High Strength Fiber Reinforced Concrete Replacement of Cement as GGBFS with Addition of Carbon Nanotubes

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Abstract— This experiment investigates the effect of Multiwalled Carbon Nanotubes (MWCNT) on Mechanical properties of High Strength Concrete with addition of 0.1% Basalt Fiber and GGBFS of proportion 0%, 10%, 20%. Concrete were made with 0.01% of functionalized MWCNTs produced by chemical vapour deposition (CVD) method and water to Cement ratios of 0.35 – 0.55. The main aim of this experiment is to identify the enhancement in the mechanical properties with the use of MWCNT. The results shows that the MWCNT can be an effective means to improve the mechanical properties. Specimens which undergone curing gained high strength with gradual increase on 7 and 28 days. The highest strength for compressive, flexural, split tensile is achieved with the proportion of 20 % GGBFS, 0.1 % Basalt Fiber, 0.01% of MWCNT.

Indexed Terms-- Basalt fiber, Carbon Nanotube, GGBFS, OPC

I. INTRODUCTION

Concrete is a composite material which compose of cement, fine aggregate, coarse aggregate and water. In recent days no construction activity has been imagined without using concrete. Concrete is essentially used building material in the construction industry. The main reason is high strength and durability. The probable application of industrial product in concrete are as partial replacement and as partial cement replacement, depending upon their grain size and chemical composition of material. The use of such materials in concrete to reduce the environmental pollution. These investigations try to satisfy the social needs for safe and economic construction with waste materials, which needs enhance and cost-effective materials. Throughout the Carbon nanotubes including the concrete industry, the cost of environmental compliances is high. Use of industrial by products such as foundry sand, fly ash, bottom ash and slag can result in significant improvement in overall industry energy efficiency and environmental performance.

II. EXPERIMENTAL STUDY

2.1 Materials

The High strength concrete consist of raw material of Ordinary Portland cement. The funtionalized multi-walled Carbon Nanotubes were collected from Ad Nano technology Pvt Ltd, Karnataka. The powdered form multi-walled CNT were difficult disperse in aqueous solution hence it is suspended using Ultrasonification process. The multi-Walled Carbon Nanotubes were of diameter varies from 0.4 – 40 nm. These Carbon Nanotubes were typically made of graphene. The major components of CNT consist of carbon. In early days, CNTs are manufactured using plasma arcing. For producing small amount of CNT this plasma arching method is used by passing electric current in inert atmosphere. At those days CVD process has not advanced enough to produce CNT. Carbon Nanotubes are said to be hundred times stronger than Steel. These CNTs are measured in nano scale because of its very small size it can be used as a good filling material in concrete. CNT as filling material gives very large aspect ratio as it increases mechanical properties. The other properties of CNT is it great conductor of heat and electricity. CNTs are of two types. If the Graphene are rolled in a single sheet it is called single walled carbon nanotube. If Graphene are rolled in a multiple layers then it is called as Multiwalled Carbon Nanotubes. The properties of Multiwalled Carbon Nanotube are mentioned in Table1

Table 1
Few specifications of Muilt-Wall Carbon Nanotubes before dispersion,

Diameter (nm)	Length(μm)	Density(g/m^3)	Specific Surface Area(m^2/g)
4 – 40	0.1 – 7	150	180

The Ground granulated basalt furnace slag (GGBFS) is collected from JSW steel plant, Salem. The basalt furnace slag is a by-product of the iron manufacturing industry. The molten slag has a composition of about 30% to 40% Sio2 and about 40% Cao, which is close to the chemical composition of Portland cement. The Properties of GGBFS are mentioned in Table 2

Table 2
Properties of Ground granulated basalt furnace slag (GGBFS),

Specific Gravity	Bulk density(g/cc)	MDD (g/cc)	Optimum Moisture Content (%)
2.8	1.8	2.56	19

The Basalt fiber is a unique product derived from basalt rock, a natural material that is found in a volcanic rocks originated from frozen lava. In ancient times it has been used as a crushed rock in construction site as the rock itself is extremely hard. This rock has excellent strength, durability, and thermal properties. These fibers are manufactured as chopped fibers and continuous fibers. Basalt fiber has good resistance to chemical attack and in seawater environment. The Properties of Basalt Fiber are mentioned in Table 3. The fibers are created by melting the basalt rock between 1500 and 1700 ^{o}C and forcing it in platinum crucible bushings.

Table 3
Properties of Basalt Fiber,

Elastic modulus (GPa)	Bulk density(g/cc)	Porosity (%)	OMC (%)
89	2.7 – 3.3	1.28	10

2.2 Mix compositions, specimen preparation and test procedures

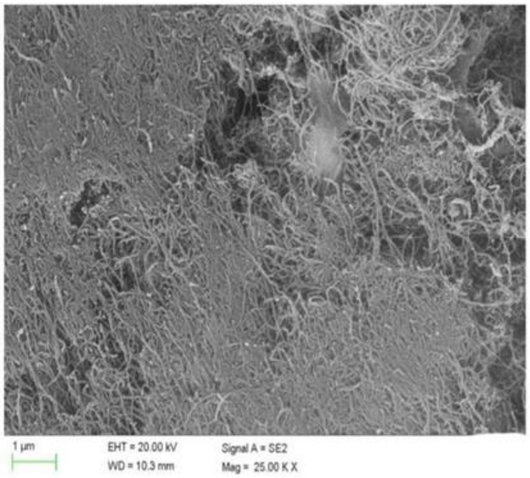
To identify the strength criteria the flexural test, Split tensile test and compressive test were taken. The mix proportion consist of 0.01 % of CNT, 0.1 % of basalt fiber and 10 %, 20 % of GGBFS by the weight of cement were used. The mix Proportion were listed in Table 4. For the compressive test 150mm X 150mm X 150mm cube were taken. The fresh concrete test like slump cone test and compaction factor test is done as per IS:1199-2018. The concrete is poured in the cube and well compacted. The compressive strength values can be calculated as per IS:516- Part 1. For flexural strength test (40 X 40 X 160 mm^3) samples were taken. The samples after water curing at 7 days and 28 days were tested using two point load. Then the flexural strength values are calculated as per IS :516 –Part 1.

Table 4
Mix Proportion

Mix	GGBFS %	Basalt Fiber %	CNT %
NC	0	0	0
M1	10	0.1	0.01
M2	20	0.1	0.01

For Split Tensile strength test cylindrical mold of 150 X 300 mm^2 were casted and test results for 7days and 28 days were taken and values are calculated. Initially, ordinary Portland cement and GGBFS are blended using a mixer for about 5 minutes with different proportion of 10 % and 20% along with the basalt fiber. Carbon Nanotubes that is activated using Ultrasonification is then added to the dry mixture and mixed for about 10 minutes. Then water is added to the dry concrete mixed thoroughly and the fresh concrete tests were conducted. Then the concrete is molded in cubes, cylinders and prism. After 24 hours specimens are demolded and it has been water cured till the test for 7 days and 28 days are conducted.

A Scanning electron microscope (SEM) analysis was conducted to identify the dispersion and shape of the Carbon Nanotubes in the High strength Concrete. From the SEM analysis it is concluded that the CNTs are well dispersed and the shape is of tubular.



III. RESULTS AND DISCUSSION

3.1. General
Samples of each and every constituent materials are tested in laboratory for their physical and Mechanical properties. This results of various tests conducted are presented. The Fresh and harden concrete tests are conducted as per Indian Standard codal provisions. The description of various materials used for the investigation is given below.

3.2 Fresh concrete Properties
3.2.1 Workability test result
Table 5 shows the slump cone and compaction factor values of the fresh concrete test with addition of 20% and 10% of GGBFS, 0.1% of Basalt fiber, 0.01% of CNT in concrete.

Table 5: Workability test results for GGBFS 0%, 10%& 20%, Basalt Fiber 0.1%, CNT 0.01%

Mix	GGBFS %	Basalt Fiber %	CNT %	Slump	Compaction factor
NC	0	0	0.01	250	0.8
M1	10	0.1	0.01	257	0.82
M2	20	0.1	0.01	260	0.85

3.3 Hardened concrete properties

3.3.1 Compressive strength
Table 6 shows the effect of compressive strength of concrete with addition of 0%, 10%, 20% GGBFS, 0.1% Basalt Fiber and 0.01% Carbon Nanotube in concrete. Addition of GGBFS, Basalt Fiber and Carbon Nanotube in concrete is similarly increases the compressive strength of concrete like previous mix proportions.

Table 6: Compressive strength for 7days and 28days with 0%, 10% and 20% GGBFS, 0.1% Basalt Fiber, 0.01% CNT (N/mm^2)

Mix	GGBFS%	Basalt Fiber%	CNT %	7 Days	28 Days
NC	0	0	0	29.02	35.63
M1	10	0.1	0.01	31.56	37.81
M2	20	0.1	0.01	34.93	43.73

3.3.2 Split tensile Strength
Table 7 shows the effect of split tensile strength of concrete with addition of 0%, 10%, 20% GGBFS, 0.1% Basalt Fiber and 0.01% Carbon Nanotube in concrete. In this table, split tensile strength of concrete is calculated in 7 days, and 28 days. Specimens which undergone curing gained high split tensile strength with gradual increases on 7 and 28 days.

Table 7: Split Tensile Strength for 7days and 28days with 0%, 10% and 20% GGBFS, 0.1% Basalt Fiber, 0.01% CNT (N/mm^2)

Mix	GGBFS%	Basalt Fiber%	CNT%	7 Days	28 Days
NC	0	0	0	2.58	2.61
M1	10	0.1	0.01	2.27	2.44
M2	20	0.1	0.01	3	3.32

3.3.3 Flexural Strength
Table 8 shows the effect of flexural strength of concrete with addition of 0%, 10%, 20% GGBFS, 0.1% Basalt Fiber and 0.01% Carbon Nanotube in concrete. In this table, flexural strength of concrete is calculated in 7 days and 28 days. Specimens which undergone curing gained high split tensile strength with gradual increases on 7 and 28 days.

Table 8 Flexural Strength for 7days and 28days with 0%, 10% and 20% GGBFS, 0.1% Basalt Fiber, 0.01% CNT (N/mm^2)

Mix	GGBFS %	Basalt Fiber%	CNT%	7 Days	28 Days
NC	0	0	0	3.79	5
M1	10	0.1	0.01	4.01	5.25

M2	20	0.1	0.01	4.5	5.78

CONCLUSION

The following conclusions are made from the various experimental and durability studies were conducted on concrete. The GGBFS is replaced and addition of Basalt Fiber, CNT. The following specimens are casted and tested at 28 days of curing period. The specimens are cubes, cylinders and prisms.

Fresh concrete Results

- The fresh concrete properties are too good but increment of GGBFS percentage it may causes the workability due to its fineness.
- The ggbfs also absorbed more water content compared to cement, it does affect the workability.
- The process of enhancing workability we adopt Basalt Fiber and CNT. In the proportions of 0.1% of Basalt fiber, 0.01% of CNT and 10% ggbfs concrete mix.

Destructive Results

- The maximum compressive strength is obtained replacement of 20% GGBFS with addition of CNT and Basalt Fiber compared to conventional concrete.
- The maximum split tensile strength is obtained replacement of 20% GGBFS with addition of CNT and Basalt Fiber compared to conventional concrete.
- The maximum flexural strength is obtained replacement of 20% GGBFS with addition of CNT and Basalt Fiber compared to conventional concrete.

RECOMMENDATION

- From this thesis it is proved that the addition of 20% GGBS, 0.01 % CNT and 0.1% of Basalt Fiber increases the overall strength by 20% as compared to conventional concrete.
- It reduces the crack formation.
- So, it is recommended that concrete with this proportion shall be used for high rise building and bridge structures.
- The main purpose is controlling the pollution in the environment.
- If the strength, characteristics and property of CNT is improved with some material like ggbfs and basalt fiber etc., it can attain its maximum strength and it is also increased in life time.

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