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Experimental Investigation of M-40 Recycled Aggregate Concrete by Adding Nano-Silica – A Review

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I. Introduction

Concrete is the most widely used construction material in the world it is a mixture of cement, sand, coarse aggregate and water. Cement is binding material in the cement concrete and its role is to provide strength to concrete. Cement fills up voids existing in the fine aggregate and makes the concrete impermeable. Provides strength to concrete on setting and hardening and binds the aggregate into a solid mass by virtue of its setting and hardening properties when mixed with water. Fine aggregate consist of small angular or rounded grains of silica. It is commonly used as the fine aggregate in cement concrete. It fills the voids existing in the coarse aggregate it reduces shrinkage cracking of concrete. It helps in hardening of cement by allowing the water through its voids. To form hard mass of silicates as it is believed that some chemical reaction take place between silica of sand and constituents of cement, Coarse aggregate makes solid and hard mass of concrete with cement and sand .it increase the crushing strength of concrete.

II. MATERIAL USED IN CONCRETE

Materials used in Concrete The materials used in the projects for making concrete mixture are cement, Fine aggregate, coarse aggregate, stone dust, are detailed describe below:

Cement: Cement is by far the most important constituent of concrete, in that it forms the binding medium for the discrete ingredients. Made out of naturally occurring raw materials and sometimes blended or underground with industrial wastes. The cement used in this study was OPC 53 grades Ordinary Portland cement (OPC) conforming to IS12269-1987.

Fine aggregate: Aggregates which occupy nearly 70 to 75 percent volume of concrete are sometimes viewed as inert ingredients in more than one sense. However, it is now well recognized that physical, chemical and thermal properties of aggregates substantially influence the properties and performance of concrete. The fine aggregate (sand) used was clean dry sand was sieved in 4.75 mm sieve to remove all pebbles.

Course aggregate: Coarse aggregate is used for making concrete. They may be in the form of irregular broken stone or naturally occurring gravel. Material which is large to be retained on 4.75mm sieve size is called coarse aggregates. Its maximum size can be up to 40 mm.

Water: water plays an important role in the formation of concrete as it participates in a chemical reaction with cement. Due to the presence of water, the gel is formed which helps in increase of strength of concrete. Water used for mixing and curing shall be clean and free from injurious quantities of alkalies, acids, oils, salts, sugar, organic materials, vegetable growth or other substance that may be deleterious to bricks, stone, concrete or steel. Portable water is generally considered satisfactory for mixing. The pH value of water shall not be less than the following concentrations represent the maximum permissible values.

A. Limits of acidity: To neutralize 100ml sample of water, using phenolphthalein as an indicator, it should not require more than 5ml of 0.02 normal NaOH. The details of the test shall be as given in IS 3025.

B. Limits of alkalinity: To neutralize 100ml sample of water, using mixed indicator, it should not require more than 25ml of 0.02 normal H2SO4. The details of tests shall be as given in IS 3025.

C. Percentage of solids: Maximum permissible limits of solids when tested in accordance with IS 3025 shall be as under:

The physical and chemical properties of groundwater shall be tested along with soil investigation and if the water is not found conforming to the requirements of IS 456 – 2000, the tender documents shall clearly specify that the contractor has to arrange good quality water construction indicating the source.

Recycled Aggregate- The crushing characteristics of hardened concrete are similar to those of natural rock and are not significantly affected by the grade or quality of the original concrete. Recycled concrete aggregates produced from all but the poorest quality original concrete can be expected to pass the same tests required of conventional aggregates.

Recycled concrete aggregates contain not only the original aggregates, but also hydrated cement paste. This paste reduces the specific gravity and increases the porosity compared to similar virgin aggregates. Higher porosity of RCA leads to a higher absorption.

Nanosilica, also called quartz dust or silica dust, is a material that, like SF, is characterized by its high SiO_2 percentage, over 99%. The use of nanosilica (crystalline SiO_2) reduces the volume of cement and completes the grading curve of the aggregate mix in the zone of the smallest sizes. Its purpose is to produce a filler effect, that is, to fill in gaps and, consequently, increase the compactness of the concrete. For this reason, when nanosilica is used in the manufacturing of UHPC, there is a higher demand for water or SPs and a delay in the setting process. Research into the differences between nanosilica and SF when added to the cement paste shows that the pozzolanic activity of nanosilica is higher than that of SF, which makes the cement paste thicker and accelerates the hydration process. In addition, greater bond strength between the cement paste and the aggregates is achieved. However, like cement and SF, nanosilica has a high cost and significant carbon footprint. It can also cause serious health problems such as silicosis. For these reasons, various studies have been conducted to find a suitable replacement.

III. Literature Survey

Habib H. Alqamish et.al [1] March, 2021

In this study, 1% and 2% of nano-silica were added to concrete mixtures that contain 30% and 70% ground granulated blast-furnace slag (GGBS). Adding 1% of nano-silica to the 30% GGBS mixture showed an increase in the compressive strength by 13.5%, 7.8%, 8.1%, and 2.2% at one day, three days, seven days, and twenty-eight days, respectively. The 2% of nano-silica increased the 30% GGBS mixture's compressive strength less effectively by 4.3%, 7.6%, and 4.9% at three days, seven days, and 28 days, respectively, when compared to the 1%. On the other hand, adding 1% and 2% of nano-silica reduced the 70%GGBS mixtures' compressive strength. Moreover, nano-silica reduced the deformability of the mixtures significantly, which caused the increase in the Young's modulus. The flexural strength of the 30% GGBS mixtures had similar behavior as the 28-day compressive strength. On the other hand, the flexural strength of the 70% GGBS mixtures increased as the nano-silica increased. Nano-silica addition improved the microstructure and the interface structure of the mixtures due to its high pozzolanic activity and the nano-filler effect, which is confirmed by RCPT results and SEM images.

Hasan Dilbas et.al [2] Feb, 2021

This paper presents influence of treatment and mixing methods on recycled aggregate concretes (RCA) designed regarding various techniques. Absolute Volume Method (AVM) according to TS 802, Equivalent Mortar Volume Method (EMV), silica fume (SF) as a mineral addition were considered in the design of concretes. In total, four groups of concretes were produced in the laboratory: (1) natural aggregate concrete (NCA) designed with AVM as control concrete, (2) RCA designed with AVM as control RCA, (3) RCA with SF as a mineral addition designed with AVM as treated RCA and (4) RCA designed with EMV as treated RCA. The tests were performed at 28^{th} days and the statistical analysis were made on the test results. According to the results, EMV and SF increased the compressive strength of concretes and this resulted an increase in the strength class of concrete. A significant statistical difference between the concretes were determined. According to multiple comparison analysis, it was found that especially there was a significant relationship among NCA, RCA and RCA-EMV. In addition, it was recommended that EMV and AVM with 5% SF could be used in the design of RCA rather than AVM only to achieve the target strength class C30/37.

S. Manivel et.al [3] Jan, 2021

In this research paper the conclusion was the addition of percentage of recycled aggregate at 20% with addition of 15% silica fume are optimized. The compressive strength of addition of 20 % of recycled aggregate along with 15% of silica fume at 28 days is 36.77 N/mm^2. Further addition leads to reduction of compressive strength. The split tensile strength of addition of 20% of recycled aggregate along with 15% of silica fume at 28 days is 3.68 N/mm^2. The flexural strength of addition of 20% of recycled aggregate along with 15% of silica fume at 28 days is 5.88 N/mm^2. Coarse aggregate utilized majorly in concrete to reach the ultimate quantity in larger proportion. The structural and non-structural elements in the construction utilize majorly the concrete. Due to the mass availability of concrete during the demolition process and hence absorbing the same material to replace the coarse aggregate with recycled aggregate is the emerging field and it is sustainable. The experimental work involving the replacement of coarse aggregates with recycled aggregates and cement with silica fumes to improve the properties of concrete and eliminate the difficulties in construction field paves way for the further researches. The experimental study concentrates in the strength properties of the concrete with recycled aggregates and silica fume and compared with the conventional concrete.

W. Xingguo et.al [4] September, 2020

This study reviews the related studies on the durability of RCA over the past decade, and the effects of RA quality and replacement percentages are also considered. Furthermore, the improving methods of RCA durability are introduced. Based on the review of related literatures and discussions, the following conclusions can be drawn: The combination of nanosilica solution concentration 2% and soaking time, 48 h, has better modification effect on the mechanical properties of recycled aggregates. Its apparent density increased by 1.6%, and crush index and water absorption decreased by 19.54% and 21.46%.

Ayser J. Ismail et.al [5] Oct, 2020

This research deals with the behavior of recycled aggregate concrete (RCA). In this study an experimental work was undertaken. The study examines the effect of using recycled coarse aggregate (RCA) on the workability and the mechanical performance of RCA. The influences of using silica fume (SF) as cement replacement material on the performance of RCA were also examined. Silica fume was used at four contents (5%, 10%, 15% and 20%). The total number of mixes was six. Four mixes of RCA made with these four contents of SF, one RCA mix was made without SF and one mix was made with natural coarse aggregate (NCA) as a reference mix. The outcomes of this study reveal that workability and mechanical performance of RCA are lower than that made with NCA. Also, Silica fume has an adverse influence on workability of the RCA. However, the silica fume possesses a positive influence on mechanical properties of RCA. Silica fume can be used at contents of (10-20)% of cement mass to obtain mechanical performance for the RCA comparable to the concrete includes NCA.

The discussion on the outcomes obtained in current research can lead to these conclusions:-

As a result of its high capacity to absorb water, high porosity and its rough surface, recycled aggregate (coarse) diminish the workability of concrete. The inclusion of SF increases this diminishes in the workability of the RCA due to the high surface area of its particles. The decline in the workability can reach 50%.

All strengths decrease when RCA is used. The diminish in the compressive strength, tensile strength and flexural strength is about 29%, 16% and 16% respectively. The weaknesses of the recycled-coarse aggregate are the key reason for this behavior.

Replacing OPC with silica fume possess a beneficial influence on compressive strength, splitting tensile strength and flexural strength of RCA mixtures. The pozzalanic reaction of the SF particles is the prime reason behind the strength enhancement.

Close strength to that mixture incorporating NCA will be obtained if silica fume is replaced with OPC at contents between 10-20%. Thus, the use SF can encourage the utilization of recycled coarse aggregate.

IV. Problem Identification

In all the literature review, we found that concentration was given to detect the maximum percentage of Nano-Silica to partially replace cement. Also in all Literature Review they partially replaced Natural Coarse Aggregate (NCA) with Recycled Coarse Aggregate (RCA). In order to produce concrete all the researchers used Nano-Silica and RCA in different ways, but there was no focus on finding new way to use RCA to replace all the NCA with partially replacing Nano-Silica with cement. The objectives of some researchers were close to the objectives of this research study and many ideas came out about the use of Nano-Silica and RCA with their results and ideas.

V. Objective

The objective of work cement is partially replaced by Nano-Silica in different percentages also Natural coarse aggregate is fully replaced by recycled coarse aggregate as shown in the table below. 6 batches are prepared in different proportions including conventional concrete mix (Cement as binder, Sand as fine aggregates & Natural Coarse Aggregates). Cubes, beams& Cylinders are casted for determining compressive, flexural & tensile strengths respectively at 7 & 28 days.

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