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Micro Structure Properties of Parent Concrete with Nano Silica and Polypropylene Fibre in Recycled Aggregate

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Abstract*— This paper involves the study made to investigare the effects of colloidal nano silica and their properties on concrete with a constant replacement of recycled aggregates at a level of 100%. Polypropylene fiber of 2% is added in all mixes to enhance tensile properties of concrete. In many cities there is a surge in construction and demolition wastes constitute the major portion of solid waste production in the world. The reuse of such wastes as a new construction material were used to reduce the huge amount of natural resources. Here, ordinary Portland cement is replaced by weight fraction of nano silica at replacement levels of 0%, 0.5%, 1%, 1.5%, and 2%. The colloidal nano silica act as a filler material which increase some of the mix properties, it also act as accelator to enhance pozzolonic action. The further presence of nano silica enhance the strength and properties of concrete up to 1.5% of replacement criteria, such as mechanical strength tests were conducted in concrete mixes. it has been concluded from scanning electron microscope (SEM) analysis that the denser matrix is formed at 1.5% of replacement of nano silica.

***Key words*— Nano silica, Recycled coarse aggregate, polypropylene fiber, Mechanical properties, Scanning Electron Microscope.**

I. INTRODUCTION

In the construction fields an intense research has been carried out to improve the results and strength of the various building materials and extensive use of sustainable concrete. Comparing all kinds of nano materials, since nano silica is used widely in the construction of concrete structure, where they improve the performance of concrete on its pozzolanic reactivity over the pore filling effects. Strength of concrete has been increased by lot of factors such as concrete materials and their corresponding ratio of water to cement materials etc. Research has been taken for improving the durability of cement and cement based products and it becomes the key factor to improve the lifespan of the structures.

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Durability enhancement of cement materials were used to extend the life time of the concrete structures, mainly to form and perfect infrastructure and special structures even for sewage system, tunnels, bridges etc. Marine structures may delay demolitions structures and reconstruction of these structures.

The results specified for the certain period with less debris has to be made for demolition and some construction materials were consumed for the reconstruction. The fact for the minimization of construction waste will be taken for the minimization of the raw materials and it is mainly required for the production of construction materials. The high performance concrete were achieved for reduced porosity, homogeneity and micro cracks for the hydrated cement waste and the zone of transaction.

II. EXPERIMENTAL PROGRAMME

A. BINDER CONTENT

Ordinary Portland cement (OPC) is 53 grade as per IS 269:1989, IS 8112:1989 and IS 12269: 1987. The main function of all the types of cement will be binding of aggregate.

Table. 1 Physical properties of cement

Properties of cement	Results
Initial setting time	30 min
Final setting time	600 min
Specific gravity	3.15

B. RECYCLED COARSE AGGREGATE

From demolished waste the recycled coarse aggregates were taken. To use graded materials, the waste demolished materials were crushed to 12.5 mm and 20 mm aggregate in the crusher.

Table.2 Recycled aggregate properties

Properties	
Specific gravity	2.47
Aggregate crushing value	20
Bulk density (kg/m^3)	1502.20
Water absorption	4.04

C. FINE AGGREGATE

Manufactured sand (M –Sand) is taken for the substitute of river sand for concrete construction and sand manufactured was less than 4.75mm.

D.NANO SILICA

The Nano silica used in the concrete mix will show the results of increase in the properties of concrete and test result as shown in table 3.

Table. 3 Element in oxide form

formula	Concentration (%)
SiO_2	99.81
Na_2O	0.06
SO_3	0.05
CaO	0.03
PbO	0.03
Fe_2O_3	73PPM
ZnO	96 PPM
Pd	71 PPM

E. POLYPROPYLENE FIBER

In the present work, polypropylene fiber was mainly used as reinforcing material for concrete structures. The physical properties for this fiber are presented in table 4

Table. 4 Properties of polypropylene fiber

Specification	Description
Specific gravity	0.91
Tensile strength	320-490Mpa
Young's modulus	6-10Gpa
Melting point	1600 to 1650
Fiber cut length	24mm
Effective diameter	25-40 microns
Physical form	Fibrillated
Bulk density	910 kg/m^3

F. SUPER PLASTICIZER

If the concrete admixture can greatly reduce the amount of mixing water under the condition that the concrete slump is basically the same, we call it a super plasticizer.
Polycarboxylate (PCE) is a new substance for this generation which is environment friendly where the cement admixture used was of advanced level of invention. For concrete, PCE can improves the fluidity in the initial stages and finally they include strength and decreasing the shrinkage cracks in addition, these super plasticizer also suitable for plaster, fire proofing materials and ceramics.

Table. 5 physical properties of super plasticizer

Description	Physical Characterstics
Appearance	Brownish
pH	Approx 6.50
Basis	Aqueous solution of modified polycarboxylate
Dosage limit	0.6-2.0% by weight of cement

G. MIX DESIGN

The characteristic compressive strength of 40 Mpa for generating the flow behavior in M-sand and recycled coarse aggregate mix proportion were adjusted along with the dosage of nano silica with different volume fraction and polypropylene fiber water ratio until the flow behavior exhibited in mix. Proportion of 1:1.21:2.17. with water cement ratio maintained at 0.40 and by obtaining the flow properties was illustrated.to develop the recycled aggregate with Nano silica and polypropylene fiber include w/c ratio dosage of super plasticizer.

- Cement - 494.9 kg/m^3
- Fine aggregate - 598.6 Kg/m^3
- Recycled aggregate - 1084.7 kg/m^3
- W/c ratio - 0.4
- Nano silica - 0%,0.5%,1%,1.5%,2%
- Polypropylene fiber - 2%
- Super plasticizer - 1%

H. CASTING DETAILS AND CURING

Cubes

The concrete cubes of size 100mm×100mm×100mm were taken and the compressive strength of various shapes were found with nano silica. They were subsequently subjected to the curing process in the ordinary condition and tested in the testing machine with a l9imit of 3000 kN

Cylinder

The cylinder of size 200 mm×100 mm were casted and a study was made to find the effect of split tension and modulus of elasticity. They were done on the compression testing machine.

Porosity

The specimen of dimension 100mm×50mm were cast and were cured in water for 28 days. These specimens were oven dried at 110°C for 24 hours and their weights are noted down to be W1. These specimens are then placed in water for 2 hours and their weights are noted to be W2.specimens are surface dried and placed in boiling water. These weights are noted to be W3. Immersed apparent weights are known using suspended weighting balance which is noted to be w4.
Porosity can be calculated = (W3-W1)/ (W3-W2)

Flexural Beam Test

The beams specimen of size (100×150×1200) mm were prepared with reinforcement in tension zone, There are two specimen were tested under Two point loading was applied.

III. TEST PROCEDURE

A.COMPRESSIVE STRENGTH TEST

The compressive strength test is the most widely used method for finding the trademark properties of concrete and auxiliary outline reason for the presence of existing amount of concrete to find f_{ck} specification given in IS 5816:1999 under normal room temperature. Fig 1 and 2 shows the experimental setup of compression and split tensile strength.

Fig.1 Experimental setup compression testing

Fig.2 Experimental setup split tensile strength test

B.SPLIT TENSILE STRENGTH TEST

The split tensile strength test was performed on the cylinders of size 100mm diameter and 200 mm height. Dried specimen with cleaned surface was placed on the testing machine. The platen was lowered and made to touch the top surface of the specimen.

C. POROSITY

The porosity is the volume of voids to the volume of specimen. The total porosity of previous concrete can be evaluated by using a water displacement method. The porosity is represented as the number of pores in a material or pores in concrete structure Porosity is usually expelled in volume percent.

D.FLEXURAL BEAM TEST

The specimens were tested in a (UTM) Universal Compression Testing machine, In order to find the applied load, the load cell of 25T capacity and Two Linear Variable Differential Transducer (LVDT) were used for measuring the longitudinal strains at the top and bottom of the beam.

Fig.3

E. SEM ANALYSIS

Electron Magnifying Instrument (SEM) is sort of electrons magnifing in the lowest range that produces picture of an electrons and the fillterings made it with an engaged light emission. SEM deals with the approach of determining greater than 1 nanometer. The SEM analysis done by control specimen and optimum valued specimen. It mainly used for to analysis micer cracks and propagation provided fundamental information for the failure mechanism of RAC.

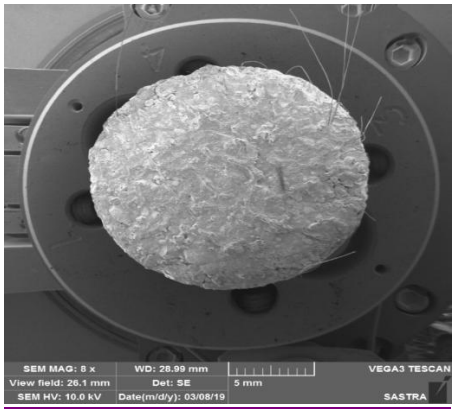

Fig.4 Experimental setup of SEM Analysis

IV. RESULTS AND DISSCUSSION

A.COMPRESSIVE STRENGTH

The compressive strength of M40 grade concrete and NS concrete at the age of 7 days and 28 days . there is a singnificance improvement in the strength of concrete because of high pozzolanic nature in nano silica and their filling ability. Themaximum 7 days cube strength of NS o% was 48.25 N/mm$^{2.}$ Compressive strength of concrte with NS at 28 days age also shows same trend of increase upto 1% of replacement and the gardually decreased. The maximum 28 days cube strength of M40 grade with 1.5% NS was 52.1% N/mm^2

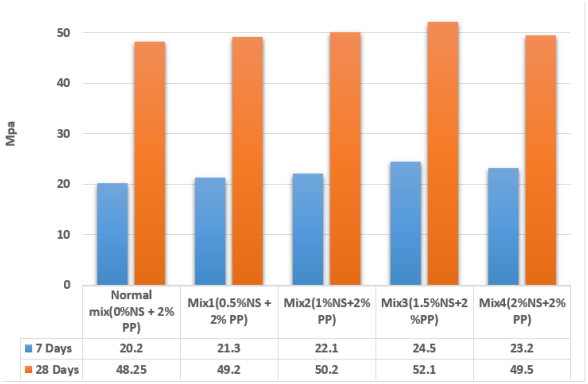

Fig.5 compressive strength for 7th and 28th days result

B. SPLIT TENSILE STRENGTH

Split tensile strength test were resulted at 28 days strength shown below fig.6. The optimum value got from the 1.5% replacement at 5.7 MPa. Further added NS at 2% it should be reduce the binder content result in reducing the value of tensile strength.

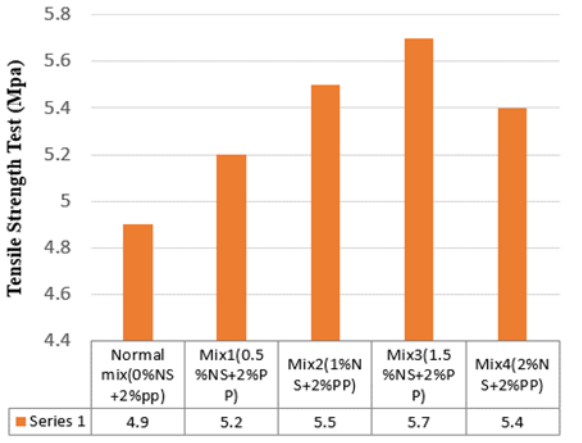

Fig.6 split tensile strength 28 days result

C. POROSITY

Porosity is a factor that is indicated in volume aspects. The porosity of concrete has an impact on the properties of concrete in various cases such as composition of concrete, casting adopted in site, curing, and strengthening of concrete. The availability that influences the porosity were considered to be important where the concrete technology handles about the porosity of concrete and the effects made by them on concrete structures.

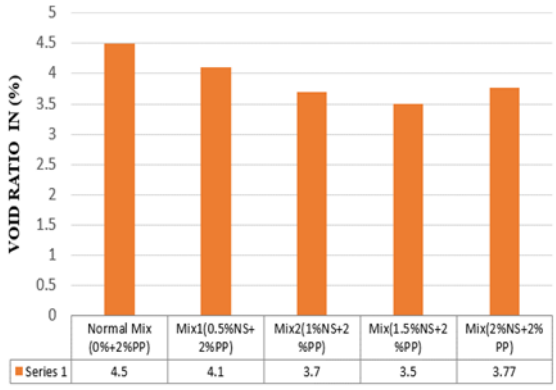

Fig.7 porosity at 28 days result

D.FLEXURAL BEHAVIOUR OF REINFORCED BEAM

The various properties like the ultimate load, stiffness, ductility ratio, crack pattern, energy absorption, load deflection curve were analyzed and observed below fig.8

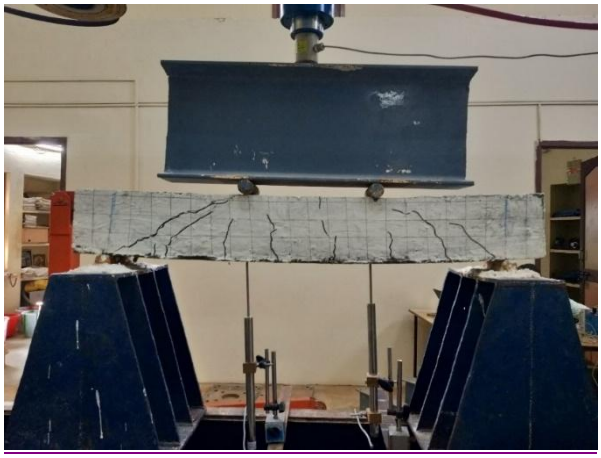

Fig.8 Flexural cracks of specimen

LOAD DEFLECTION BEHAVIOUR

Load deflection and energy absorption values for both control and optimized mix (1.5% NS+2%pp) are shown below.

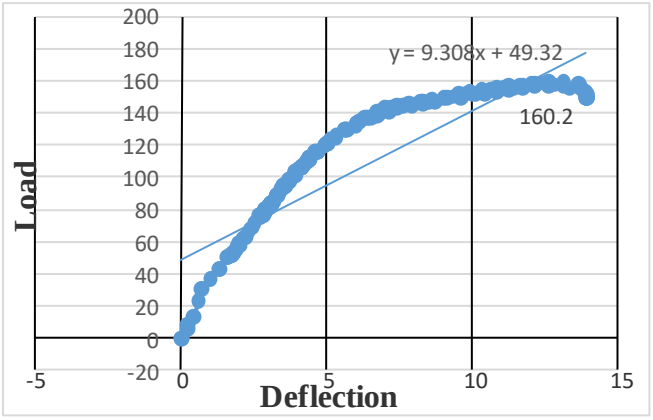

Fig.9 load verse deflection for control Mix

The ultimate load of control mix is 160.2 kN were observed at fully recycled aggregate concrete without any special properties added.

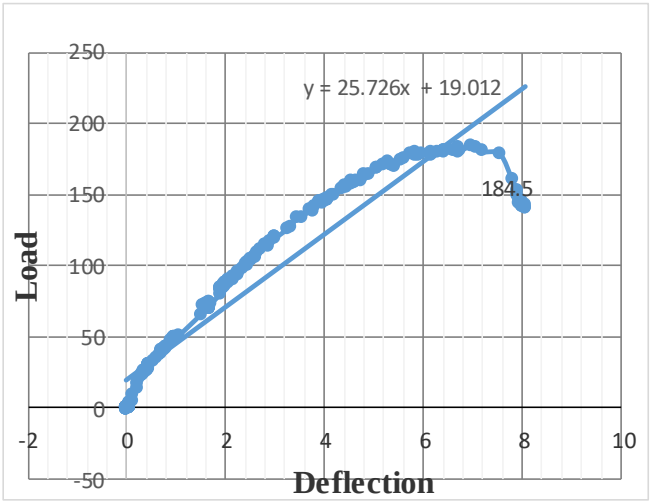

Fig.10 load verse deflection for optimum Mix.

Crack pattern

From ultimate strength and energy absorption, crack pattern developed for both control mix and optimized mix were observed almost to be same. The proper placement of shear reinforcement has resulted in no shear cracks and showing perfect flexural behavior of beam.

Stiffness

The amount of load required to produce a unit deflection can be calculated using stiffness. The slope of the load deflection curve gives the stiffness. The stiffness was observed in control mix to be 9.038 kN/mm while the value of stiffness was optimized mix to be 25.726 kN/mm.

Table.6 Flexure behavior of mix proportions

Mix proportion	Ultimate load (kN)	Energy absorption (kN-mm)	Stiffness (kN/mm)
Control mix	160.2	1645.7	9.038
Optimized mix	184.5	1937.8	25.726

E. SEM ANALYSIS

The SEM picture of concrete demonstrated that exists note better contrast between the 0% and 1.5% replacement of nano silica concrete. The micro cracks should be arrested in 1.5% replacement level when compared to the control mix. Denser matrix formed at the level replacement.

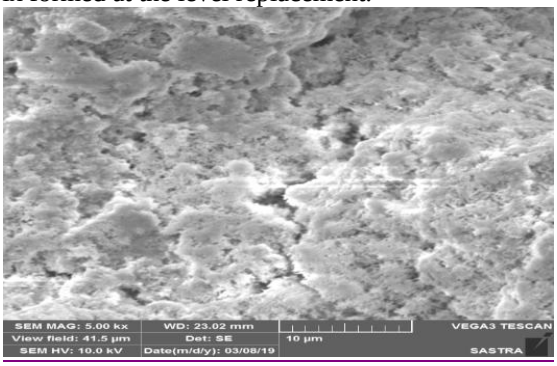

Fig.11 concrete hydrated for 28 days with 1.5% NS

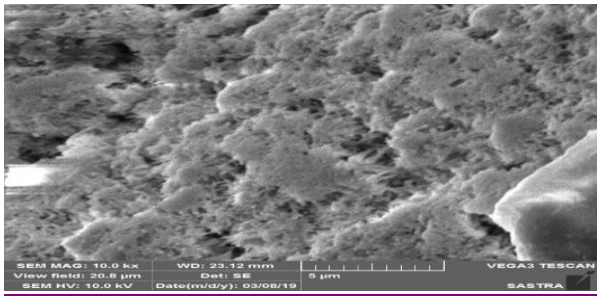

Fig.12 Concrete hydrated for 28 days with 0% NS

V. CONCLUSION

The results obtained from the various tests has the following general conclusion

- The conclusion made analyses directed on specimen in standard condition, the results found were the expansion of nano silica and some mechanical properties were represented to induce the results.
- Replacement of NS in concrete plays major role because it is the major factor for the changes made in the micro structures of the test specimens, where it reduces the permeability by controlling the penetration of water which promote prevention in corrosion.
- The load carrying capacity of beam and mechanical strength characteristic resulted at 1.5% replacement gets higher value.
- It has been concluded from Scanning Electron Microscope (SEM) analysis that the denser matrix is formed at 1.5% replacement of NS.

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