Research Paper Engineering

Nanotechnology in Cellular Lightweight Concrete

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ABSTRACT

The world of the construction sector is being changed by new technologies, new materials, new building typologies, new concerns and opportunities. The construction sector has been slow to embrace nanotechnology, but nanotech innovations have an enormous impact on building design and construction. Nanotechnology represents a major opportunity for the construction sector to develop new products, substantially increase quality, and open new markets. In this paper the performance of Cellular Lightweight Concrete by addition of Nano-silica has been studied through measurement of compressive Strength. The experimental results show that the durability of the concrete mixed with the nano particles were better than that of a plain concrete.

Keywords : Nanotechnology, Nanomaterials, New construction, Cellular Lightweight Concrete

I. Introduction

Nanotechnology is a recently developed, major enabling tool, already well established in several sectors of science, which is expanding rapidly into applied sciences, technology and engineering. It leads to development of advanced characterization and eventual prediction and control of properties of materials at a sub-micron level. Applications of Nanotechnology are expected to lead to better, cleaner, cheaper, faster and smarter products. In addition, much more effective use of basic resources and development of environmentally sustainable production processes are predicted.

It has been well recognized that the use of pozzolanic materials such as silica fume and fly ash is necessary for producing high performance concrete, because of significant improvements attained on the interfacial zone of cement paste-aggregate. In recent years, there has been a growing interest in the use of Nano silica (NS) as a mineral admixture for similar purposes. Nano silica particles can react with calcium hydroxide crystals, which are arrayed in the interfacial transition zone (ITZ) between cement paste and aggregates, and produce C-S-H gel. A stable gel structure can be formed and the mechanical properties of cement paste can be improved when a smaller amount of Nano silica is added.

However, up to now, there are few published reports on the durability of Nano silica concrete. The research shows that Nano silica can improve the micro structure of the ITZ and durability of concrete.

Nanotechnology (sometimes shortened to “nanotech”) is the study of manipulating matter on an atomic and molecular scale. Generally, nanotechnology deals with developing materials, devices, or other structures possessing at least one dimension sized from 1 to 100 nanometres. Quantum mechanical effects are important at this quantum-realm scale.

Cellular concrete is generally defined as a lightweight cementitious material that contains stable air or gas cells uniformly distributed throughout the mixture at a volume greater than twenty percent. In lay terms, it can be thought of as a concrete, which utilizes a stable air cell structure rather than traditional aggregate. Cellular concrete is engineered, low-density concrete with special properties germane to solving a sweeping assortment of construction, mining, and manufacturing challenges.

In instances where projects are sited on marginal lands with areas of soft or loose soils incapable of supporting typical aggregate loads, the use of pervious cellular lightweight concrete (PCLWC) technology permits designers and geotechnical engineers to control both site bearing capacity and drainage characteristics.

Fig: Cellular Lightweight Concrete

II. Experimental

A. Materials

Cement: The cement used is Binani Cement and physical test result shown in Table 1. (IS: 12269-1987)

Table 1: Physical Test of Cement

Sr No.	Test	Result	I.S. Requirements
1	Consistency	28.50%	-
2	Setting time	-	-
a	Initial Setting time	85 minutes	Shall not be less that 30 minutes
b	Final setting time	190 minutes	Shall not be less than 600 minutes
3	Soundness test	2.40	Expansion shall be less than 10mm
4	Compressive test	-	-

a	3-days strength	30.46 N/mm^2	Shall not be less than 27 N/mm^2
b	7-days strength	39.13 N/mm^2	Shall not be less than37 N/mm^2
c	28-days strength	55.68 N/mm^2	Shall not be less than 53 N/mm^2
5	Fineness (blain's)	2380 cm^2/ gm	Specific surface shall be >2250 cm^2/gm

Sand: The Sand used is washed river sand 1.18mm particle size from sevaliya and bodeli. (IS: 2116-1965, IS: 383-1963).

Water: The water used in the manufacture of concrete is from BVM college, free from matter harmful to concrete (IS:3025).

Table 2: Test result of Water

Sr No.	Tests	Test Result	Limit as per IS 456-2000
1	pH value	6.68	Min. 6.0
2	Chloride (as Cl) (mg/l)	39.19	Max. 2000 mg/l for P.C.C. Work and Max. 500 mg/l for Concrete with steel and R.C.C. Work
3	Sulphate SO_3 mg/l	62.14	Max. 400 mg/l
4	Inorganic Matter mg/l	98.60	Max. 3000 mg/l
5	Suspended Solids mg/l	0.42	Max. 2000 mg/l
6	Organic Matter mg/l	19.50	Max.200 mg/l
7	Neutralization with 0.02N HCL, ml	2.60	It should not more than 25 ml in 100 ml sample
8	Neutralization with 0.02N NaOH, ml	1.50	It should not more than 5 ml in 100 ml sample
9	Turbidity, NTU	0.17	-
10	Colour, Hazen unit	Colourless	-
11	Odour	Unobjectionable	-
12	Total hardness($CaCO_3$), mg/l	10.00	-
13	Dissolved solids, mg/l	114.00	-
14	Calcium (as Ca), mg/l	1.20	-
15	Magnesium (as Mg), mg/l	1.70	-
16	Total Alkalinity (as $CaCO_3$),mg/l	26.0	-

Preformed Foam: The foam used is REMIFOAM MYK Schomburg. Preformed foam is created by diluting a liquid foam concentrate with water in predetermined proportions and passing this mixture through a foam generator. Technical data sheet is given Table.

Table 3: Technical Data Sheet

Raw material base	Surfactant
Colour	Clear
Form	Liquid
Processing Temp.	Beyond +5^{0}C
Density	1.00g/cm^3
Storage	Protect from frost and dirt
Shelf life	12month at 20^{0}C in closed original containers

DOSAGE:

- Use with foam generator, Mix MYK REMIFOAM with water in the ration 1:40. 1kg MYK REMIFOAM yields approx 550-600 litres of foam dosage quantities of the construction material.
- Used as an admixture.

Nano-Silica: The Nano Silica used is taken from Material and Science department, Sardar patel University, V.V.Nagar. Nano Silica (NS) can contribute to efficient 'Particle Packing' in concretes by densifying the micro and nanostructure leading to improved mechanical and durability properties. Nano Silica can control degradation (through blocking of water entry on account of pore refinement) of the fundamental binder system of hydrated cement i.e., C-S-H(calcium-silicate-hydrate) gel caused usually due to calcium leaching out when immersed in water.

Mix proportion:

Nano-Silica	-	0.810 kg
Cement	16.2 kg	16.2 kg
Sand	44.55 kg	44.55 kg
Water	6.48 litre	6.48 litre
Foam agent	25 ml	25 ml
Water in Foam	1 litre	1 litre
Quantity of Foam	12 litre	12 litre

Note: Nano Silica added 5% of Cement

B. Specimen Fabrication:

First, the sand, which was saturated surface dry, was placed in the mixer. The cement and Nano Silica (premixed) were added and mixing resumed for 1 min, then gently adding the 75% of mixing water and mixed for 2.5 min, the 25% mixing water. Then Foam (preformed) was added in to mixer and mixed for 4 to 5min. Finally, the fresh concrete is poured into oiled molds. The specimens are demolded at 24h and then air-cured in a standard at temperature of 20±3 C.

C. Testing Method:

Sr No.	Tested After (Days)	Load for Complete Crushing (Tones)	Stress for Complete Crushing (N/mm^2)	Average Stress for Crushing (N/mm^2)
1	3	16.5	7.2	6.8 N/mm^2
2	3	14.3	6.2	
3	3	15.8	6.9	
4	7	20	8.7	8.7 N/mm^2
5	7	19.8	8.6	
6	7	20.3	8.9	
7	28	26.5	11.6	11.7 N/mm^2
8	28	27.2	11.9	
9	28	26.4	11.5	

The compressive strength test was performed in accordance with IS:6441, IS:516 cubic tests of 150 millimeters for compressive strength.

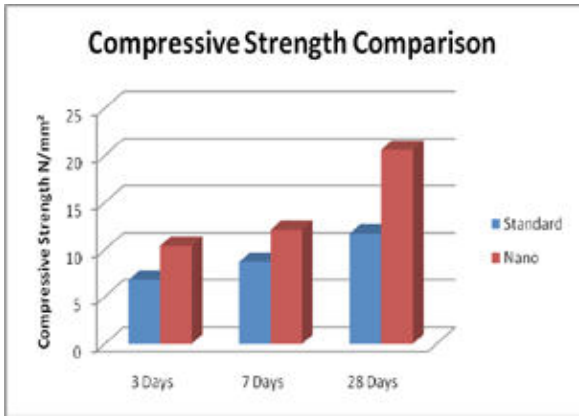
III. Test Result and Discussions

Table 4: Test Result Cellular Lightweight Concrete - Standard

Table 4: Test Result Cellular Lightweight Concrete - Nano

Sr No.	Tested After (Days)	Load for Complete Crushing (Tonnes)	Stress for Complete Crushing (N/mm^2)	Average Stress for Crushing (N/mm^2)
1	3	22.7	9.9	10.4 N/mm^2
2	3	24.5	10.7	
3	3	24.3	10.6	
4	7	28.4	12.4	12.1 N/mm^2
5	7	27.8	12.1	
6	7	27.1	11.8	
7	28	48.2	21.0	20.6 N/mm^2
8	28	47.0	20.5	
9	28	46.6	20.3	

The Graph show the compressive strength of all specimens at 3rd, 7th and 28th days. It can be seen that, when Nano particles in a small amounts are added, the compressive strength of concrete can be enhanced. This result is a result of increasing the bound strength of cement paste-aggregate interface by means of the filing effect of Nano silica particles.



techniques in traditional materials.

Compressive strength of the Cellular concrete can be increases with adding the Nano-Silica, especially at early ages. Research shows that the early strength of the concrete decreases slightly with adding the silica fume, but increases at later ages. These results indicate that the pozzolanic activity of Nano-silica is greater than that of silica fume.

Nano-silica consumes calcium hydroxide crystals, reduces the size of the crystals at the interface zone and transmute the calcium hydroxide feeble crystals to the C-S-H crystals, and improves the interface zone and cement paste structures.

IV. Conclusion

The development of novel materials and the improvement of existing materials in response to scarcity of natural materials become a possibility through application of nanotechnology

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