Implementation of Deicing Technology in Concrete using Conductive Materials

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Abstract

This paper discuss about the removal of ice or snow formation from the pavements, airport runways, parking garages and the building roof etc..,. Through the de-Icing concrete the conventional concrete containing a certain amount of electrically conductive components (steel scraps, graphite powder and copper mesh) to induce electrical conductivity in concrete and generate heat for melting the ice or snow on the surfaces by using this concrete.
Keywords- Deicing, Graphite Powder, Copper Mesh, Conductive

I. INTRODUCTION

Snow formation on roads, bridge decks, parking garages and airport runways has always been an arduous problems. There are number of conventional ways for removing ice from pavements such as plowing, chemical treatment, natural melting and laser treatments. Plowing will not alone be efficient due to the strong bonding between ice and pavements. The use of chemicals and salts are efficient but it corrodes the reinforcing steel in the concrete and damages the concrete pavement. This problem is significant to transportation and public works. Which affect the public in their day to day life.

The Normal concrete is Insulator. The electrical resistivity of conventional concrete ranges between 6.54-11Ωm. In cement paste the electrical resistivity is ranges between 0.25-0.35Ωm.

To overcome this problem conductive concrete can be used for deicing. It is the conventional concrete containing a certain amount of electrically conductive components (steel scraps, graphite powder and copper mesh) to induce electrical conductivity in concrete. Due to the electrical resistivity in the concrete, its generates enough heat to prevent ice formation on pavements when connected to power source.

II. PRINCIPLE

The principle in this concrete is to bind the electrically conductive materials such as steel fibers and graphite powder using cement, to achieve uninterrupted 'electrical percolation' through the concrete specimen. It's based on the flow of electrons through the composite constituents in the concrete which increases the conductivity until it reaches critical threshold value and due to the electrical resistivity of the concrete the heat is gradually generated and de-icing is done. The assurance of high electrical conductivity, mechanical strength and good mixing condition for the specific amount just over the threshold content is designed.

III. METHODOLOGY

De-Icing concrete mixture composite of cement, water, aggregate and conductive materials. Conductive materials used are waste steel fibers and graphite powder (40µm) is added in the concrete mixer of about total 20%-25% by weight. Graphite powder is added about 5% by the weight of cement and the waste steel fibers of about 15%-20% by the weight of aggregate. Then de-icing concrete mixer is prepared and casted for testing it on compressive strength and tensile strength.

From the compressive and tensile strength results a suitable percentage of conductive materials to be added will be finalized. Afterwards a rectangular slab of 1' x 1'6" is casted with copper mesh placed in between to supply electrical power through the slab. After curing periods it is tested on electrical conduction and De-Icing.

IV. EXPERIMENTAL

A. Mix Design

The design formulation is based on the IS CODE 10262:1982 for M30 grade of concrete (Fck=30Mpa). Water cement ratio calculated is 0.45.the mix ratio for M30 is (1:1.1:3.5) which contains steel fibers and graphite powder with concrete mix of about total 20% by weight.

B. Fresh Concrete Test

The workability tests were taken as per IS CODE 456:2000.The tests conducted are slump cone test and flow table test. The test results satisfied the water cement ratio 0.45 which was calculated from Mix design using IS CODE 10262:1982.

C. Hardened Concrete Test

As per IS CODE 456:2000 the hardened concrete test for compressive strength and tensile strength were taken. Results are given below.

Table 1: Compressive strength for 20% and 25% of conductive materials added in concrete

Percentage of Materials Added	*Specimen*	*7days*	*14 Days*	*28 Days*
		Strength (N/Mm2)	*Strength (N/Mm2)*	*Strength (N/Mm2)*
20%	*Cube*	*18.554*	*25.108*	*28.231*
25%	*Cube*	*15.055*	*21.581*	*26.42*

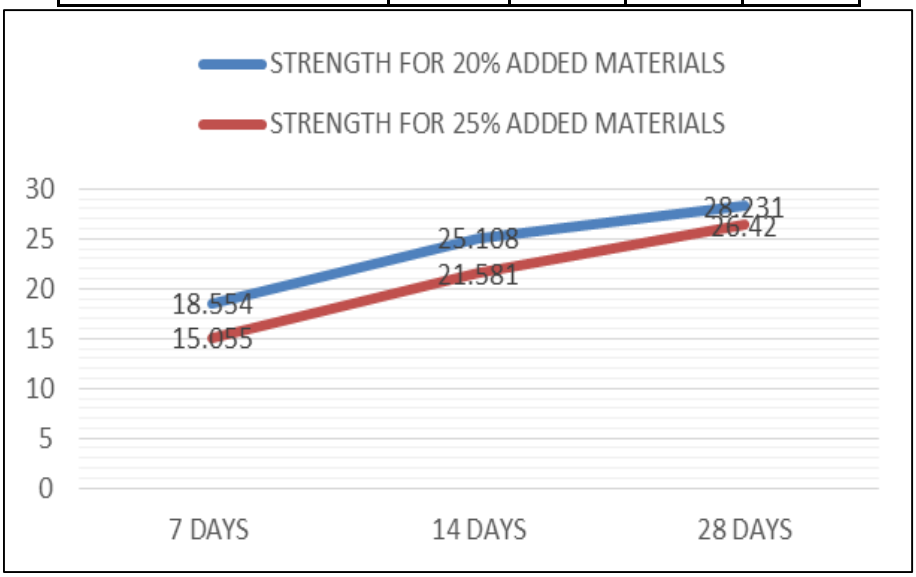

Fig. 1: Graphical representation of compressive strength of concrete specimens

Fig. 2: (compression testing on cube specimen)

Table 2: Tensile strength for 20% and 25% of conductive materials added in concrete

Percentage of Materials Added	*Specimen*	*7days*	*14 Days*	*28 Days*
		Strength (N/Mm^2)	*Strength (N/Mm^2)*	*Strength (N/Mm^2)*
20%	*Cylinder*	*2.50*	*3.451*	*4.50*
25%	*Cylinder*	*2.33*	*2.96*	*3.96*

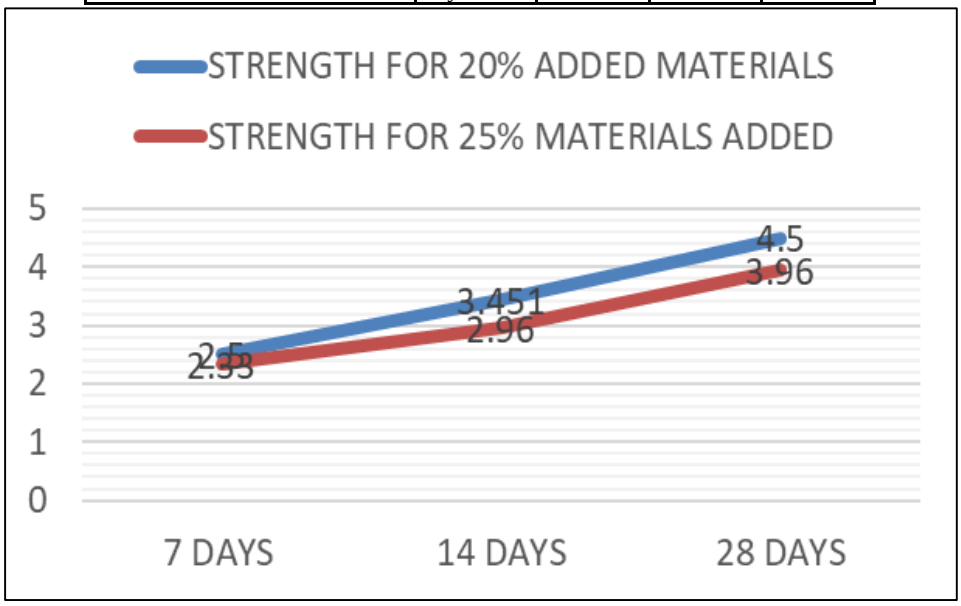

Fig. 3: Graphical representation of compressive strength of concrete specimens

Fig. 4: (tensile testing on cylinder specimen)

From the above test results the percentage of materials added 20% has been finalized for casting of slab for conduction of electricity through it.

V. CONDUCTION ELECTRICITY THROUGH DE-ICING CONCRETE SLAB

Slabs of 1' x 1'6" were casted using de-icing concrete mixer of 20% of added conductive constituents (steel fibers (15%) and Graphite powder (5%)). The copper mesh with 2.5mm wire diameter and 19mm opening size with mess count of 300 is placed for the purpose of supplying power supply to the slab as shown in fig.. After the curing periods, conduction test for the slab was conducted by passing alternate current (AC) of variable voltage using auto-transformer.

In the beginning the slab was tested at 25ºC or Room temperature. The flow of electron through deicing concrete. Due to the electrical resistivity in the concrete the temperature starts gradually increased. The change in surface temperature of the slab varied with time.

There was no constant power control on the power supply due to which the power supply was variable. It took an average 30- 40 Minutes for rising in temperature in the slab. After reaching a particular temperature the process of de-icing was started.

Fig. 5: Mould with Copper mesh

Fig. 6: De-Icing Concrete slab

VI. PROPERTIES

De-Icing concrete is cement based composite that contains certain amount of electrically conductive material to attain stable and relatively high electrical conductivity and to generate heat. The certain percentage of steel fibers and carbon-based material is added with the aggregate in concrete to achieve electrically conductivity in De-Icing concrete.

Table 3: De-icing concrete properties

Electrical resistivity	*1-45(omega-cm)*
Compressive strength	*30 (Mpa)-*
Tensile strength	*3.5-5(Mpa)*
Density	*1250-1750(kg/m^3)*

Table 4: Steel fiber properties

Tensile strength	*414-828 MPa @ 21°C (60,000-120,000 psi @ 70°F)*
Modulus of elasticity	*200,000 MPa @ 21°C (29,000,000 psi @ 70°F)*
Density	*7865 kg/m3 (491 lb/cu ft)*
Melting point	*1507°C (2745°F)*

Table 5: Graphite powder properties

Specific gravity	*1.9-2.3*
Crystal system	*Hexagonal*

Density	*2.09-2.23g/cm3*
Thermal conductivity	*191°-100°C*

Fig. 7: Graphite powder and Steel fibers

VII. CHARACTERISTICS

The engineering properties and mixing characteristics of de-icing concrete and conventional concrete are comparable, de-icing concrete does not any have other differences except ability to conduct electricity.

- The electrical percolation value is stable in deicing concrete.
- The water content, temperature effect and curing periods on conductivity are insignificant.
- Deicing concrete is similar to normal concrete in its bonding characteristics.
- Deicing concrete is black in colour due to presence of Graphite content.

VIII. FUTURE ADVANCEMENTS AND APPLICATION

De-Icing concrete has many important engineering applications:

- De-icing of roads, bridges, Airport runway and parking garages.
- Cathodic protection of reinforcement in concrete structures
- De-Icing can be easily done, without special equipment.
- Military operation can be effective even in cold weather (snow fall regions).
- Electrical grounding
- Electromagnetic shielding

IX. CONCLUSION

De-Icing concrete due to its effectiveness in De-Icing so it can be used in roads, bridges, Airport runway and parking garages through the de-icing concrete we can avoid the usage of de-icing chemicals and de-icing salts. De-icing concrete will reduce the number accidents in snowfall regions. It also improves the transportation facilities in those regions.

Although concrete has existed in many forms but this de-icing concrete has brought wide changes in the field of Engineering.

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