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# Feasibility Performance of Nano-silica to Improve Performance of Recycled Aggregate Concrete

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**ABSTRACT:** Recycling of concrete can be a vital step towards achieving sustainability in concrete construction. Recycling of concrete is need of an hour. The study aimed to reduce the negative effects of Demolition Waste recycling in fresh concrete. Demolition Waste recycling is an important component of a sustainable material flow. Recycled Coarse Aggregates (RCA) is not being reused due to the low quality of concrete production. Availability of attached mortar around recycle coarse aggregate hampers majorly to the mechanical properties of recycled aggregate concrete. Negative effects of recycled concrete in terms of strength need to be eliminated to popularize its use in recycled aggregate concrete. Here in this research attempt has been made to use nano-silica along with recycled coarse aggregates to check the performance improvement of recycled coarse aggregate. Different doses of nano-silica i.e., 1.5%, 2.5% and 3.5% will be added by weight of cement. Natural coarse aggregates will be completely replaced by recycled coarse aggregates. Results of natural coarse aggregate and performance of recycled aggregate concrete will be highlighted in this study.

**KEYWORDS:** Demolition waste, Nano-silica, recycled aggregate concrete, Recycled coarse aggregate.

## I. INTRODUCTION

In addition to addressing the issue of the rising demand for aggregates, recycling leftover concrete also lessens the environmental burden associated with disposing of the enormous volume of demolition trash. Researchers from all over the world have expressed interest in the effective application of recycled coarse aggregate, which is regarded as a crucial step towards the sustainable development of the building sector. The pressure on landfills and the extraction requirements have decreased as a result of employing Demolish trash as an aggregate in concrete production. In addition to reducing environmental issues, it also promotes the preservation of resources found in the natural world. Concrete technology has recently been introduced to nanomaterials with extremely large surface areas and activity. The porosity and water absorption of concrete were decreased by the nano silica. Compressive strength was increased while the microstructure of RCA was improved. The high strength and optimized microstructure were both a result of the nano-silica and RCA combination. It has been noted that the addition of Nano Silica greatly enhanced the hydration rate.

## II. RELATED WORK

Amnon Katz et al [1] discussed the crushed old concrete used to create the RCA microstructure. The RCA's poor mechanical qualities were found to be caused by the NCA's old cement paste, which was still there but was porous and broken. To get over this restriction, the treatment of RCA using ultrasonic cleaning and silica fume solution impregnation was researched. Significantly more early strength was added to the new concrete. Deva Kumar M et al [2] test that crushed old concrete used to create the RCA microstructure. The RCA's poor mechanical qualities were found to be caused by the NCA's old cement paste, which was still there but was porous and broken. To get over this restriction, the treatment of RCA using ultrasonic cleaning and silica fume solution impregnation was researched. Significantly more early strength was added to the new concrete. Ruijun Wang et al [3] reviewed that in concrete, the ingredient that makes up around 3/4 of the volume is called coarse aggregate. Because the surface of the aggregate is



covered with porous old mortar, recycled coarse aggregates (RCA) are not frequently used. By filling surface holes with precipitation, the bio deposition treatment produced a satisfactory improvement in the characteristics of the RCA. The result is a decrease in water absorption and an improvement in mechanical characteristics. Nishikant Kiskua et al [4] discussed that by considering the remaining mortar content on the surface of the recycled concrete aggregate, a two-stage mixing strategy and roughly equal mortar volume mix design method are used to prepare recycled aggregate concrete. In this mixing technique Depending on the value of the individual recycled aggregate concrete, the appropriate percentage of recycled aggregate concrete will be used in the design. The appropriate percentage of recycled aggregate concrete for the suggested method of mix design is found to be 61.01% for the current source of recycled aggregate concrete. The implementation of the mix design method and the mixing methodology, as shown by the microstructural study, has improved the interfacial transition zone (ITZ) and its attributes. Yanchao Yue et al [5] reviewed that the pozzolanic reaction, C-S-H gel concentration, and cement hydration were all enhanced by the nano particles. The strength boost of recycled aggregate concrete did, however, deteriorate over time; to address this issue, CaCO<sub>3</sub> microparticles were added. In addition to enhancing particle dense packing of binders, the combination of nano- and micro-sized particles also increased multilayer hydration of cementitious materials.

### III. PROPOSED ALGORITHM

The research's resources came from a local site in Pune, Maharashtra, India. The physical value, crushing value, specific gravity, water absorption, etc. were assessed and contrasted. To create the design mix, material attributes were utilized. Indian Standard IS 10262-2019 was used as a reference when creating the concrete mixture.

#### A. Materials

##### 1) Cement

Ordinary Portland Cement (OPC) of Birla Shakti brand, 53 grade, was utilized for this research, and its physical properties are mentioned in table I.

Table I: Properties of OPC

Sr. No.	Physical Properties	Test result
1	Initial setting time (minutes)	90
2	Final setting time (minutes)	580
3	Consistency (%)	32
4	Fineness (%)	5
5	Soundness (mm)	2.33
6	Specific gravity	3.15

##### 2) Fine aggregates (FA)

Crushed sand of zone-I with a maximum size of 4.75 mm was utilized. The physical properties are mentioned in table II.

##### 3) Coarse Aggregates (CA)

As coarse aggregates, natural and recycled coarse aggregates were used. Crushed stone with a maximum of 20 mm graded aggregates was utilized for NCA, while RCA was sourced from a nearby Demolishing site. The RCA were crushed in a crusher and then screened using a 20-mm sieve. Table II lists the physical properties of coarse aggregates.

##### 4) Nano-silica



The grey powdered nano-silica utilized in this research was supplied from Mumbai. Nano-silica having a specific gravity of 1.03 was used for the study.

Table II: Properties of FA, NCA & RCA

Sr. No.	Properties	FA	NCA	RCA
1.	Silt Content	7.33	-	-
2.	Specific Gravity	2.8	2.6	2.43
3.	Water Absorption (%)	4.43	1.31	5
4.	Bulk Density (%)	20.18	-	-
5.	Sieve	Zone I	20mm max. size	20mm max. size
6.	Impact Value (%)	-	12.66	20.03
7.	Abrasion Value	-	5	9.8
8.	Crushing Value (%)	-	20.94	25

#### B. Properties of Coarse Aggregates

For the study, coarse aggregates included the NCA and RCA. We study the characteristics of RCA and NCA. Due to the old mortar that is present on the RCA surface, it was found from the properties that RCA absorbs more water than NCA. Additionally, NCA has a higher specific gravity than RCA. NCA has a bulk density that is 22.47% higher than RCA. RCA has a higher impact and crushing value than NCA. The approved value of coarse aggregates for road paving for impact and crushing is 30%.

#### C. Treatment of Recycled Coarse Aggregates

There are two methods for improving the qualities of RCA: removing attached mortar and strengthening attached mortar.

##### 1) Removal of Attached Mortar

The attached mortar can be removed using a variety of techniques, such as mechanical grinding, pre-soaking in acid or water, etc. Pre-treatments for this study included pre-heating and soaking to get rid of the adhered mortar. The RCA was roasted in the oven for 24 hours at 250°C. Following the pre-heating procedure, they were submerged in cold water. The loose, weakened mortar was removed using the soaking procedure. This technique removed a little bit of mortar.

##### 2) Strengthening of Attached Mortar

The pre-treatment method only partially removed the attached mortar from the surface of the aggregates; it is challenging to get rid of the associated mortar entirely. Microcracks in the recycled aggregates weaken the concrete made from recycled materials. Filling these cracks can be done in several ways. In this study, these fissures were filled using nano-silica. The RCA is reinforced as a result.

#### D. Concrete Mixtures

In this study for M25 mix design, a total of five series of mixes were assessed. The proportions of the design mix are listed in Table III. A 100 % NCA mix made up the initial series. The second series was identical to the first, but RCA was used exclusively in place of NCA. The percentage of cement varied between 1.5%, 2.5%, and 3.5%



for the third, fourth, and fifth series, which all contained 100% RCA + Nano-Silica. The mix had a water-cement ratio of 0.5 and included 372 kg/cum of cement. A two-stage mixing procedure was used to mix concrete properly. Section E provides information on the two-stage mixing process.

Six cubes of 150x150x150 mm were cast for each concrete mixture. After 24 hours of casting, specimens were demolded and kept for curing. On the 7<sup>th</sup>, 14<sup>th</sup> and 28<sup>th</sup> day, cubes were tested were tested for compression.

Table III: Mix Proportions

Mix	Title	Mix Proportion (M25) (W/C: C: S: A: Admixture)
NCA1	Natural Coarse Aggregate	0.5:1:2.468:2.011
RCA2	Recycled Coarse Aggregate	0.54:1:2.13:2.2
RCA3	RCA+1.5 % NanoSilica	0.54:1:2.12:2.19:2.005
RCA4	RCA+2.5% NanoSilica	0.54:1:2.11:2.19:2.011
RCA5	RCA+3.5 % NanoSilica	0.54:1:2.11:2.18:2.015

E. Two-Stage Mixing Approach

In a typical mixing procedure, fine particles are added to coarse aggregates after which cement and water are added. For the purpose of this study, a two-stage mixing technique was used to create the mix containing recycled aggregates. The necessary water was divided into two parts in proportion for the two-stage mixing operation. The fine and coarse aggregates were combined during the first 60 seconds. Again, the fine and coarse aggregate mixture was mixed for 60 seconds while half of the water was added. After that, cement was added, and the mixture was again blended for 30 seconds. After adding the last of the water, the mixture was stirred for an additional 120 seconds. A thin layer of cement slurry created on the surface of RA during the initial mixing cycle.

The Cracks and spaces are filled by the slurry when it seeps into the porous cement mortar. To complete the concrete mixing process, the remaining water was added during the second stage of mixing.

IV. SIMULATION RESULTS

Total of 45 cubes were tested on the 100-tonne compressive testing machine. The graph of the 7th , 14th day and 28th day is plotted in figure 1 , 2 and figure 3.

- The strength declination is occurred from RCA with 3.5 % NS plotted in graph.
- It is high workable concrete as the slump value varies between 100 – 150 mm.

Table IV: Results

Sr.no	Description	7 days N/mm <sup>2</sup>	14 days N/mm <sup>2</sup>	28 days N/mm <sup>2</sup>
1.	NCA	19.35	21.55	26.7
2.	RCA	10.95	14.25	15.38
3.	RCA + NS 1.5%	14.7	16.2	19.3
4.	RCA + NS 2.5%	17.44	20.2	23.7
5.	RCA + NS 3.5%	17.8	19.92	21.34

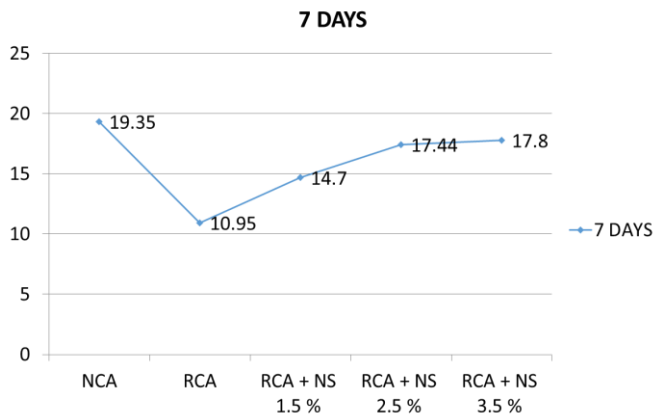


Fig 1: 7th-day compressive strength

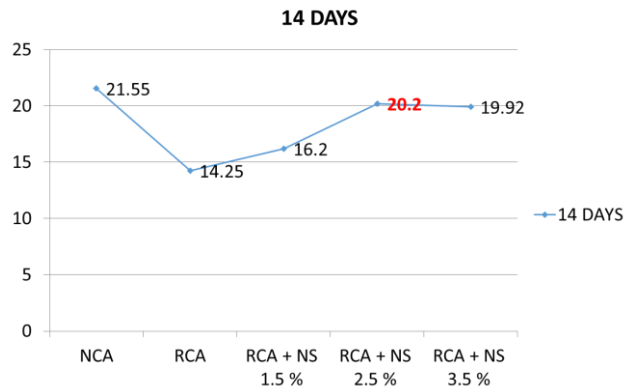


Fig 2: 14th-day compressive strength

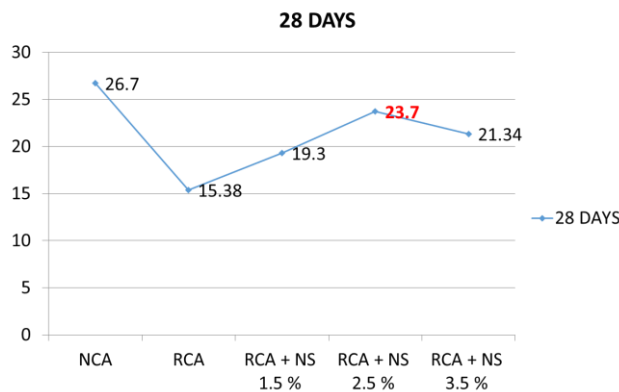


Fig3:28th day compressive strength

### V. CONCLUSION AND FUTURE WORK

Gradual increase in the compressive strength is seen as the dose of nano-silica increases from 1.5% to 2.5% and reduces at 3.5 %. The strength of RCA can be improved by increasing the dosage of nano-silica. The use of nano-silica up to 2.5% is feasible by adding 3.5 % strength decreases due to excess alumina. It's setting time is prolonged so it effects on strength.

Nano silica has higher pozzolan activity in the early stage, the early strength improvement effect of nano silica SiO<sub>2</sub> concrete is more obvious due to the more sufficient pozzolanic reaction. As the curing time increases, the nano SiO<sub>2</sub> particles become smaller and the pozzolan response become weaker, therefore the improvement effect of nano SiO<sub>2</sub> on concrete strength in the later period is reduce.

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