ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
Vol. 2, Issue 4, April 2015

MECHANICAL CHARACTERIZATION OF PLAIN CEMENT CONCRETE WITH STONE WASTE AGGREGATE

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Abstract: Reinforced cement concrete (RCC) plays a pivotal role in construction, with granite stone commonly used as coarse aggregate. However, the depletion of natural resources necessitates the exploration of alternative materials. This study focuses on the utilization of stone waste, specifically from the layered stone also known as Kadapa slab in Tadpatri, Andhra Pradesh, India, for concrete construction. Stone waste generated during the production of finished goods is a major environmental concern, prompting an investigation into its feasibility as a concrete aggregate replacement at different levels (25%, 50%, 75%, and 100%). The current study assessed the strength characteristics, including compression, split tensile, and flexural strengths, shedding light on the potential of stone waste in construction.

Keywords: Stone Waste Aggregate, Concrete Construction, Workability, Compressive Strength, Split Tensile Strength, Flexural Strength, Sustainable Construction.

I. BACKGROUND

In the realm of general construction, the use of granite aggregate as coarse aggregate has been customary. However, the depletion of natural granite aggregate due to rapid urbanization poses a threat to future generations. Addressing this concern necessitates the exploration of alternative materials, whether new or recycled, for concrete works. Despite the urgency, the local populace in these areas is resistant to accepting alternative materials of slightly lower quality, such as limestone or quartzite, in lieu of natural aggregate. Nevertheless, ongoing research in civil engineering continues to discover new materials that may offer viable alternatives. In this context, the following research endeavors shed light on the potential of alternative aggregates.Torres et al. (2004) conducted experiments on the compression and bending strength of concrete by incorporating granite cutting sludge into tile formulations. The results indicated a significant increase in both compression and bending strengths. Nuno Almeda et al. (2007) replaced fine aggregate with stone slurry in concrete experiments. The findings revealed that a 5% substitution of sand with stone slurry led to higher compressive strength, increased split tensional strength, and a higher modulus of elasticity.Hanifi Binici and colleagues (2007) delved into the mechanical characteristics of concrete incorporating marble and lime dust, juxtaposing outcomes with traditional concrete. The findings of the study indicated that concrete containing marble and lime dust exhibited enhanced workability and abrasion resistance, akin to conventional concrete. In a separate exploration, Karasshin and Terzi (2007) scrutinized the applicability of marble waste as a filler material in asphalt mixtures, discerning its efficacy and cost-effectiveness in asphalt-related projects.Binci and collaborators (2008) communicated improved mechanical attributes in concrete formulations incorporating marble waste, granite, and ground blast furnace slag (GBFS). Alyamac and Ince (2009) dedicated their study to evaluating the impact of marble powder incorporation in self-compacting concrete (SSC), registering positive influences on both the fresh and hardened properties of the concrete. In a distinct experimental venture, Bahar Demirel (2010) conducted trials involving concrete and the utilization of waste marble dust (WMD) as a substitute for sand, documenting an augmentation in compressive strength. Nagabhushna and Bai (2011) systematically explored the behavior of concrete produced with crushed rock powder, serving as a replacement for fine aggregate. Their observations revealed that replacement levels up to 40% were feasible without compromising the strength of the concrete. Shirazi and colleagues (2012) scrutinized the integration of stone waste into concrete, showcasing that substituting 5% of fine aggregates with stone waste resulted in heightened compressive strength compared to control specimens.

In light of the existing literature, it is evident that considerable attention has been given to marble powder, while relatively little research has focused on marble or stone waste. This study attempts to contribute to this gap by exploring the utilization of stone waste from industries in Tadapatri, India, for construction purposes.

II. RESEARCH SIGNIFICANCE

A total of 15 cubes, 15 cylinders, and 15 beam specimens in the laboratory for evaluating the mechanical properties. Specifically, three cubes, three cylinders, and three beams were cast using natural granite aggregate, while the remaining specimens were prepared by replacing natural aggregate with limestone aggregate at varying percentages (25%, 50%, 75%, and 100%) in place of granite aggregate.

 DOI 10.17148/IARJSET.2015.2428

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The cube dimensions were 150 × 150 × 150 mm, cylinders had a diameter of 150 mm and depth of 300 mm, and beams were cast with dimensions of 150 × 150 × 600 mm. The mix proportion for all specimens followed a ratio of 1:1.91:3.17, with a water-cement ratio of 0.50, as per the design stipulated by IS Code 10262:2009.

III. EXPERIMENTAL PROGRAM

Fifteen cubes, fifteen cylinders, and fifteen beam specimens were cast and tested in the laboratory. Three sets were prepared with natural granite aggregate, while the rest used lime stone aggregate as a replacement at varying levels. The mix proportion followed IS Code 10262:2009 standards. Chemical properties of the stone waste aggregate were analyzed.

IV. MATERIALS USED

Cement: Portland pozzolana cement conforming to IS 8112: 1989 was utilized, with a specific gravity of 3.10. The initial and final setting times were 45 minutes and 360 minutes, respectively.

Fine Aggregate: Locally available river sand passing through a 4.75 mm I.S. Sieve was sourced, with a specific gravity of 2.7.

Coarse Aggregate: The crushed granite aggregate from local sources was carefully graded, with 60% passing through a 20 mm I.S. sieve and retained on a 12.5 mm I.S. sieve. Additionally, 40% passed through a 12.5 mm I.S. sieve and was retained on a 10 mm I.S. sieve. The specific gravity of the combined aggregate was 2.7.

Limestone Coarse Aggregate: The raw material for limestone aggregate was obtained from stone polishing industries. The waste material was crushed into 20 mm and 12.5 mm aggregates using a crusher machine. The aggregate was then graded, with 50% passing through a 20 mm I.S. sieve and retained on a 12.5 mm I.S. sieve. The remaining 50% passed through a 12.5 mm I.S. sieve and was retained on a 10 mm I.S. sieve. The specific gravity of the combined aggregate was 2.68. The chemical composition of stone-waste aggregates is presented in table 1.

Table 1. Chemical properties of stone waste aggregate

Sl. No.	Property	Values
1	Calcium Oxide (CaO)	38.91%
2	Silica (SiO_2)	22.35%
3	Alumina(Al_2O_3)	2.80%
4	Magnesium Oxide(MgO)	2.75%
5	Ferric Oxide(Fe_2O_3)	1.30%
6	Loss on Ignition(LOI)	30.52%

Water: Potable fresh water from local sources was employed for both mixing and curing.

V. RESULTS AND DISCUSSIONS

The study investigated the influence of lime stone aggregate on various properties of concrete mixes, specifically examining different replacement levels. Five concrete mix types were considered:

The workability of the mixes was assessed through the Compaction Factor test, revealing an increase in

Nomenclature	Description
NC-0	Natural Granite Aggregate Concrete with 0% replacement of Natural Coarse aggregate by Lime stone Concrete.
LC-25	Lime stone Concrete with 25% replacement of granite aggregate by Lime stone aggregate.
LC-50	Lime stone Concrete with 50% replacement of granite aggregate by Lime stone aggregate.
LC-75	Lime stone Concrete with 75% replacement of granite aggregate by Lime stone aggregate.
LC-100	Lime stone Concrete with 100% replacement of granite aggregate by Lime stone aggregate

compaction factor with the rise in the percentage of lime stone aggregate. This aligns with findings from Binci et.al. (2008) in marble concrete, suggesting improved workability due to the lower water absorption and smoother texture of lime stone aggregate compared to granite aggregate.

The influence of lime stone aggregate on compressive strength indicated a consistent decrease with increasing replacement percentages (figure 1). For instance, at 25% replacement, there was a 9.94% reduction in cube compressive strength compared to granite aggregate concrete. This trend continued, with 100% replacement resulting in a significant 42.42% decrease in compressive strength compared to the reference mix. This contrasts with the observations of Hebbon et.al. (2011) for marble concrete, highlighting the impact of different surface textures in the aggregates.

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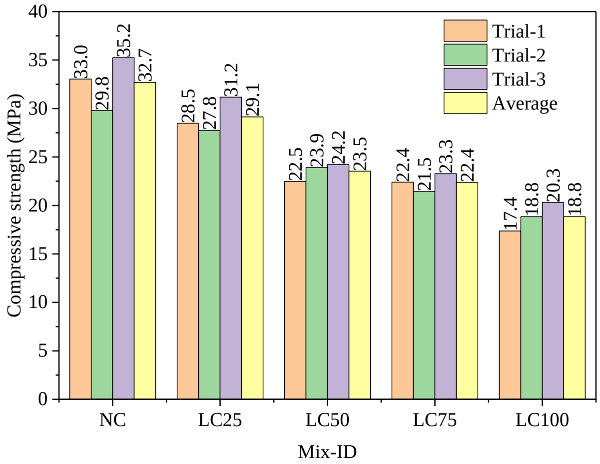

Figure 1. Effect of waste-aggregate on compressive strength of concrete

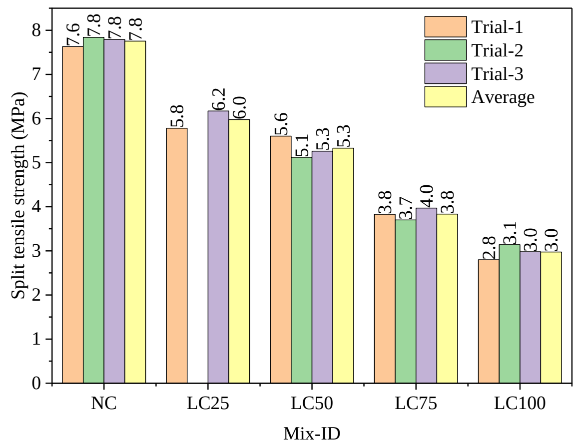

Figure 2. Effect of waste-aggregate on split-tensile strength of concrete

Split tensile strength and flexural strength followed similar patterns, with both decreasing as the percentage of lime stone aggregate increased (figure 2). For split tensile strength, there was a 21.64% decrease at 25% replacement, escalating to 61.98% at 100% replacement. Flexural strength exhibited a 12.5% reduction at 25% replacement and a substantial 42.53% decrease at 100% replacement (figure 3).

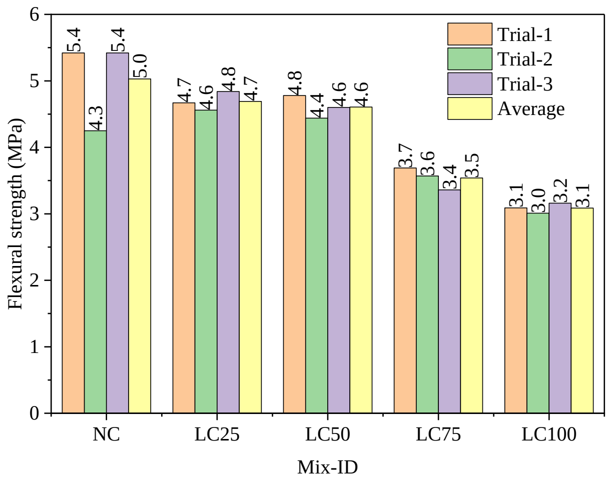

Figure 3. Effect of waste-aggregate on flexural strength of concrete

The effectiveness of lime stone aggregate in concrete works was assessed by comparing the compressive strength of different mixtures. It was observed that up to 90% replacement level, the lime stone aggregate exhibited design strength, but beyond this level, the concrete did not meet the design strength. This suggests that lime stone aggregate can be effectively used up to 90% replacement in concrete works, providing a useful indication for further research in this area

VI. CONCLUSION

The research concludes that while lime stone aggregate enhances workability, its incorporation leads to a reduction in compressive, split tensile, and flexural strengths. The study suggests that lime stone aggregate can be effectively used up to a 90% replacement level, providing a potential solution to disposal and environmental concerns.

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DOI 10.17148/IARJSET.2015.2428