A Crucial analysis for Impact of Nano Material on Durability of Concrete

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Abstract—*This paper present the construction industry becoming the second largest industry in the world. As there are various problems occurs due to environmental effects. In which situations the Nano materials gives superior results in various studies. Study shows various durability checks like acid attack, sulphate attack, permeability parameters gives good result by the use of nano materials. The study also shows that it required specific conditions for the study area to perform the durability tests. So, most of the problems created by the voids available in the concrete which can be reduced by using nano materials. This types of issues solved by using Nano materials using in the construction field.*

Keywords- Environmental Issues, Strength, Durability, Concrete, Nano Materials.

I. INTRODUCTION

Concrete is the widely used construction material, its reacts in aggressive environment due to extremely permeable composition. Durability is the parameters which justify the life long strength of structure in various atmospheric conditions. Nowadays the Nano material is widely used as they can provide certain properties at nano level. They are used as a filler material in concrete. Due to which the permeability of the concrete also reduced. Carbon nano tubes and fiber seal the cracks at nano level. So the nano material improves the ductility of concrete which are generally brittle in nature. With comparing various nano materials nano silica has esteemed advantage in hydration of cement paste also.[1].

From diverse studies it is observed that nano silica increases the cement hydration at younger age. The study of nano silica based on concrete is also very rare. Earlier studies on nano silica mostly focused on the fresh properties and its tests regarding that.

In most of the studies nano silica increase the microstructure properties of concrete and make the concrete more dense and durable. The amount of nS also influenced on concrete durability properties. There are very few study has been carried out on durability of plain concrete.

In adding up to strength water permeability, sorptivity and other tests were performed for concrete at nS usage of 0%, 0.5% and 1% respectively. The effect of nano silica on microstructure of concrete also studied. The permeability of concrete also find by pore size distribution, the microstructure analysis and chemical parameters.

The effectiveness of using nano-silica to improve the impermeability and durability of concrete is also discussed.

II. OBJECTIVES

To check Possibility of utilization of the Nano Materials like Nano Silica or Nano Fly Ash as a solution as the Durable Structures. Use Nano Silica in Concrete make more sound and Homogeneous Material to improve the strength and durability. Cost Comparison with Normal Concrete. Recommend another Waste Material with use of nS to reduce or balance cost compare with Normal Concrete.

III. MATERIALS AND METHODS

Materials

Nano materials used of about 40 – 80 nm size were used.[3]
Nano silica, which reacts with calcium hydroxide (CH) to develop more of the strength carrying structure of cement -calcium silica hydrate (CSH).[8]
Coarse aggregates of 9.5-mm granite aggregates with an oven-dry unit weight and specific gravity of 1650 kg/m3 and 2.65 were used. The study used a commercial nano-silica, in powder form, with an average primary particle size of 13 nm, corresponding to a surface area of 200 m2/g. [2]
Nano silica in dispersion with water in 40:60 ratio (40% Nano silica). physical properties of the cement are Fineness is 2946 cm2/gm, Normal Consistency is 30%, Initial and final setting time is 64 and 192 minutes, Specific gravity is 3.15. Locally available river sand of specific gravity 2.64, fineness modulus 2.91, and conforming to Zone II was used as fine aggregate. Plaster of Paris, quick setting Gypsum plaster consisting of a fine, white powder, calcium sulphate hemihydrates, which hardens when moistened and allowed to dry. [5]
Silicon Dioxide Nano powder (Hydrophilic SiO2) M.W. 60.08. Crushed granite coarse aggregate of 20mm size and specific gravity of 2.86 confirming to IS 383-1987 was used. [7]
Cement used in the investigation was 43 Grade Ordinary Portland cement confirming to IS: 12269. Cement with Initial setting time : 51 min, Final setting time : 315 min, Fine Aggregate bulk density Bulk Density :1.49 g/cc, Specific Gravity=2.28, Coarse Aggregate Bulk Density :1.44 g/cc, Specific Gravity :2.89 [1]

The cementitious materials used during this study were OPC, fly ash, and nano silica. The fineness of fly ash is 3200 cm2/gm and its specific gravity is 2.25. Nano silica used in this investigation is synthetic product with spherical particles in the range of (24 – 35) nm, imported from Sigma - Aldrich (Germany), it consists mainly of pure silica, 97%. Polycaboxylic ether polymer based PCE sky, Glenium ACE 30 obtained from passive company in Egypt was used during this study. [9]
Nano silica was supplied by Visa chemical Industries Chemical Analysis of nano silica was done by the manufacturer itself. The mean particle diameter (particle size) was only 17.00 nm. Fly ash particles range from less than 1–150 μm. River sand having fineness modulus 2.87 and specific gravity 2.63 was used as fine aggregate. [6]
Ordinary Portland cement (53 grade as per IS: 12269-2013) is used. 20 mm size coarse aggregate and fine aggregates were used. The size of nano silica is 49.7nm. [4]

IV. METHODOLOGY

Nano materials used of about 40 – 80 nm size were used.[3]
The compressive strength test follows ASTM C 39/C 39M-04a with the specimen size 100 mm x 200 mm. Testing was performed for concrete at ages 1, 3, 7, 28 days. Meanwhile, the permeability test follows DIN 1048 Part 5 with specimen size 200 mm x 200 mm x120 mm. Rapid Chloride permeability test (RCPT) follows ASTM C 1202. An RCPT specimen has a nominal diameter of 100 mm and thickness of 50mm cut from the centre of a cylindrical sample. Then, SEM (Scanning Electron Microscope) images was also taken to study concrete microstructure.[3]
Cement, fly ash and Nano silica were mixed for one minute and after that the fine aggregate was also included and mixed and coarse aggregate was mixed thoroughly in dry state and cement were mixed for one minute, Super plasticizer is mixed with water and it being added within two minutes now concrete was allowed to mix for three minutes than all the specimens were well-compacted using table vibrator, and cured for 28 and 56 days respectively. [8]
Compressive strength was determined at 1, 7, 28 and 91 days, using three Ø100 _ 200 mm cylinders for each, Water sorptivity was measured from three Ø100 _ 500 mm cylindrical slices in accordance with STM C 1585. Chloride diffusion test was carried out by immersing a Ø100 _ 100 mm cylindrical specimen in a 185 g/L NaCl solution for 56 days. [2]

The increase in weight as a percentage of the original weight is expressed as its absorption (in percent). The water absorption is expressed as percentage water absorption in terms of oven dried weight of aggregate. [4]

Three trial mixes of M20 grade were used. The high strength behaviour of concrete and the durability enhancement of the concrete have been studied by performing the following tests: Compression strength test, splitting tensile strength of cylindrical concrete specimen, Water absorption test. The standard method is to cure the specimens in an oven for three days, at a temperature of 50°C and relative humidity of 8%. [7]

Standard cement paste was prepared according to determine the water – cement ratio, which was found in this study 26% for mixes without super plasticized, while was 23% for other mixes (with super plasticizer). M1, and M2 are control mixes, while mixes M3, M4, M5, M6, M7 are main mixes with different values of NS (1%, 2%, 3%, 4% and 5% respectively). Thirty cube of size 20 x 20 x 20 mm were cast for each mix. All samples were numbered and weighed, then 1st half of them was cured in potable water and the second half was cured in sulphatic acid of concentration 0.2 N (7.35 ml/lit), after 24 hours until the age of testing (3 days, 7 days, 28 days and one year). At the date of testing three samples of each group were extracted from curing conditions, weighed and measured their dimensions, then tested in compression testing machine and the average result is recorded. The compressive strength loss of specimens due to immersion in acid solution was monitored at ages 3-day, 7-day, 28-day and one year. [9]
One control mix and other three concrete mixes by replacing cement by NS in 0.5%,1.5% and 3% of the total weight of cementitious materials. The remaining three mixes are prepared by replacing cement by 25% of fly ash (kept constant) and varying the percentage of NS in 0.5%,1.5% and 3% of the total weight of cementitious materials. [6]
2% of cement was replaced with nano silica and specimens were casted. The cubes of concrete were cured and then immersed in 5% Na2SO4 solution up to 28 days. The specimens were weighed once again and the weight is compared with the normal concrete in order to calculate the percentage of loss in concrete. Chloride solution has been prepared by adding 5% sodium chloride in water. The initial weights of these cubes are found. Then are they immersed in a chloride solution. After drying the cubes, the change in weight was found. The specimens were cured in curing tank for 28 days. After 28 days all specimens are kept in atmosphere for 2 days for constant weight, subsequently, the specimens are weighed and immersed in 5% sulphatic acid (H2SO4) Solution for 28 days. After 28 days of immersing in acid solution, the specimens are taken out and were kept in atmosphere for 2 days for constant weight. After drying the cubes, the changes in weight were found. [4]

V. RESULT AND DISCUSSION

RESULT

Nano materials used which gives excellent result in compressive strength, while nS addition more than 10% does not seem to be good result in compressive strength.[3]

Finally the permeable strength of 56 days cured Nano concrete possess an incremental strength by 12.25% than the PPC concrete. [8]

Powder paste samples were heated up to 950OC at a constant rate of 10 C/min and the weight loss was recorded in TGA. This Pozzolanic reaction was expected to densify the microstructure of the porous cement paste and affect the pore structure. It is clear that the concrete strength increased with the increase of nano-silica content. The resistance to water penetration for concrete can be greatly increased by incorporating a small amount of nano-silica. [2]

The average absorption of the test samples shall not be greater than 5% with no individual unit greater than 7%. According to the test results, it can be conclude that concrete can increase durability by partial replacement 2.5% of cement by nano-silica and addition of admixture (plaster of Paris). By sorptivity test the special concrete shows less capillary rise than ordinary Portland cement concrete. [5]

When the percentage by weight of nS exceeds 1.5% of the total weight of cement, it results in agglomeration. The results obtained from water absorption test suggest that nS concrete is more durable than conventional concrete. [7]

The increase in strength is maximum for NS 1% b.w.c and least for NS 0.3% b.w.c. The Nano SiO2 added to the mix filled up the pores in between the C-S-H gel, hence, making the microstructure more compact and uniform. [1]

X-ray diffraction (XRD) was carried out in HBRC at Raw Building Materials Institute and its pattern show that the used NS is highly amorphous materials and has low crystallinity. Transmission Electronic Microscopic (TEM) of nanosilica was carried out in National Research Centre (NRC) at physics department, which shows the morphology of NS, it can be seen that NS particles are highly agglomerated clusters with size (24 – 35) nm. It can be seen also that nanosilica mix of percentage 1% enhanced compressive strength from 3-days up to one year in comparison with control mix (without nanosilica), the % of enhancement was 1.4% after 3-days, 5.7% after 7-days, 26.8% after 28-days, and 13.5% after one year. It can be seen also that when the amount of NS increased than 1%, the compressive strength decreased at all ages (from 3-days up to one year) in Comparison with 1% NS mix and control mix (without nanosilica). Resistance of cementing materials exposed to sulphatic acid attack can be improved by the addition of 1% NS and 10% FA by weight of cementitious materials, which concluded to be optimum mix. [9]

The main objective of the present investigation was to study the effect of nanosilica on the mechanical and durability and flexural properties of concrete. [8]

The compressive strength of concrete is increased by almost 40% by adding 2% nano silica in concrete. The durability of concrete containing 2% nano silica exhibits better resistance against sulphate attack, chloride attack and acid attack. [4]

DISCUSSION

The properties and results of nano silica (nS) were studied and major conclusions are as follows:

- ✓ In all cases, the nS give more durability than normal concrete with the same mix proportion.
- ✓ The nS give better result if it is used limited to 1 or 2 % maximum.
- ✓ The nS decrease the permeability of concrete.
- ✓ As the permeability of the concrete decreases the durability increases.
- ✓ Micro and Nano fly ash also affected on the durability properties.
- ✓ nS is not greater responsible for strength but responsible for durability parameters.

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