# Health Monitoring of Concrete

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**Abstract** – *By making use of the advancement in the Nanotechnology we provide solutions for some of the biggest and unexpected problems that occur in the structures. Nanotechnology precisely speaking of Carbon Nano-tubes can be made use in the research. Carbon Nano-tubes have vast variety of promising and exceptional properties. Here in this thesis we use those properties to make the structure to sense the danger/problems by the structure itself prior to the occurrence of fractures. The exceptional piezoresistive property of CNTs is made use and variation of this resistance w.r.t loading conditions is taken into considerations and the results are obtained efficiently. At the end we get know that CNTs provide very good results when used and the purpose is served.*

***Key Words***: **Carbon Nano-tubes, Resistance**

## 1. INTRODUCTION

Structure is an element composing of many components such as beams, columns, roofs, slabs, foundations and basements. The process of implementing a damage detection and characterization strategy for engineering structures is referred to as **Health Monitoring (HM).** The HM process involves the observation of a system over time to determine the current state of system health. HM is used for rapid condition screening and aims to provide, in near real time, reliable information regarding the integrity of the structure. Then there comes the thought of making Concrete Self-sensing i.e. monitoring the concrete.

### 1.1 Objectives

a. Uniform dispersion of multi walled carbon Nano-tubes in liquid medium.
b. To make cement/concrete matrix electrically conductive by the addition of MWCNT's.
c. To study the electrical resistivity behavior of CNT cement composite for varying load.
d. To study the mechanical properties of CNT cement/concrete composites such as compressive and flexural strength.

### 1.2 Probable outcomes

a. Enhancement in the strength and performance characteristic of concrete.
b. Decreased micro level and nano level cracks and improvement in interfacial bond.
c. This study helps to develop intelligent infrastructure with elegantly integrated sensing and health monitoring technique.

## 2. MATERIALS AND METHODOLOGY

### 2.1 Materials

OPC 53 grade cement, water, MWCNT, Sodium lauryl sulfate, copper electrodes of 7cm length and dia 2mm, fine and coarse aggregates are used.

**Table – 1:** Properties of MWCNTs

| MWCNT | Description |
|---|---|
| Production method | Chemical vapor deposition ( SLV ) |
| Available Form | Black powder |
| Diameter | Av. Outer diameter: 20nm |
| Length | Av 20μm |
| Nanotubes purity | > 98% |
| Metal Particles | < 1% |
| Amorphous carbon | < 1% |
| Specific Surface area | 330 $m^2/g$ |
| Bulk density | 0.20-0.35 $g/cm^3$ |

**Table – 2:** Properties of fine aggregates

| Tests conducted | Results |
|---|---|
| Gradation | Zone – 1 |
| Specific gravity | 2.60 |
| Water absorption | 1.8% |

**Table – 3:** Properties of coarse aggregates

| Test conducted | Results |
|---|---|
| Bulk Density | 1.49 gm/cc |
| Water absorption | 0.2% |
| Specific gravity | 2.5 |

### 2.2 Methodology

**CEMENT MORTAR**

- Cube size 70×70×70mm is used.
- Water consistency adopted is 32%, SDS of concentration 1mg/lit.
- SDS is dissolved in required quantity of water with the help of magnetic stirrer.
- Multi walled carbon nano-tubes i.e. 0.6% weight of cement is added to the SDS solution and sonicated in Ultrasonic sonicator for an hour.
- The above solution is used for preparation of cement mortar of ratio 1:3.
- Copper electrodes are placed as shown below.
- Specimen is cured.

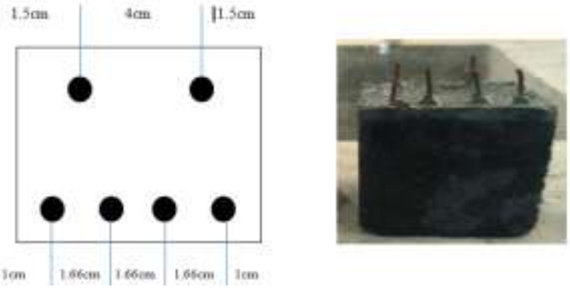



**Fig 1:** Cement mortar specimen

**BELOW SPECIMENS ARE PREPARED OF CONCTETE**

- Mix design 1: 1.79: 2.10 is adopted for $M_{35}$ grade.
- Cube size of 150×150×150mm, beam of size 500×100×100 and cylinder of length 300mm and dia 150mm are prepared without multi walled carbon nano-tubes.
- Above specimens are prepared with 0.2% MWCNT.
- These specimens are kept for curing.

## 3. TEST RESULTS

### a. ELECTROMECHANICAL TEST

- Voltage of 15V is applied to extreme electrodes and current is measured in the exterior electrodes as shown and simultaneously load is applied.
- Resistance is measured using Ohms law

**Table – 4:** Resistance values wrt to load

| Load (kg) | Voltage (volts) | Current ($10^{-3}$ A) | Resistance (ohms) $10^3$ |
|---|---|---|---|
| 1000 | 15 | 0.16 | 93.75 |
| 2000 | 15 | 0.16 | 93.75 |
| 3000 | 15 | 0.16 | 93.75 |
| 4000 | 15 | 0.16 | 93.75 |
| 5000 | 15 | 0.16 | 93.75 |
| 6000 | 15 | 0.15 | 100 |
| 7000 | 15 | 0.15 | 100 |
| 8000 | 15 | 0.14 | 107.14 |
| 9000 | 15 | 0.12 | 125 |
| 10000 | 15 | 0.12 | 125 |
| 11000 | 15 | 0.11 | 136.36 |
| 12000 | 15 | 0.10 | 150 |
| 13000 | 15 | 0.11 | 136.36 |
| 14000 | 15 | 0.13 | 115.38 |
| 15000 | 15 | 0.28 | 53.57 |
| 16000 | 15 | 0.47 | 31.9 |
| 17000 | 15 | 0.90 | 16.67 |
| 18000 | 15 | 0.90 | 16.67 |
| 19000 | 15 | 0.36 | 41.67 |
| 20000 | 15 | 0.23 | 65.21 |
| 21000 | 15 | 0.05 | 300 |
| 22000 | 15 | 0.02 | 750 |

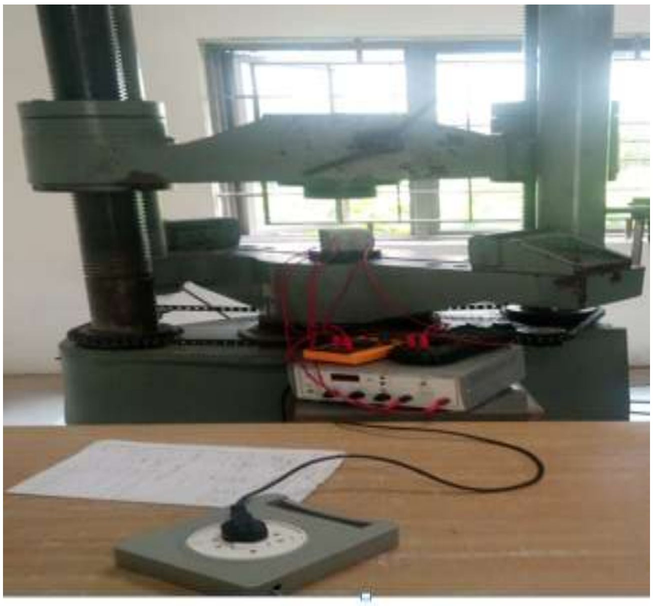
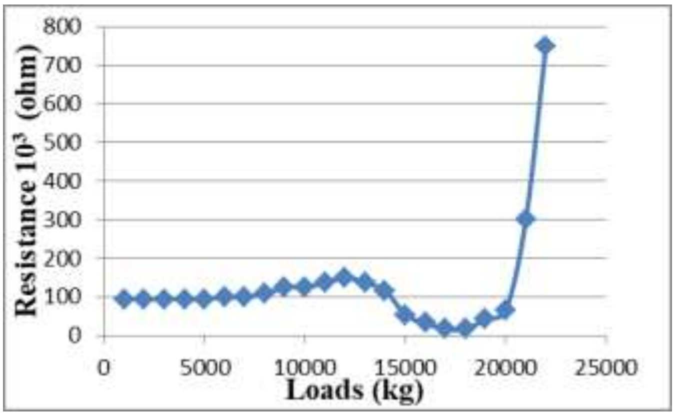


**Fig 1:** Circuit connections of cement mortar

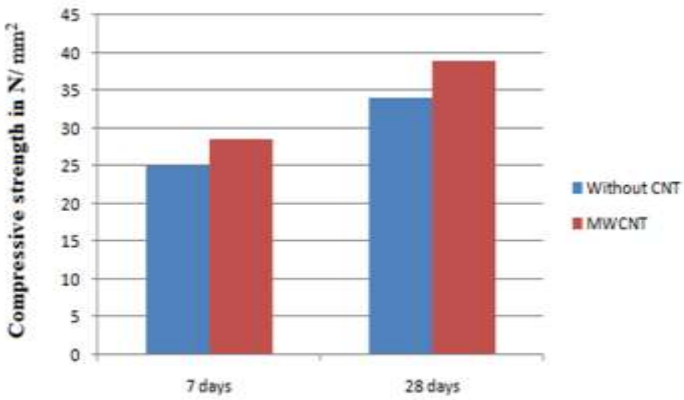



**Graph 1:** Variation of resistance wrt Load

### b. COMPRESSIVE TEST OF CONCRETE CUBE

**Table – 4:** Compressive stress

| Specimen | Compressive strength (N/mm²) | |
|---|---|---|
| | 7 Days | 28 Days |
| Without MWCNT | 25.04 N/mm² | 34.67 N/mm² |
| With MWCNT | 28.65 N/mm² | 38.84 N/mm² |

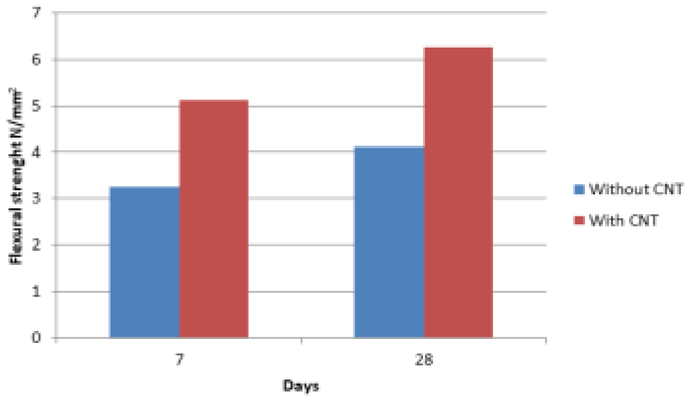



**Graph 2:** Compressive stress

### c. FLEXURAL TEST OF BEAM

**Table 5:** Flexural stress

| Specimen | Flexural strength (N/mm²) | |
|---|---|---|
| | 7 Days | 28 Days |
| Without MWCNT | 3.26 N/ mm² | 5.12 N/mm² |
| With MWCNT | 4.11 N/ mm² | 6.26 N/mm² |

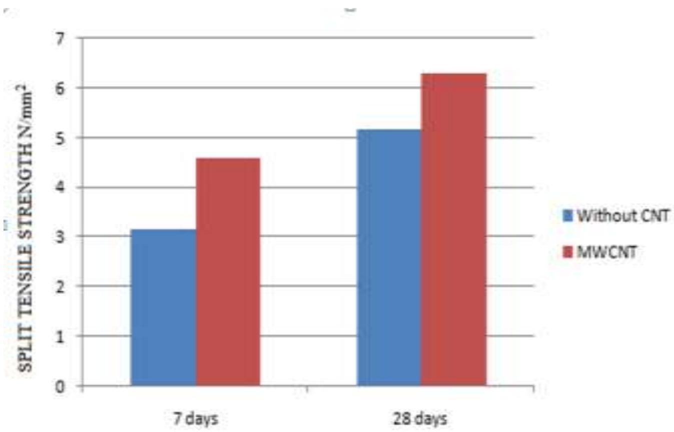



**Graph 3:** Flexural stress

### d. SPLIT TESILE TEST OF CYLINDER

**Table – 6:** Split tensile stress

| Specimen | Split tensile strength (N/mm²) | |
|---|---|---|
| | 7 Days | 28 Days |
| Without MWCNT | 3.15 N/ mm² | 5.16 N/mm² |
| With MWCNT | 4.60 N/ mm² | 6.30 N/mm² |




**Graph 4:** Split tensile stress

## 3. CONCLUSIONS

- Compressive strength of concrete with carbon nanotubes is 14.41% greater comparing to the conventional concrete.
- Flexural strength of concrete with carbon nanotubes is 22.26% greater comparing to the conventional concrete.
- Split tensile strength of concrete with carbon nanotubes is 22.091% greater comparing to the conventional concrete.

- Micro cracks can be detected; hence people can be evacuated safely before failure.

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