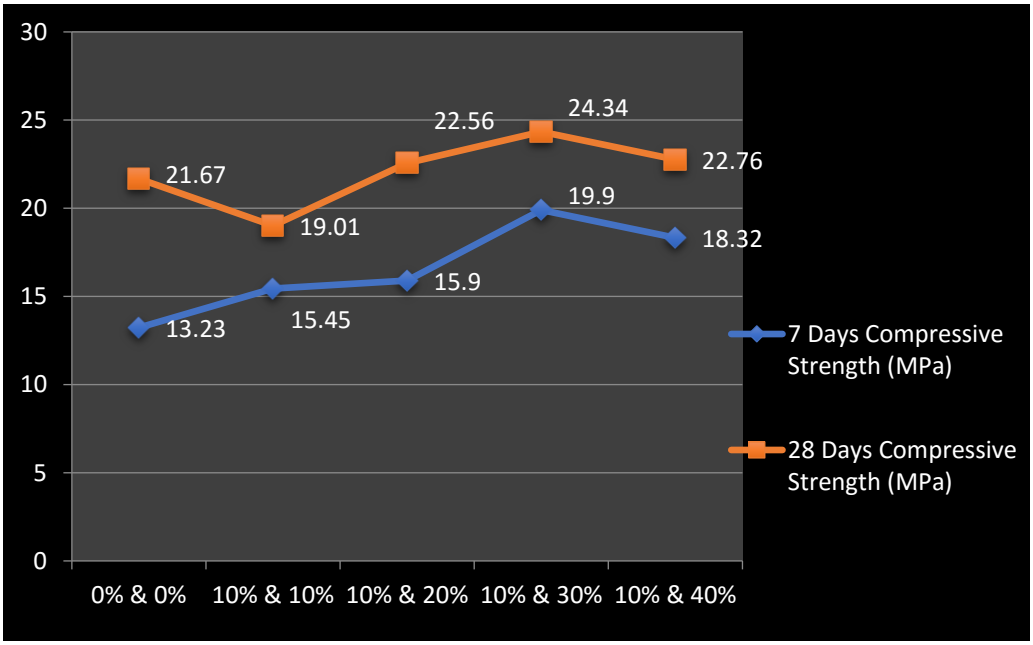

Figure 2. Compressive Strength of M20 Concrete with different % age Mix (Cement partially replaced by Limestone Dust & Limestone Chips) for 7 and 28 Days

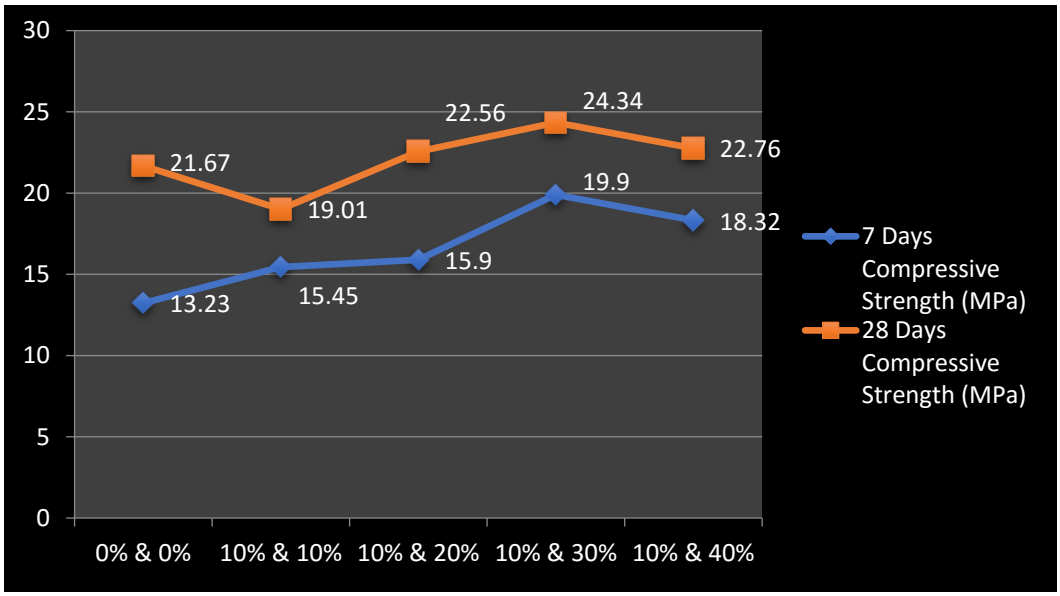

Figure 3. Compressive Strength of M25 Concrete with different % age Mix (Cement partially replaced by Limestone Dust & Limestone Chips) for 7 and 28 Days

VI. CONCLUSION

Compressive Strength test were done for concrete mixes at age of 7 and 28 days for Limestone Dust to be partially replaced by Cement by 10% for all mixes and Limestone

Chips to be replaced partially by River Sand by 10%, 20%, 30% and 40%. The tests result was compared to Conventional Concrete result and it is seen that the mix with 10% and 30% replacement was suitable for making Concrete and in use of Structural Members of building structures. The costs of building construction can also be reduced as the Limestone Dust and Limestone Chips are waste materials of quarries and due to high demand the cost of River sand is also increasing rapidly.

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