SEM ANALYSIS OF NANO CARBON BLACK CONCRETE

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Abstract: The objective of the present research work is to study the effect of nano carbon black on the mechanical performance and microstructure behaviour of concrete. Cement the main compound of concrete was replaced with nano carbon black by 5%, 10% and 15% against normal concrete mix. The concrete mixes were prepared and cubes were casted. The cubes were tested after 7, 14 and 28 days curing for compressive strength test and a remarkable increase in the value of compressive strength was observed in replacement with 15% nano carbon black sample. From Scanning Electron Microscopic analysis it was observed that additional growth of C-S-H gel is due to the reaction of Ca $(OH)_2$ with nano carbon black. Also evenly formation of niddle like structure and reduction in porosity leads to improve mechanical properties of 15% concrete sample.

Index Terms **- Nano Material, Concrete, C-S-H gel, Microstructure, Scanning Electron Microscopy.**

I. INTRODUCTION

Concrete: A unique construction material with scope of improvement at nanoscale.

Concrete is unique, most popular and the second highest consumable material on the planet after water (Taylor et al, 2007, Ashani et al. 2015). Main ingredient of the concrete is cement which is about 10% to 15% by volume of concrete is responsible of desired mechanical properties like – strength, durability etc. Response amongst cement and water known as hydration process makes, calcium-silicate-hydrate gel which is considered as a quality phase of the concrete (Al-Jumaily et al, 2015 , Monteiro and Roesler, 2000) and is responsible for holding the aggregates together with 28% of voids correlation with aggregate volume of gel (Raki et al, 2010). Presence of voids in concrete and gel structure turns out to be a significant issue since ever it was found and adversely affecting mechanical properties of concrete (Al-Jumaily et al, 2015). Concrete after all is a nanostructured material having multiple phases composed of an amorphous paste phase, aggregate phase, interfacial transition zone and bound water (Ulrik, 1993). All this stages and its result like gel structure, the tie length, strength and density of the chemical relationship forming during hydration can be studied by using nanomaterial and nanotechnology.

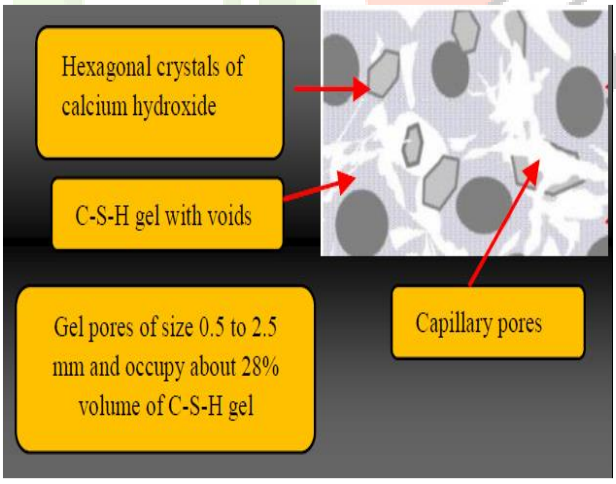

Figure 1: microstructure of cement paste

Nanomaterial: Global market and use in construction industries.

Nano Materials will have a greater impact in the near term on the construction industry than any other industrial sector (Mishra et al, 2011). In fact, the application potential of nano materials in construction is high and involves almost all technical fields of this industry (Ganesh, 2012 and Firoozi et al, 2014, Markna, et al,2017).

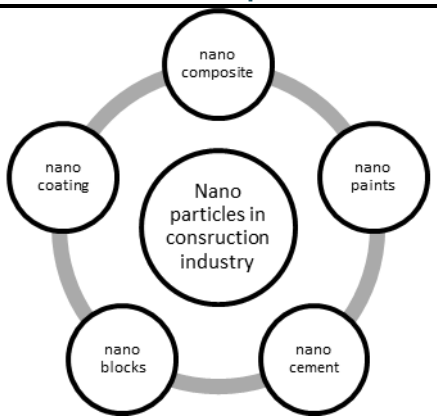

Figure 2: field application of nano particles in construction industries

The growth of the global nanomaterial market between 2000-2015 is about 120% & 2015-2021 shows a remarkable increase, mainly explained by the commercialization of nanomaterials, such as nanotubes and nanoparticle, increase in research projects in recent years [McWilliams, 2010].

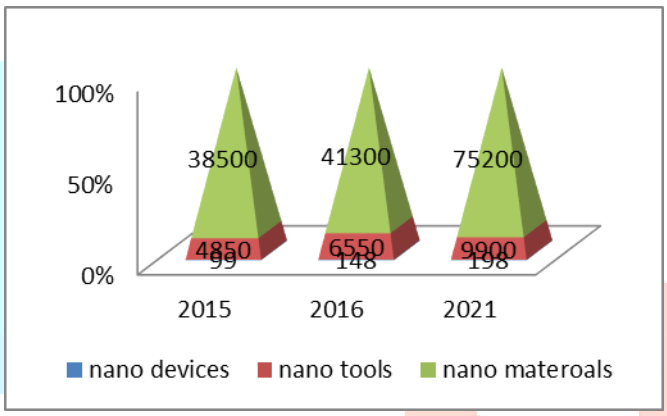

Figure 3: global nanomaterial market: 2015 -2021

II. Preparation of mix (Bureau of Indian Standards, 2009):

For the present analysis work M25 grade of concrete was prepared and concrete mix design was done as per BIS: 10262:2009. Major ingredient of concrete i.e. cement was replaced by nano carbon black with 5%, 10% & 15%. For each sample set 15 cubes were casted. Mix proportion of different mixes are shown below in table no -1

Table 1: percentage replacement

sample set	cement, kg	sand, kg	aggregate, kg		water, kg	carbon black, kg
			20 mm	10 mm		
0%	21.69	53.82	39.53	26.34	10.38	0
5%	20.60	53.82	39.53	26.34	10.38	1.08
10%	19.52	53.82	39.53	26.34	10.38	2.17
15%	18.43	53.82	39.53	26.34	10.38	3.25

III. Experimental work:

1. Compressive strength test:

The compressive strength of 4 sample set was obtained and its comparison is shown in figure 4. Concrete cube sample set were tested after 7, 14 and 18 days curing and remarkable value of compressive strength was obtained in 15% replacement sample set compare to other sample sets.

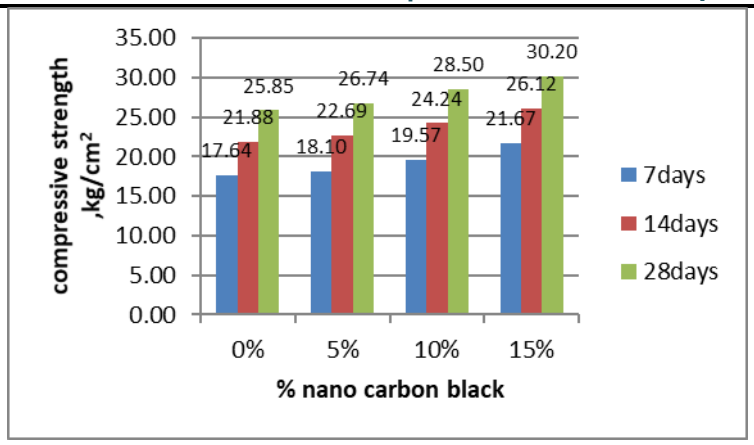

Figure 4: compressive strength analysis

2. SEM analysis :

The distribution and formation of hydrated product of hydrated cement past for all the sample sets are pictured as below. For the entire sample sets microstructure was studied and compared with normal sample set in terms of unhydrated cement particles present, growth and distribution of C-S-H gel, voids present, formation and growth of niddle like structure. The reason behind the strength of concrete was analyzed based upon the study of growth of hydration product at microstructure in concrete samples.

Sample set 1: 0% nano carbon black

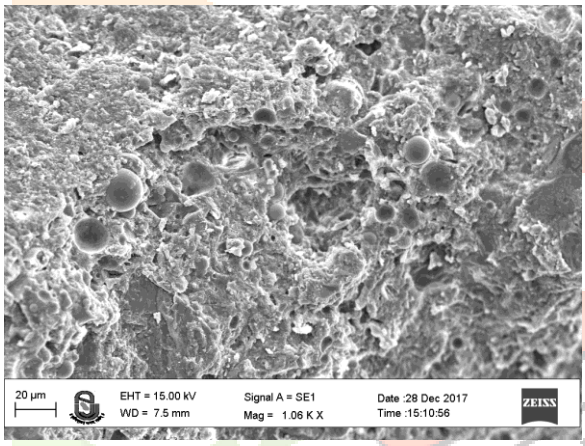

Figure 5: SEM image of 0% sample

From the figure 5 which show the SEM image of concrete sample set with 0% nano carbon black at age of 150 days the following observations are concluded.

1. Unhydrated cement particles are observed in sample, which indicates that hydration process is not reached to desired level in concrete.
2. Formation of by product like calcium hydroxide does not react with any other elements in concrete which restricts formation of additional C-S-H gel.
3. Unequal spreading of C-S-H gel is observed.
4. Voids are clearly visible which indicates porous concrete.
5. Formation of niddle like structure is not visible in sample.

Sample set 2: 5 % nano carbon black

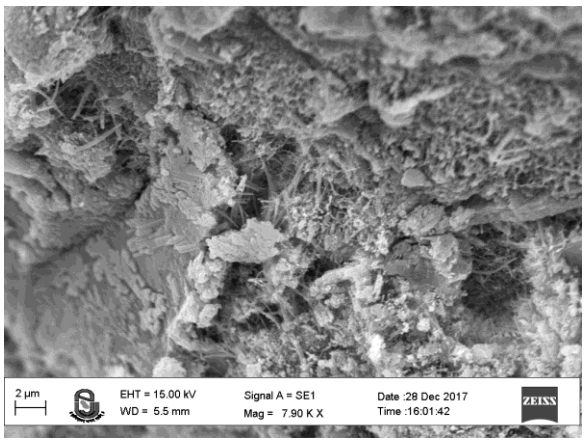

Figure 6: SEM image of 5% sample

The figure 6 shows the SEM image of concrete sample with 5 % nano carbon black at age of 150 days. After SEM images analysis it is come to know that,

1. Micro / nano structure of concrete is different than normal concrete mix.
2. Dancer cement past is observed in sample which indicates good rate of hydration and less amount of unhydrated cement particle.
3. Addition of nano carbon black composite helps to modify micro / nano structure of concrete.
4. Evenly spread C-S-H gel formation is observed which gives more compressive strength value to concrete compare to sample set-1.
5. Formation of niddle like structure is observed.

Sample set 3: 10 % nano carbon black

Figure 7: SEM image of 10% sample

The figure 7 shows the SEM image of concrete sample with 10 % nano carbon black at age of 150 days The following observations in terms of unhydrated cement particles, voids present and formation of C-S-H gel are.....

1. Formation of by products like calcium hydroxide is very less due to chemical reaction with nano composite.
2. More C-S-H gel formation with evenly distribution in sample is observed.
3. Very less not of voids are present which indicates modification in micro / nano structure of concrete due to pore filling effects of nano material.
4. Large and more growth of niddle like hydrated structure is observed.

Sample set 4: 15 % nano carbon black

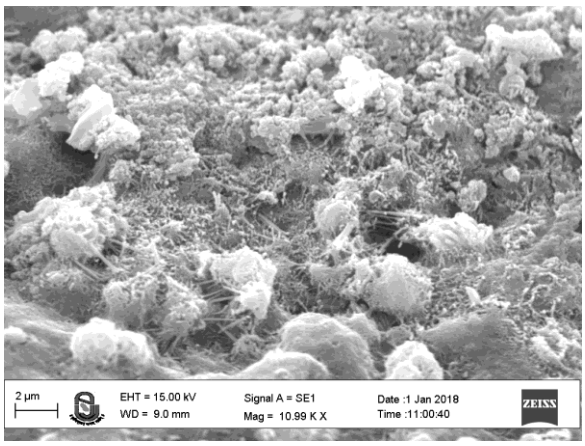

Figure 8: SEM image of 15% sample

The figure 8 shows the SEM image of concrete sample with 5 % nano carbon black at age of 120 days The following observations in terms of unhydrated cement particles, voids present and formation of C-S-H gel are.....

1. From the scanning electron microscope (SEM) analysis It was observed that very denser microstructure with lower porosity was obtained.
2. Nano-particles improved the hydration reaction, act as a filler material, and thus improved microstructure when the nanoparticles uniformly distributed.
3. The nano-particles of enormously small size could fill up the voids in the paste and improves the strength of concrete compare to other sample sets.
4. Denser growth of C-S-H gel is observed in the sample compare to 0%, 5% and 10% concrete sample, which indicates that strength phase is excellent.
5. Uniformly & Heavy Growth of Needle like structure is observed in sample.

IV. Discussion:

The addition of Nano carbon black helps to alter the behaviour of microstructure of concrete and also the microstructural behaviour of concrete influences the strength characteristics of the mix. The addition of cost-effective materials such as nano carbon black changed the behaviour of microstructure of concrete and also impact positively on the compressive strength of concrete mixes. From the test results of compressive strength, it was observed that replacement of cement with nano carbon black fairly improves on the strength of concrete mixes. The strength of sample set 4 was highest among all samples.

From SEM result analysis, the existence of mineral elements and their reactions with the nano carbon black is studied which gives an opportunity to understand the microstructure of the concrete mixes. From scrutiny of the microstructure of concrete mixes, it is clear that the hydration process in the mixes with supplementary materials was different from conventional concrete mix. In sample set 4 the hydration process was quiet similar to the normal concrete mix but, the development of C-S-H gel in the mix was quiet higher compared to the normal concrete mix.

V. Conclusion:

Findings of the present research work are as follow:

1. Addition of nano carbon black act as pore filler in concrete which makes concrete more dancer and homogeneous.
2. The compressive strength test results indicate that increase in compressive strength of concrete is achieved due to addition of a nano carbon black. The maximum increase in compressive strength was observed in 15% replacement of cement.
3. SEM and EDX analysis indicates that nano carbon black not only act as filler material it also enhance hydration process thus improve microstructure of concrete.
4. Nano carbon black reacts with Ca $(OH)_2$ which forms additional C-S-H gel, leads to increase in compressive strength of concrete.

VI. Acknowledgment

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