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Strength Properties of Nano Silica Recycled Sustainable Concrete

S. Yuvaraj, V. Anish.

Abstract**:** ***This experiment highlights the salient features of concrete under nanotechnology. Concrete production requires huge amount of cement and aggregates which eventually increases carbon emission and contaminates environment. Hence, incorporation of 'F' class fly ash which is partially replaced for cement, recycled aggregate and cactus gel can be done which can reduce dumping issues, carbon emission and cost. However, incorporation of fly ash in ordinary Portland cement deviates its strength consequently. Hence, Nano-silica can be added as an additive to fill up the deviation, thereby increasing its workability and improving the strengthening factor of concrete. In this paper mineral admixture such as Nano-silica were used to increase the strength of concrete and natural polymer substances such as cactus jelly is used to increase the workability of concrete. For the binding material cement were replaced with the fly-ash at the percentage of 60% respectively and for the coarse aggregate quarry aggregate has been replaced with recycled aggregate with the proportion of 40% and 60% respectively. In the investigation three specimens were casted say conventional, replacement of 60% and replacement of 60% with Nano silica and cactus extract solution. The result of compressive and flexural strength were compared. The aim of this experiment is to maintain the economy and environmental effect.***

Index Terms: **Nano-silica, Cactus Jelly, Recycled Aggregate, Sustainable Concrete and Fly-ash.**

I. INTRODUCTION

Concrete plays a major role in construction because of its significant properties such as low cost, durability and high strength. As the cement production is expensive and produces environmental issues, fly ash being produced gives the dumping issue. Hence these issues can be terminated with the idea of incorporating 'F' class fly ash in the concrete. Use of Cactus Jelly as a water reducing agent will improve the workability to the maximum and thereby deviating the strength that can be regained by adding Nano-silica. With the incorporation of these materials a Cylinder, cube and beam or column can be designed thereby giving a good flexural strength and reasonable durability.

Recently, There is a increased attention in Nano particles due to their application in many fields to fabricate new materials with novel functions due to their unique physical and chemical properties. The mechanical properties and durability of concrete are studied through measurement of compressive, tensile and flexural strength at this experiment. This paper aims to present the state Nano-Silica application in concrete, focusing on the properties to render it suitable to be applicable in concrete.

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II. EXPERIMENTAL PROGRAM

A. Scope of work

This investigation is to achieve the optimum economic as well as to create the concrete which is sustainable and eco-friendly. This can be only accomplished by replacing the cement (binding material) with fly-ash up to 60% in OPC and 27% in PPC cement and to increase the strength of concrete with mineral admixtures. Nano-silica and natural polymer substances such as cactus jelly are used to increase the workability of concrete and most importantly to achieve the reduction of carbon emission in construction industries.

B. Raw Materials

Portland pozzolana cement confirming to IS 1489(part 1)-1991 was used for this project. Commercially available powder Nano silica of size ranging from 35nm to 46nm was added to the weight of the cement. Locally available fine aggregate of size less than 4.75mm was used as per IS: 2386(part-1). The fine aggregate also confirms to Zone II of IS: 383 – 1970. Recycled aggregates of 20 mm size was used for coarse aggregates. Class F Fly ash as per IS 3812:1981 which is obtained from Power plant was used. Cactus (opuntia / prickly pear) were collected from the local area and are further crushed and mixed with a particular proportion of water and was stored in a moist area open in sunlight for 7-10 days until the gel has acquired reasonable viscosity.

C. Concrete Mix Design

The concrete mix design is done for M50 grade in accordance with IS 10262-1982. The concrete mix consist of fly ash as a partial substitution material for cement. For the experiments fly ash was added into the concrete mix as a cement partial substitution at about 60% with the addition of nanosilica at 2.5% of the weight of cement. Recycled aggregates are replaced at 60% for coarse aggregates. Cactus gel is added at 1.5% to the weight of water.

III. EXPERIMENTAL SETUP

A. Specimen Details

This experimental program consists of casting and testing of 9 concrete cubes of standard size 150 x 150 and 9 number of beams of size 230 x 180 casted, their id, descriptions and their curing period are summarized below.

Table 1 Specimen details of partially replaced fly ash and Nano concrete Beam Element

Specimen id	Replacement	No of Specimens per mix	
		Cube	Beam
C	0	3	3
R	FA 60% & RA 60%	3	3
N	FA 60%,RA 60%,NS 2.5% & CEX 1.5%	3	3

Figure. 1 The casted Cube specimen

Figure. 2 The Beam specimen

B. Test Setup

Test specimens are cured for the required days and shall be tested immediately on removal from the water. The beam specimens are provided with a reinforcement of 2 no's of 10 mm diameter for tension zone, 2 no's of 12mm diameter for compression zone and 8mm diameter of stirrups. The dimensions of each specimen's shall be noted before testing.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

A. Compressive Strength

The cubes of size 150 x 150 x 150 mm are placed in the machine such that load is applied on the opposite side of the cubes as casted. Align the specimen carefully and the load is applied till the specimen breaks.
The formula used for calculation:
Compressive Strength = Total Failure Load/Area of the Cube.

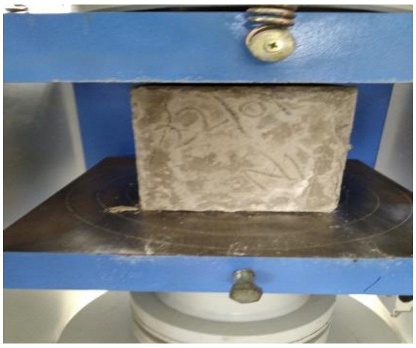

Figure. 3 Compressive strength test on cube

.Compressive strength of specimens with various proportions

Table: 2 Compressive strength of various specimens

Specimen for testing	Conventional cube without any replacement	Cube with 60% replacement of materials(28 days)	Cube with 60% replacement of materials with the addition of mineral admxtures
Compressive strength in N/mm^2	51.5N/mm^2	29.5 N/mm^2	55.6 N/mm^2

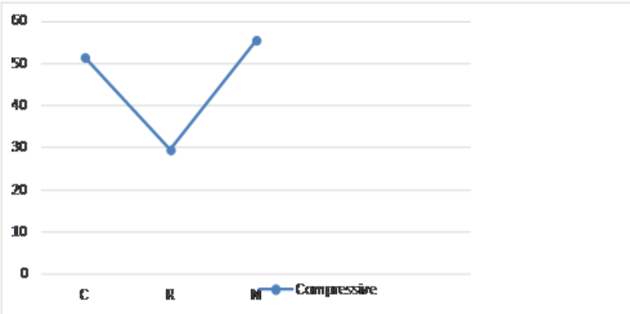

Figure. 4 Compressive Strength of concrete

B. Flexural Strength

The cast specimens were removed from the mould on the next day and are cured in water under normal atmospheric conditions up to the date testing. The testing of various specimens at the age of 28days has to be carried out, when they were in wet conditions. These specimens were tested as per I.S.516:1959 on Flexure testing machine. The under mentioned procedure has to be followed to test the beam specimens for deflection. A three point flexural bending system is to be adopted. Specimens has to be tested in a loading frame of capacity 200T and the loads have to be applied using a hydraulic jack of capacity 50T, with an effective span of 2000mm. Load cell of 50T capacity has to be used to measure the applied load. For flexure test, the loads has to increased in stages till the failure of the specimen and at each stage of loading; deflection at the mid-span and the deflection at a distance L/3 from both the ends have to be measured using a dial gauge.

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The strains at the compression face and tension face were measured using a mechanical strain gauge.

The flexural strength was calculated by the following

Flexural strength (MPa) = PL /bd2
Where,
P = Failure load,
L = Unsupported length between the supports
b = width of specimen, d = depth of specimen

Figure. 5 Flexural strength test on Beam

C. Flexural Strength test of various specimens

From the results it can be observed that the beams with 60% replacement of Recycled aggregates and Fly ash with Nano silica and cactus jelly as an additive has deflected less than other specimens. The load carrying capacity is also increased as the specimens cracked at more load than control concrete and the specimens without Nano silica and cactus jelly

Table: 3 Flexural strength of conventional beam

Load in kN	Deflection in Dial gauge.	Deflection in mm	Surface area of specimens mm^2	Flexural strength in N/mm^2
12	335	8.5	230x180	7.36
18 (initial crack)	**530**	**13.5**	**230x180**	**10.86**
20	675	17.1	230x180	12.07
24	770	19.5	230x180	14.49
26(final crack)	**835**	**21.2**	**230x180**	**15.70**

Table no: 4 Flexural strength of R beam

Load in kN	Deflection in Dial gauge.	Deflection in mm	Surface area of specimens mm^2	Flexural strength in N/mm^2
11	300	7.6	230x180	6.64
14 (initial crack)	**525**	**13.4**	**230x180**	**8.45**
17	650	16.5	230x180	10.26
20 (final crack)	**820**	**20.9**	**230x180**	**12.07**

Table no: 5 Flexural strength of N beam

Load in kN	Deflection in Dial gauge.	Deflection in mm	Surface area of specimens mm^2	Flexural strength in N/mm^2
22	715	16.7	230x180	13.28
26	810	18.2	230x180	15.70
28(initial crack)	**850**	**20.5**	**230x180**	**16.90**
30	910	21.6	230x180	18.12
34 (final crack)	**965**	**24.5**	**230x180**	**20.50**

Figure 4 Flexural strength of Concrete

D. Comparative Study

Table 6 Comparison between the three specimens.

Trial	Load in tonnes	Deflection in Dial gauge	Deflection in inch	Surface area in mm^2	Flexural strength in N/mm^2
conventional	26	835	21.2	230x180	15.70
R Beam	25	820	20.9	230x180	12.40
N Beam	34	965	24.5	230x180	20.50

Above is the comparison among the three specimen, it was found that maximum flexural strength was attained by N Beam that is 60% replacement of material with adding of mineral admixture. Comparative study of the tested specimens compression strength and Flexural strength are as follows

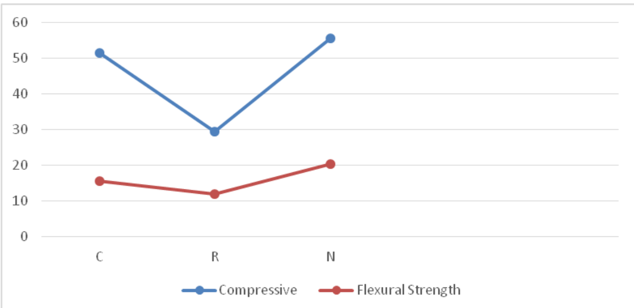

Figure. 5 Comparative analysis of Concrete

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V. CONCLUSION

From the above experimental work, the results have concluded some specific points which are mentioned below:

- The concrete with 60% replacement of Recycled aggregates and Fly ash with the addition of Nano silica and cactus extract solution has more compressive and flexural strength compared to conventional and the concrete without cactus extract solution.
- The compressive strength increases about 8 percentage when compared to conventional or C beams but in R beams there is a decrease in strength at about 42.7 percentage of Conventional beams.
- The Flexural strength also decreases in R beams at about 22 percentage of C beams and increases at about 30.5 percentage when compared to C beams.
- The load carrying capacity of the N beam is more when compared to the C and R beams. Deflection is also less at more loads in N beam when compared to other specimens.
- There is also considerable improvement in flexural strength due to the silica nano-particle content. Due to the addition of a little nano-Sio^2 the low pozzolanic activity of Fly ash-based cements are increased. Thus, nano-SiO^2 activates fly ash.
- Cactus extract was tested in a Portland cement mortar at this work. There is a increase in the plasticity of mortar, improvement in water absorption and freeze-thaw resistance. This is because of the Calcium hydroxide produced by Portland cement hydration reacts with the components of cactus extract, polysaccharides or proteins, and forms complexes.

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