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Effect of addition of Multiwalled Carbon nanotube (CNT) on Sorptivity, water absorption and impact energy of Self Compacting Concrete (SCC)

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ABSTRACT - ***Self compacting concrete (SCC) is a versatile concrete which doesn't required any vibration or tamping compaction and has great ability to flow and reach the farthest corner or within congested reinforcement while casting an RCC member like beam, column and slab. Recent technological advancement in nano materials as well as increasing popularity of SCC has urged the researchers to study the use of nano materials in concrete. Carbon nanotube imparts massive changes in material's strengths and durability. In this paper an attempt is made to investigate the effect of addition of carbon nanotube (CNT) in Self Compacting concrete such as durability. To achieve this, CNT dosage from 0 to 0.75% by weight of cement in the increment of 0.25% are incorporated and fresh as well as hardened concrete test derived from above is tested. For durability aspect water permeability, Sorptivity and impact resistance are performed and analyze. The results revealed that SCC derived with 0.75% CNT by weight of cement shows significant improvement on its durability in terms of reduction in water absorption, less capillary action in Sorptivity and reduced impact energy absorbed as compared to normal SCC.***

Key words: Self Compacting Concrete (SCC), Carbon Nanotube (CNT), Durability of concrete, Water absorption, Sorptivity, Impact test.

I. INTRODUCTION

A. Self compacting concrete:-

Self-compacting concrete (SCC) is a newly concrete which do not require vibration for setting and compaction.
SCC was created by Japanese engineers in 1980 to reach durable concrete by using viscous modifier material as admixture, which is responsible for exceedingly workable concrete. Such a concrete can flow in its own particular weight through confined segment without any segregation and bleeding.

The VMA improves both initial and final settling time. Such a Self compacting concrete focused on superior performance, more frequent and stable quality. So SCC can be use as high performance concrete in M40 to M100 or more in grade.
For the fresh Self compacting concrete should be design in such a ways that the flow into and fill totally all spaces within the formwork by under its own particular weight (i.e. filling ability) as well as flow through hard openings such as gap between reinforcement bars without any blockage (i.e. passing ability) and also remain parallel in composition during transport and placing (i.e. segregation resistance).
For checking these factors; the tests like slump flow, L-box and U-box test should be carried out.

B. Nanotechnology:-

Nanotechnology is the department of science which is related with particle size which is less than 100 nm in size.
Generally Nano materials are available in powder form like Nano Silica, Zink oxide, Alumina and Carbon Nanotube (CNT) etc.

Figure 1 A nano silica powder (source: - nano materials.org)

In carbon nanotube mainly two types of carbon nanotube

- Single Walled Carbon nanotube (SWNTs)
- Multiwalled carbon nanotube(MWNTs)

Those materials can used to progress the durability.

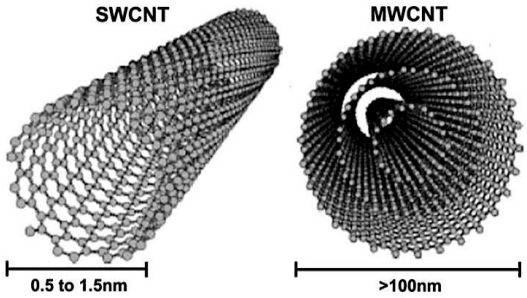


Figure 2 Single walled carbon nanotubes (SWNTS) & Multiwalled Carbon Nanotubes.

CNTs have special properties of high amount Young's modulus, strength, density as shown in table 1. Due to this versatility of CNT, can improves the strength, durability, life of structure etc.

Table 1: Comparison of physical properties of CNT with Mild Steel

Properties	CNT	STEEL
Young's modulus (GPa)	1200	208
Tensile Strength (GPa)	150	0.4
Density (Kg/m^3)	2600	7800

Charul Dudani(2018)& Dinesh A. et al(2017) reviews various nano material used in SCC. Most of the analysts have utilized CNT, Nano TiO_2 & Nano Silica in addition with cemntitious paste to improve its properties. When Nano silica and fly ash remains is included to concrete then from the experimental outcomes, compressive strength reduces with the raise in level of fly ash & increases with the increment in sum of silica glue and also increase in workability with respect to change in the proportion of the silica fume and fly ash. With change in cement ratio, the tests like split tensile test they improves compressive strength by 8%, 5% and 3% respectively.[**Javier puenets et al(2015)]**reviewed the progression of conduct due to expansion of nano silica and carbon nano fibers in SCC. The objective was to distinguish at early age in the hardened form because of consideration of nano-size components. **LingshiMeng et al(2016)]**Additionally studied the impact of MWCNTs on the absorption properties and strength of polymer latex-altered cement mortar. After investigation and outcomes extensive increment of compressive quality and flexural strength, also improvement in durability, by the expansion of MWCNTs-COOH. With using of SEM conducted on both the latex arrangement and cement composite, the micro structural came about as a outcome because of MWCNT expansion are uncovered They observed that the expansion of 6% wt. PVA latex somewhat decayed the absorption property of plain mortar and concrete by generally 4% and 6% respectively.In a study [**Qasimali I. et al (2017)]** found SSC's strength using different dosage of MWCNTs & compare with normal SCC with the help of different tests, in that research increase in compressive strength, split tensile test and flexural strength approximately by 30% , 40% and 32% respectively.In current research of [**Quingha Li et al(2015)**]exercises and key advances on MWCNTs strengthen cementitious composites are outlined, including the impact of material(MWCNTs) on modulus of flexibility, porosity, crack and physical and micro structural properties of concrete they also conclude that MWCNTs influence the hydration procedure of cement by giving connection locales to the C–S–H gels which goes about as filler bringing about a higher strength and denser microstructure of framework.[**Rameeja et al(2015)]** refers that Nanotechnology offers immense measures of improvement in the structural building field. It has enhanced the quality and fathomed numerous issues with building materials, for example, cement and steel.**[Riahi et al(2017)]**As strength assessments and the level of water retention of SCC containing GGBFS and Al_2O_3/TiO_2/SiO_2nanoparticles as binder have been investigated they also investigated that these materials reduces the workability, so it adjusted by super plasticizers.**[Veerendar kumar et al(2016)]**found Sometimes the Fly ash improved workability of self compacting mortar but at higher volume replacements the compression at 28 days has extremely reduced & increase in nano silica which improves the compressive strength of Self compacting mortar.**[Yanpeng wang et al(2017)]**saw that effective scattering of two distinctive measurement of MWCNTs dosages in water were refined by implementing ultrasonic vitality and in blend with the utilization of a

surfactant.**[Zoran Grdić et al(2008)]** investigated The silica fume, a more costly added substance, grants in the SCC a similar behavior to the one of normal concrete compacted by vibrations. It is caused by a logical inconsistency between silica rage and super plasticizer requiring an in expansion of w/c proportion for the similar concrete workability.

II. Experimental Setup

Material usage

Cement:-the cement used for current work was an ordinary Portland cement of 53 grade.
Coarse Aggregates:-The aggregates are parts in two types i.e. type-a (having size up to 20mm) and type-b (having size up to 10mm)
Fine aggregates:-The Bhogavo river sand was used as fine aggregate. (Having fineness modulus 2.82)
Admixtures: - Class F grade and low calcium content fly ash was used.
Multiwalled Carbon nanotube properties are as shown in table 2;

Table 2 : Properties of MWCNTs

Property	Value
Diameter	20-40 nm
Length	5-15 µm
Purity	98%
Specific surface area	>150 m^3/gm
Bulk density	0.27 gm/cm^3

Mix design

The mix design was done by according to EFNARC specifications.
The quantities of different materials are as shown in table 3;
For 1m^3

Table 3 : Mix Design

Grade	Cement in Kg	Coarse aggregate(type-a) Kg	Coarse aggregate(type-b) Kg	Fine aggregates in Kg	Fly ash in Kg	Super plasticizer in ml	Water in lit.
M40	400	320	480	800	180	500	189

The adoptable dosages of MWCNTs are in table 4;

Table 4

Mix design	MWCNT dosage % of cement content
SCC 0	0
SCC 0.25	0.25
SCC 0.5	0.5
SCC 0.75	0.75

III. Test for fresh concrete

According to EFNARC the SCC should be in filling ability, passing ability and segregation resistance. For that slump flow test, L-box test and V-funnel test was carried out. Here fig.3 shows the slump flow test and table 5 shows the flow value which is satisfies as per EFNARC.

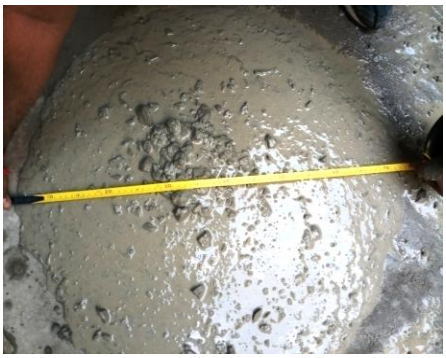


Figure 3 Slump flow of SCC

Table 5 : Slump Flow Test

Mix	EFNARC's Specified flow value(in mm)	Flow value(in mm)
SCC 0	650-850	700
SCC 0.25	650-850	660
SCC 0.5	650-850	680
SCC 0.75	650-850	750

IV. Test for hardened concrete

A. Compressive strength

The test result was calculated at 7and 28 days of curing period with the CNT dosage of 0%, 0.25%, 0.5% and 0.75% in standard cube mould.

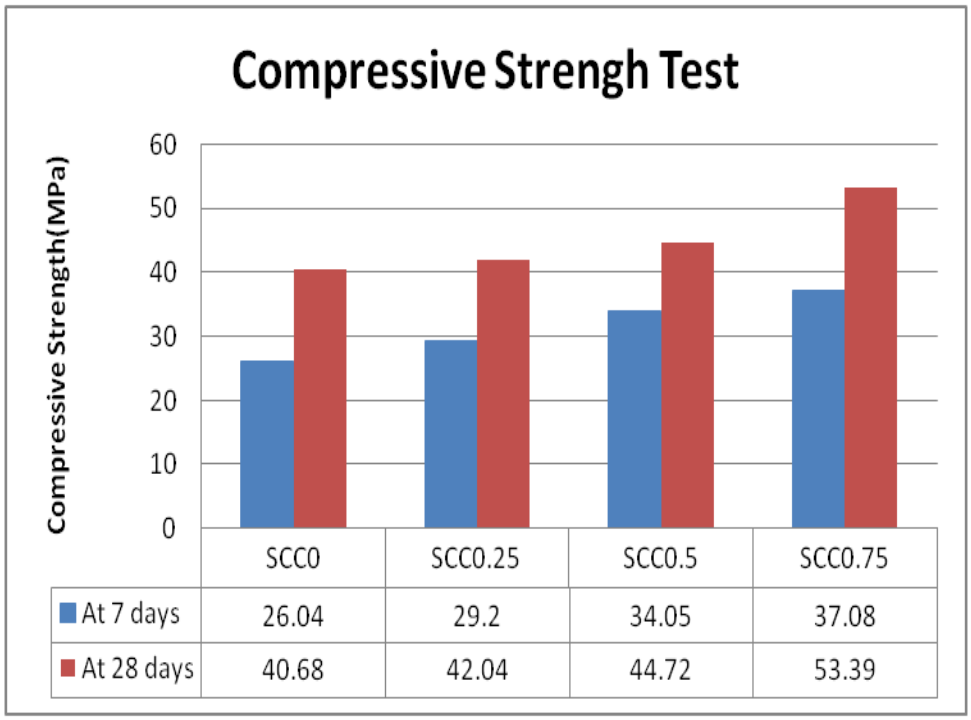


Figure 4: compressive strength of various Mix Designs

B. Split Tensile Strength

The test result was calculated at 28 days of curing period with the CNT dosage of 0%, 0.25%, 0.5% and 0.75% in standard cylinder mould.

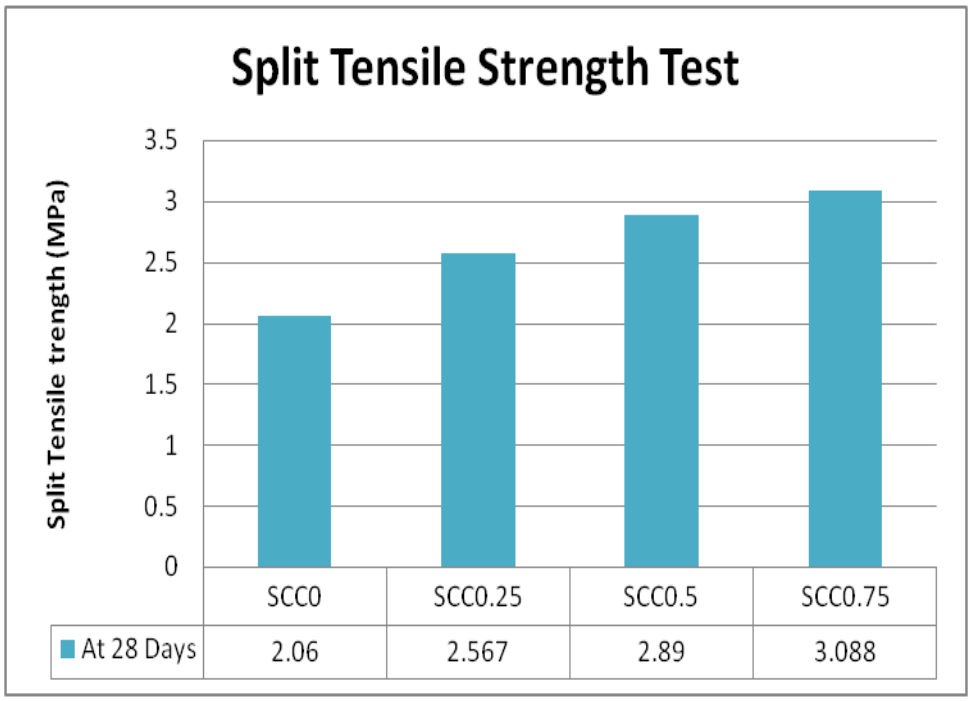


Figure 5 : Split tensile strength of various Mix Designs

C. Water Absorption

Water absorption is utilized to decide the measure of water retained under determined conditions. For this test 15cm X 15cm X 15cm size for 0%, 0.25%, 0.5% and 0.75% dosages of MWCNTs.

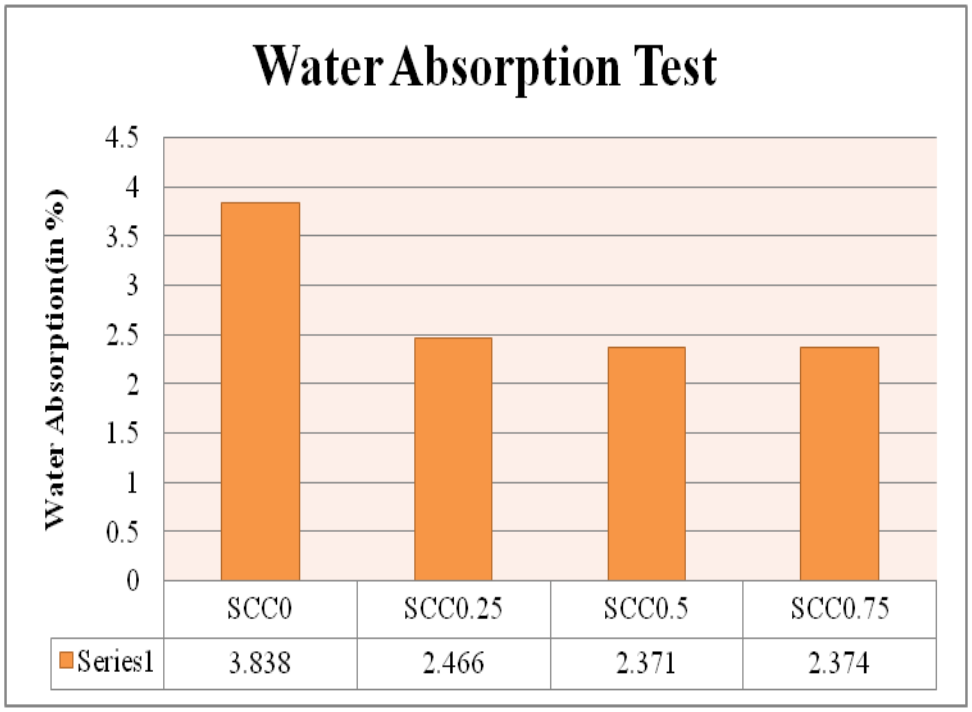
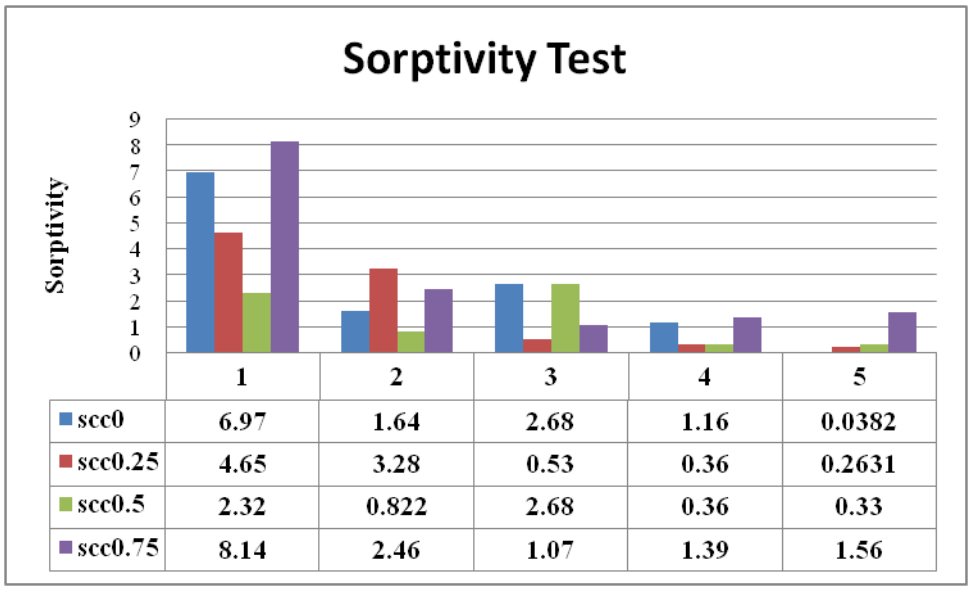


Figure 6 : Water Absorption of various Mix Designs

D. Sorptivity

Sorptivity test shows the capillary action in Concrete specimen as per ASTM1585-04.



	1	2	3	4	5
scc0	6.97	1.64	2.68	1.16	0.0382
scc0.25	4.65	3.28	0.53	0.36	0.2631
scc0.5	2.32	0.822	2.68	0.36	0.33
scc0.75	8.14	2.46	1.07	1.39	1.56

Figure 7 : Sorptivity of various Mix Design

E. Impact Test

Impact test shows the impact energy in concrete specimen as per ASTM C1747.

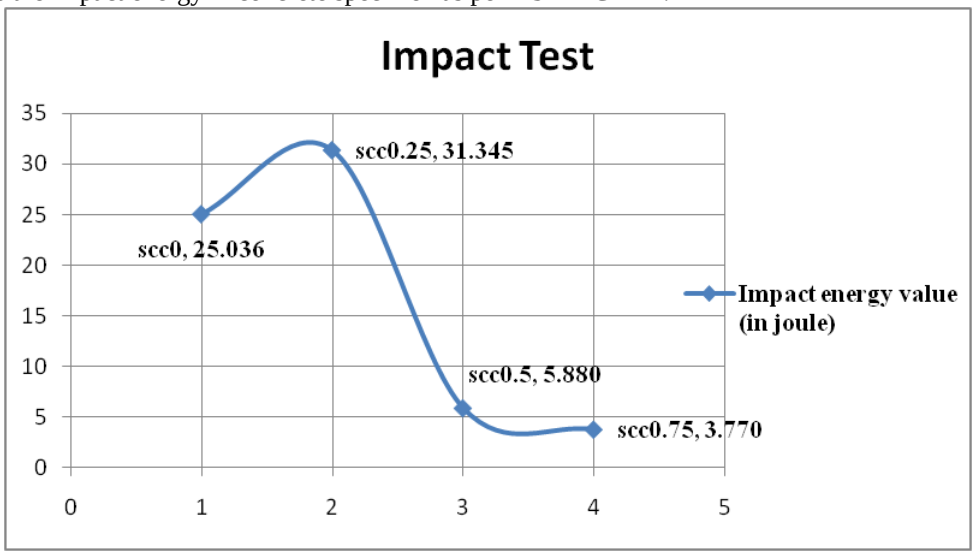


Figure 8 : Impact test of various Mix Design

V. Conclusion

From the different tests concluding that;

- The compressive strength increases around 56% and 35% at 7 and 28 days respectively.
- The split tensile strength increases around 50% after 28 days.
- The water absorption reduces around 38% after 28 days.
- Capillary action reducing 56.67% at optimum CNT dosage in Mix SCC at 28 days.
- Increase in carbon content reduced the impact energy and make brittle.

VI. Discussion

From the above results, the effect of addition of Multiwalled carbon nanotube could be concluded that increase in dosage of carbon nanotube can improve the strength (compressive, split tensile) and also reduces the water absorption. In microstructure, the pores are filled by CNT that can be shows that the capillary action has been reducing in Sorptivity test. Also increasing CNT dosage in SCC makes brittle material and less soaks the impact energy.

VII. Acknowledgement

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