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Experimental Study to Improve Recycled Coarse Aggregate Using Partial Replacement of Cement with Marble Dust

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Abstract - *The objective of the research is to study effect on concrete when recycled coarse aggregate is used as a substitute to natural coarse aggregate, by partial replacement of cement with marble dust. Since we know that the rapid demand for infrastructure with fast industrialization and increase in the population results in huge construction and development and also the demolition of previously existing structure to make space for new structure.*

This leads to the accumulation of large amounts of concrete wastes, when such waste can be reused to produce concrete to be used in concrete of new structures, it will lead to the preservation natural resource for future.

Key Words: Marble dust, Cement, Aggregate, Recycle

1. INTRODUCTION

Cement and water are combined to make concrete, which is the most widely used building material. As a result of rapid industrialization, expanding infrastructure, rising population, and massive construction projects, reinforced concrete buildings that collapse produce enormous amounts of demolished concrete trash. Recycled coarse aggregate is a product of using concrete waste to create coarse aggregate, helping to protect the environment for future generations. Numerous environmental advantages also result from the creation of new concrete from recycled coarse material.

For this reason, recycling concrete debris is a great way to get coarse aggregate for making fresh concrete. It has been noted that the recycled coarse aggregate made from leftover concrete is angular, rough-textured, and absorbs more water than natural coarse aggregate; these characteristics have an impact on the proportion of the concrete mix. Concrete is the most frequently used building material in the world because of its adaptability, toughness, affordability, and sustainability. Globally, each person produces roughly four tons of concrete annually, with the United States producing about 1.7 tons per person.

A mixture of aggregates, typically sand, and either crushed stone or gravel, bound together by a cementation paste binder, is called concrete. In addition to water and Portland cement, the paste may also include chemical admixtures and supplementary cementing materials (SCMs) such fly ash or slag cement. To make high-quality concrete, one must grasp the basics of the material. Consideration is being given to the components of concrete as well as the necessities for designing and managing concrete mixtures for a broad range of constructions.

OBJECTIVE OF THE PRESENT STUDY

The main objectives of the present study are:

- To use recycled coarse aggregate as an active construction material.
- To find out the optimum percentage of recycled coarse aggregate that can be used as partial replacement of naturalcoarse aggregate.
- To study the effect of Recycled coarse aggregate on the workability of concrete.
- To study the mechanical behavior of concrete when the cement is partially replaced with MARBLE DUST in terms ofhardened properties.

2.LITRATURE REVIEW

In an effort to enhance the qualities of both RAC and recycled aggregates, Tam et al. [2007] have suggested new treatment techniques, such as pre-soaking recycled aggregate in three acidic solutions. The water absorption of pre-treated recycled aggregate was found to be greatly reduced by the authors, along with an improvement in the mechanical qualities of RAC. Simultaneously, there was no negative impact on the sulphate and chloride contents of recycled aggregate, nor on the alkalinity of RAC.

Etxeberria et al. [2007] have studied about the possibility of using recycled aggregate concrete as a structural material.

Khaldoun [2007] carried out an experimental program to study the mechanical properties of RAC as compared with conventional NAC, and found that the compressive strength of RAC was approximately 90% of that of NAC.

Padmini et al. [2009], Examined the effect on strength of RAC made with different maximum size of recycled coarse aggregate (10, 20 and 40 mm).

Cabral et al. [2010], analyzed for compressive strength and elastic modulus were performed and models were obtaining.

Li et al. [2009] proposed a novel method for enhancing the quality of recycled aggregate concrete, which involves coating the surface of recycled aggregate with pozzolanic powder (fly ash, marble dust, and blast furnace slag). The writers separated the entire blending process into two phases in this. A portion of the entire mixing water was used in the first stage to mix with pozzolanic powder (PP) for one minute to create a slurry. The RCA was then added to the slurry and stirred for an additional minute to coat the RCA's surface. After about three minutes of mixing, the remaining water, fine aggregate, and cement were added. When compared to conventional mixing, the workability, according to the authors, was much improved.

According proposal by Hameed et al., [2009], replacing fine aggregate with 50% marble sludge powder and 50% green concrete produces great results in terms of strength and quality. His study's findings demonstrated that the M4 mixes increased splitting tensile strength and compressive strength. More than a 50% increase in marble sludge powder content makes the concrete more workable but decreases its compressive and split tensile strengths.
The application of a methodology for the calibration of the partial safety coefficient has been applied. The various provisions and indications regarding RAC were found using structural codes.

Macro Breccolotti et al. [2010] conducted a theoretical investigation on the structural use of concrete manufactured with recycled aggregates. The study examined the statistical properties of the compressive strength of normal and recycled concretes, which demonstrated that RACs displayed higher scattering in the compressive resistance. Theoretical analyses carried out in the framework of the structural reliability theory allowed to put in evidence that the higher scattering of RAC

The results of both the experimental and theoretical works suggested for the adoption of appropriate adjustments to the design procedure when dealing with RAC for structural use.

Marble has long been used as a building material, particularly in palaces and monuments, according to Corinaldesi et al. [2010]. The building industry itself uses the waste at the quarry or sizing business largely unmonitored for use as filler or plasticizer in mortar or concrete, however the use is restricted to stone bricks in walls or arches or as lining slabs in walls, roofs, or floors. As a result, the mass—which accounts for 40% of all marble quarried—has increased to millions of tons. This massive unmanaged pile of extremely fine marble trash is one of the global environmental issues of our day.

Fraternali et al. [2011], studied with an experimental analysis of the thermal conductivity, mechanical strength. Xiao et al. (2012) found that recycled aggregates which were used in wet condition but not saturated, could control the fresh concrete properties.

Rai et al. [2011] Increased waste marble powder (WMP) or waste marble granule (WMG) ratios improve the workability and compressive strengths of the mortar and concrete when they are partially substituted for cement and typical fine aggregates in varied percentages.

The use of freshly concrete waste (FCW) that has been recycled into coarse aggregates was investigated for viability by Kou et al. (2012). We measured the new concrete's workability, split tensile strength, compressive strength, static modulus of elasticity, chloride ion penetration, and drying shrinkage. As the percentage of FCW aggregate increases, the compressive strength falls. However, a replacement contents of less than 30% weight would still allow for the achievement of the desired 28-day strength (32–44 MPA). It was discovered that as FCW content grew, slump value increased as well. Concrete's ability to absorb water was rising as the percentage of FCW increased. At every curing age, a 15% FCW decrease in the mix's tensile splitting strength was noted.

Elastic modulus and resistance to chloride ion penetration was decreases with an increase in FCW.

Researchers and investigators are paying close attention to the usage of marble dust as a fine aggregate in concrete, as reported by Mishra et al. [2013]. When compared to controls, specimens containing 6% waste sludge showed the highest compressive and flexural strengths. It was also discovered that waste sludge up to 9% may be employed successfully as an additive material increment.

In an experimental investigation on the usage of marble dust in concrete, Aalok D et al. [2014] found that adding 50% more marble powder to cubes of M25 grade concrete increases their compressive strength; however, adding more waste marble powder causes the strength to gradually drop. When leftover marble powder is added to cylinders, its split tensile strength increases up to 25% and then falls with more addition. At 50% marble powder mix, the flexural strength is achieved.

The study conducted by Abdullah Anwar et al. [2014] examined the compressive strength of concrete when marble dust powder was used in place of some cement. The researchers came to the conclusion that marble dust powder could serve as a viable substitute for cement and aid in both environmental preservation and financial equilibrium. Compressive strength characteristics of concrete with varying percentages of Portland cement (0%, 5%, 10%, 15%, 20%, and 25%) and marble dust powder. The main goal of the inquiry was to find a way to use marble dust in the manufacturing of concrete as a sustainable building material to address the issue of marble dust disposal. The 28-day compressive strength result shows that a substitution of 10 % or such with marble dust powder is the ideal percentage for cement.

A study by Singh et al. [2015] on the partial replacement of cement with waste marble powder (M25 grade) found that all mechanical properties increased when cement was replaced by waste marble up to 12% of the total. The highest compressive and tensile strength is achieved when discarded marble powder is substituted for 12% of the cement.

For both cube sand cylinders, the ideal replacement percentage of cement in place of marble powder is close to 12%. to reduce building costs by using readily available or reasonably priced marble powder. Our primary goal is to reduce environmental pollution through cement production.

3.RESULT AND DISCUSSION

3.1. Slump Test

Slump test is the most commonly used method of measuring the consistency of concrete. It is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch, which is shown in Fig.1.

Slump value for Various Mix proportion

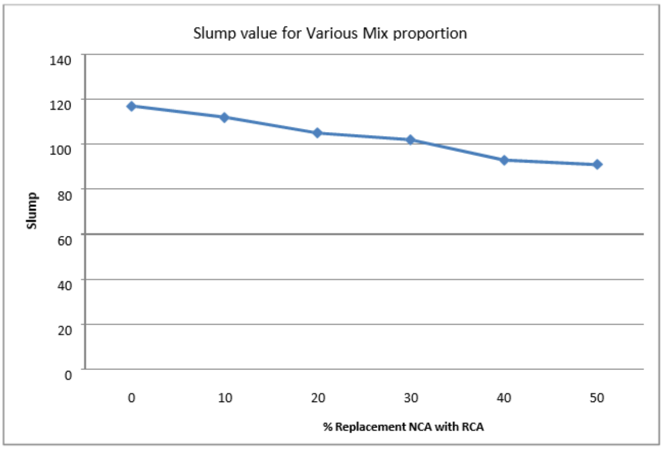

Fig.1.Slump value for mix proportions with varying % of RCA

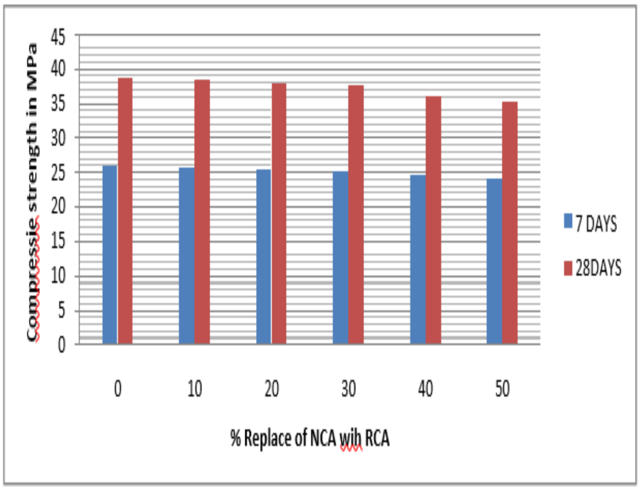

Fig. 2. Relation between compressive strength to varying % of RCA

In this study, it has been decided to study the characteristic strength of concrete with various proportions of locally available constituents. For this waste material MARBLE DUST, and the locally available coarse aggregates, fine aggregates and PSC 33 grade cement were used. Sand obtained from Kanchi river Bundu and MARBLE DUST was obtained from Burdwan. The test for cement, fine aggregates, coarse aggregates, recycled aggregate, MARBLE DUST were performed at the lab of C.I.T Tatisilwai for their properties, which is shown in Fig.2.

The properties of concrete at two stages are performed.

Stage-I: The properties of concrete at different percentage replacement of NCA with RCA as 10%, 20%, 30%, 40% and 50% has been obtained.

Stage-II: The properties of concrete at different percentage replacement of cement with MARBLE DUST as 3%, 6%, 9%, 12% and 15% has been obtained.

4. WORKABILITY

Workability is the effort required to manipulate a concrete mixture with a minimum of segregation. It is the ease with which concrete can be transported, placed and compacted hundred percent having regard to mode of compaction and place of deposition. It is a parameter, a mix designer is required to specify in the mix design process, with full understanding of the type of work, distance of transport, loss of slump, method of placing and many other parameters.

Fig.3 shows the present mixture which have been prepared for present analysis.

Fig.3. Workability test (Slump test)

4.1.Split Tensile Test

Fig.4 shows the split tensile strength machine into which the test will be performed.

Fig.4. Split tensile strength

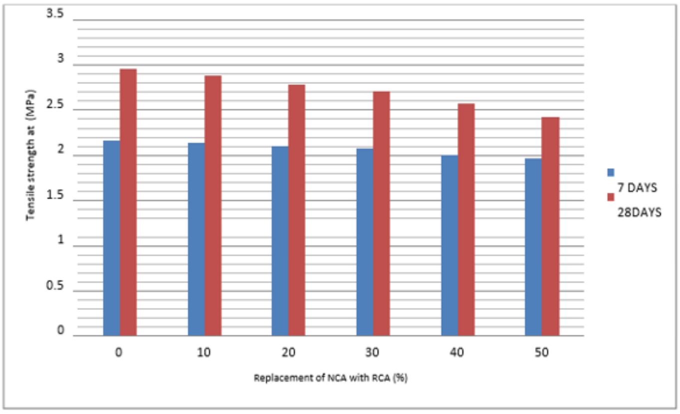

Fig.5. Relation between split tensile strength and varying % of RCA

The effect of partial replacement of NCA by RCA on Split tensile strength at 7 and 28 days has been studied. The split tensile strength achieved at 28 days for 30% replacement of NCA with RCA is 2.71 MPa that is 8.44% lesser than the strength of referral mix. Also the strength achieved for 50% replacement of NCA with RCA is 2.43MPa, which is 17.90% lesser thanthe strength of referral mix which is shown in Fig.5.

5. CONCLUSION

From the analysis and results, the following points were concluded:

(1) For the replacement of 30% RCA with NCA and 9% marble dust with cement, the compressive strength of the concrete increased up to 10.85%.
(2) For up to 30% RCA with NCA and 9% replacement of cement with marble dust, thesplit tensile strength of concrete increased by 15.20%.
(3) The flexural strength of concrete increased by 0.76% for the replacement of 9% cement with marble dust and 30% NCA with RCA.

(4) For 15% of the partial replacement of cement with marble dust and 30% partial replacement of NCA with RCA, the compressive strength obtained is 38.79 MPa which is slightlymore than the target mean strength of M30 i.e. 38.25 MPa.

Hence, the optimum percentage of marble dust that can replace cement in concrete is 15%.

(5) The cost of normal concrete was calculated as 4762.01/- per cubic meter. The reduced cost of concrete when NCA is partially replaced with RCA are 4693.80/-, 4626.07/-, 4558.10/-, 4490.11/- and 4422.15/- respectively for 10%,20%, 30%, 40% and 50% replacement of NCA with RCA.

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