IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 1 Ver. II (Jan. - Feb. 2016), PP 07-12
www.iosrjournals.org

Electrically Conductive Concrete Formed By Using Waste Coke Proving Beneficial For Grounding.

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Abstract: *In this research, the issues of grounding problems in transmission towers during lightening and economic concerns of communication and transmission are addressed by using of waste coke powder rich with carbon in concrete foundation of towers.In case of transmission towers the compressive strength of underground concrete foundation is of less concern but should be more conductive for providing a continuous flow path for high voltage electric current up to deeper depths safely. The coke was oven dried ground finer and sieved through 150 micron IS sieve.The finely powdered coke were added as 2%, 4%, 6%, 8%,10% and 12 % by weight of cement for M-30 mix. The concrete were tested for workability in the fresh state and concrete specimens for compressive strength, durability density and conductivity at 28 days of age and the results obtained were compared with those of normal concrete. The results concluded the permissible dosage of using coke powder as partial replacement of cement up to 10% by weight for coke particle size finer than 150 microns. This form of concrete can be called as "Cokecrete".*

Keywords: *Coke powder, Sustainability, Grounding, Conductivity, Concrete foundation.*

I. Introduction

Conventional concrete is not electrically conductive. A hydrating concrete consists of pore solution and solids, including aggregates, hydrates and unhydrated cement. Conduction of electricity through concrete may take place in two ways: Electronic: Electronic conduction occurs through the motion of free electrons in the conductive media. Electrolytic: Electrolytic conduction takes place by the motion of ion's in the pore solution in the fresh state. Controlled conductive materials are used for controlled electrical conduction, static charge dissipation, lightning protection, and electromagnetic interference shielding in electronic, mechanical, structural, chemical applications and electrically powered transit lines. In particular, controlled resistivity ceramics, such as alumina-matrix composites containing electrically conducting particulates filler are used as substrates for handling semiconductor wafers, which require static protection [1]. It was found that Electric resistivity of the concrete is infinite as there is no conducting medium within the concrete mass for the current to flow. When a conducting material i.e, carbon based material (coke breeze), waste steel residue is mixed with ingredients of concrete ,its electrical resistivity increases upto some percentage of additive and then decreases as the continuous path for current flow is set up by steel particles [2]. Conductive concrete is a cement-based composite that contains a certain amount of electronically conductive components to attain stable and relatively high conductivity. In essence, the aggregates normally used in concrete can be largely replaced by a variety of carbon-based materials to achieve electrical conductivity in conductive concrete [3]. While the engineering properties and mixing characteristics of conductive concrete and normal concrete are comparable, conductive concrete does have other distinctive characteristics beyond its ability to conduct electricity [4]. Controlled electrical resistivity materials are typically in the form of composite materials with an electrically insulating matrix and electrically conductive discontinuous filler, which can be particulate or fibrous. The higher filler content, lower resistivity of composite. These composites include those with polymer, ceramic and cement matrices [4,5]. Compressive strength of concrete is dependent on the W/C ratio. The higher the ratio the lower is the strength. Electrical resistivity of concrete decreases almost linearly with increasing W/C ratio for a given cement content and therefore resistivity can be diagnostic of the compressive strength [6]. Approaches to improving the electrical conductivity of a concrete mix include:

1. Use of conductive aggregates such as iron ore, raw slag etc.
2. Increasing the conductivity of the cement paste by adding carbon based materials such as coke breeze, graphite or carbon fibres, etc.

In this research, cement were partially replaced by waste coke powder as 2%, 4%, 6%, 8%,10% and 12% by weight.The concrete in fresh state is checked for workability by doing Slump test and Concrete specimens were tested for compressive strength, conductivity by four-probe method and Temperature rise by thermocouples of the specimen. The results obtained were compared with results of normal M-30 concrete mix and it was found that appreciable decrease in compressive strength occurred for the concrete mix containing 8% coke powder as cement replacement. With increase in coke content, conductivity and the temperature rise increases contineously and 8% replacement is considered as optimum value because upto this value decrease in compressive strength is negligible, no electric shocks are felt and after this value sensitive shocks are observed.

II. Materials Used

2.1. Cement and Aggregates: Khyber ordinary Portland cement of 43 grade confining to IS 8112 [7] was used throughout the work. Fine aggregates used throughout the work comprised of clean river sand with maximum size of 4.75mm conforming to zone II as per IS383-1970 [8] with specific gravity of 2.6. Coarse aggregates used consisted of machine crushed stone angular in shape passing through 20mm IS sieve and retained on 4.75mm IS sieve with specific gravity of 2.7.

2.2. Coke: The waste raw material i.e. coke in this study is collected from Himalayan Rolling Steel Mill, SIDCO Complex, Rangreth srinagar .After the collection of the material, it is oven dried, finely powderded and sieved through 150 micron IS-Sieve as shown in Figure 1

Figure 1. Two forms of coke

III. Work And Experimental Methodology

3.1. Mix Proportion

The concrete mix design was proposed by using IS 10262 [9].The grade of concrete used was M30 with water to cement ratio of 0.45 (inclusive of free moisture in aggregates). The design mix obtained from the trial mix of the ingredients is 1:1.346:2.44. The mixture proportions used in laboratory for experimentation are shown in TABLE 1.

3.2. Test on Fresh Concrete

The workability of all concrete mixtures was determined through slump test utilizing a metallic slump mould. The difference in level between the height of mould and that of highest point of the subsided concrete was measured and reported as slump. The slump tests were performed according to IS 1199-1959 [10].

3.3. Tests on hardened concrete

From each concrete mixture, cubes of size 150mm x 150mm x 150mm have been casted for the determination of compressive strength. The concrete specimens were cured under normal conditions as per IS 516-1959 [11] and were tested at 3 days, 7 days and 28 days for determining compressive strength as per IS 516-1959 [12].

3.4. Light weight character

The average dry weight of concrete cube specimens containing 2%, 4%, 6%, 8%, 10% and 12% waste coke powder in place of cement was compared with average dry weight of normal M- 30 concrete cube specimens and the percentage decrease in dry weight was measured.

3.5. Tests for Conductivity $(ohm\text{-}cm)^{-1}$

The Conductivity of the concrete is the inverse of resistivity and which is found by four-electrode method refers to the four electrodes applied to conductive concrete cube as shown below.

Figure 2. determination of cconductivity by Four- Probe method.

Figure 3. Determination of Resistivity by Four-probe method.

The four electrodes are embedded in the conductive concrete in equidistant mode. The two electrodes inside is connected to voltmeter and the two electrodes outside are connected to ammeter. This method makes voltage and current of measuring electrodes separate.The outside electrodes are supplied by the DC source and the value of voltage and current are recorded [13].

The resistivity is then calculated using the following equation:

$$\rho = \frac{2\Pi dV}{I}$$

where, ρ is resistivity (ohm.cm), d is distance between inner electrodes (cm), V is voltage between probes P1, P2 (volts), I is current between probes C1, C2(amperes).

3.5. Test for Temperature: The rise in Temperature of the concrete is checked by means of a Thermo-couple after half an hour (30 min.) from the instant of applied current.

IV. Results And Discussion

4.1. Concrete in Green state

The slump values of all the mixtures are represented in TABLE 1. The slump is decreases contoneously with the increase in coke content due to high specific surface area of coke. The variation of slump with coke is depicted in Figure.3.

4.2. Compressive strength (C.S)

The compressive strength tests are presented in TABLE 2. Compressive strength tests were carried out at 3, 7 and 28 days. An appreciable decrease in compressive strength was observed at 8% replacement of cement. The variation of C.S with coke is shown in Figure.4.

4.3. Conductivity and Temperature results

The conductivity, temperature test results are presented in TABLE 3.These tests are carried out after 28 days curing period. The conductivity increases continuously and the temperature rise increases only up-to 8% cement replacement by coke. Figure.5 and 6 presents the conductivity and temperature of all mixtures at 28 days respectively.

4.4. Light weight character

Average dry weight of cube specimens of each mixture as compared to reference mix was studied and it was observed that density decreased with increase in coke content. The results showed 3.28% reduction in dry weight of concrete cube specimens for concrete mix with 12% coke content as compared to reference mix. Thus, Cok-crete is light weight in nature. TABLE 3 depicts the value of dry density and percentage change in dry weight with respect to reference mix and Figure. 7 represents dry density of cubes for all mixtures.

TABLE-1. Mix Proportion, Slump (mm) Determination.

S. no	Coke (%)	W/C	Water (kg/m^3)	Cement (kg/m^3)	F.A (kg/m^3)	Coke (kg/m^3)	C.A (kg/m^3)	Slump (mm)
1	0	0.45	206.55	459	617.8	0	1120	50
2	2	0.45	206.55	449.82	617.8	9.18	1120	45
3	4	0.45	206.55	440.64	617.8	18.36	1120	42
4	6	0.45	206.55	431.46	617.8	27.54	1120	35
5	8	0.45	206.55	422.28	617.8	36.72	1120	28
6	10	0.45	206.55	413.1	617.8	45.9	1120	20
7	12	0.45	206.55	403.92	617.8	55.08	1120	12

TABLE- 2. Compressive Strength Test results.

S.NO	Coke (%)	Avg. C.S @ 3days (N/mm^2)	Avg. C.S @ 7days (N/mm^2)	Avg. C.S @ 28days (N/mm^2)
1	0	11.5	28.34	41.2
2	2	11.0	28.2	40.8
3	4	10.8	27.8	40.22
4	6	10.5	27.4	39.5
5	**8**	**7.5**	**24**	**33.4**
6	10	6.2	21.8	29.6
7	12	4.5	17.5	24.22

TABLE- 3. Conductivity,Temperature and density results.

S.NO	Coke (%)	Conductivity (Ohm-cm)$^{-1}$	Tempt.Rise (°C)	Avg. dry density of cube (KN/m^3)	Change in dry density (%)
1	0	1.33x 10^{-5}	5	24.94	0
2	2	3.4 x 10^{-5}	9	24.92	-.080
3	4	5.45 x 10^{-5}	12	24.86	-0.32
4	6	8.95x 10^{-5}	15	24.75	-0.76
5	8	25 x 10^{-5}	21	24.62	-1.28
6	10	75 x 10^{-5}	18	24.33	-2.45
7	**12**	**94 x 10^{-5}**	**15**	**24.12**	**-3.28**

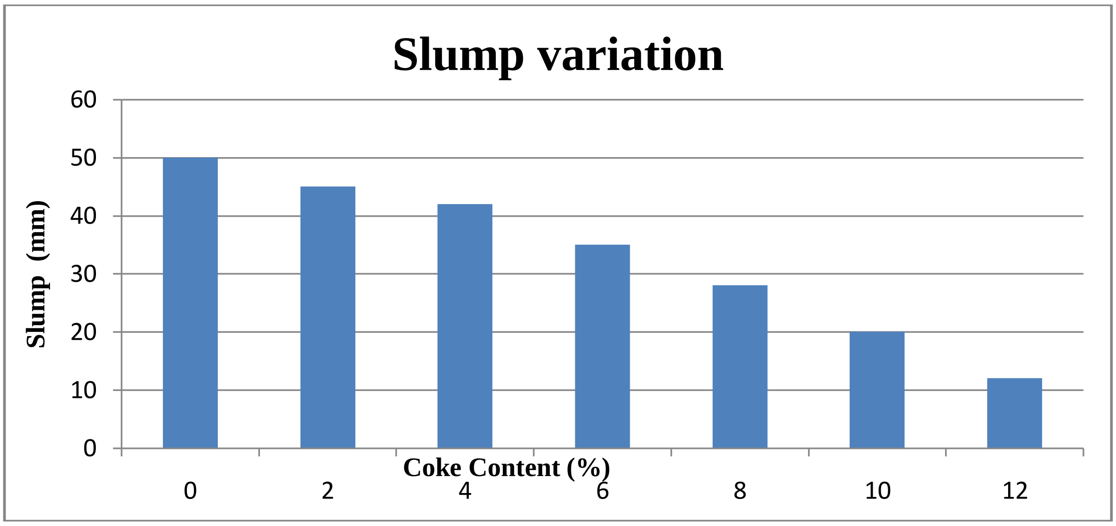

Figure 3: Variation of slump with Coke content.

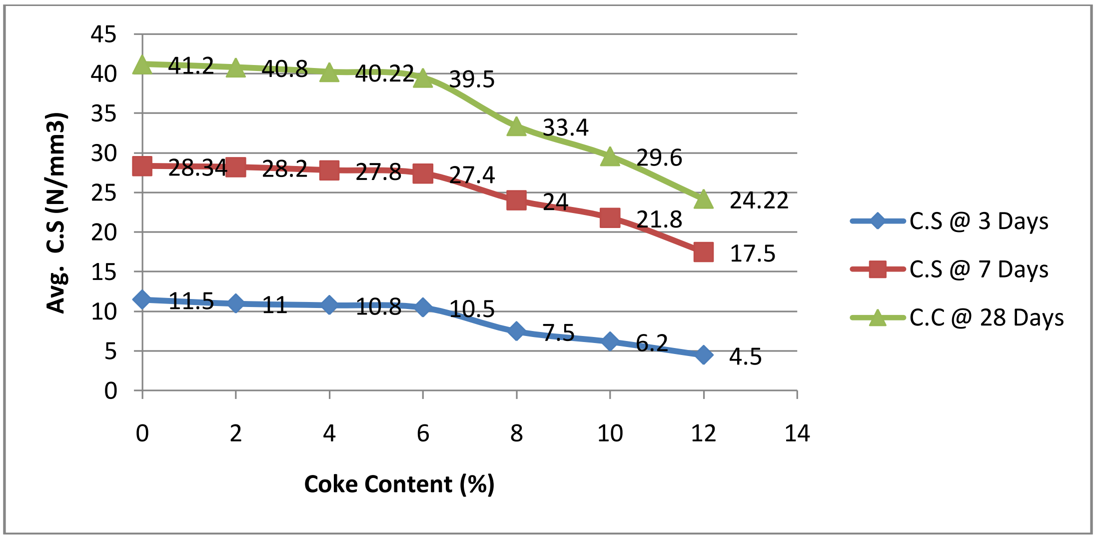

Figure 4: Variation of C.S with Coke content.

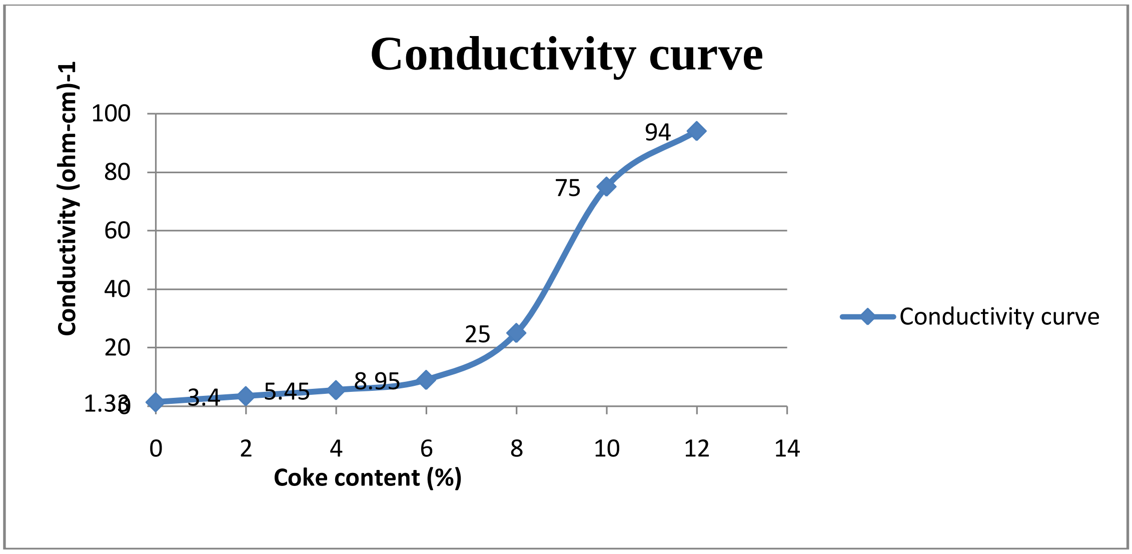

Figure 5: Variation of Conductivity with Coke content.

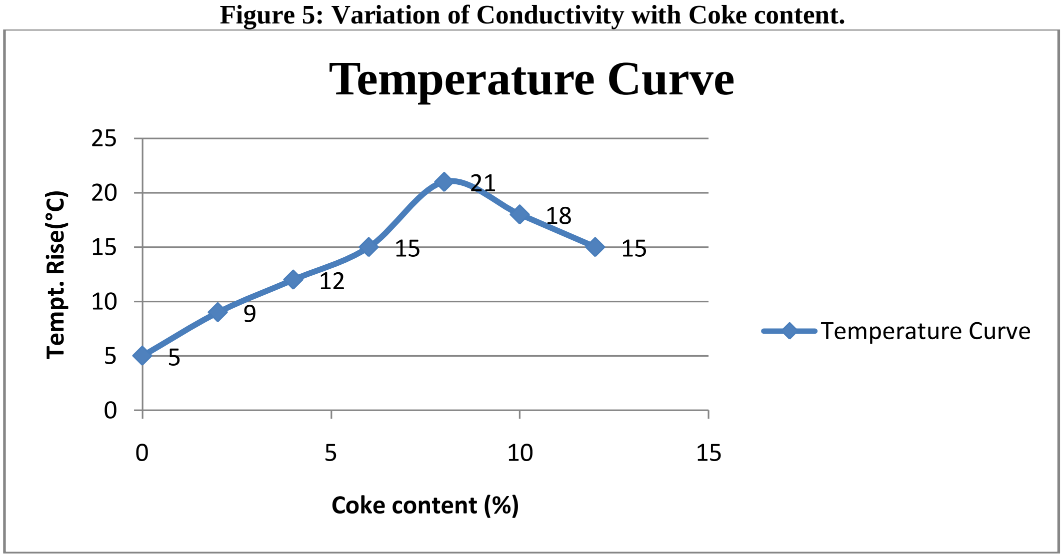

Figure 6: Variation of Temperature rise with Coke content.

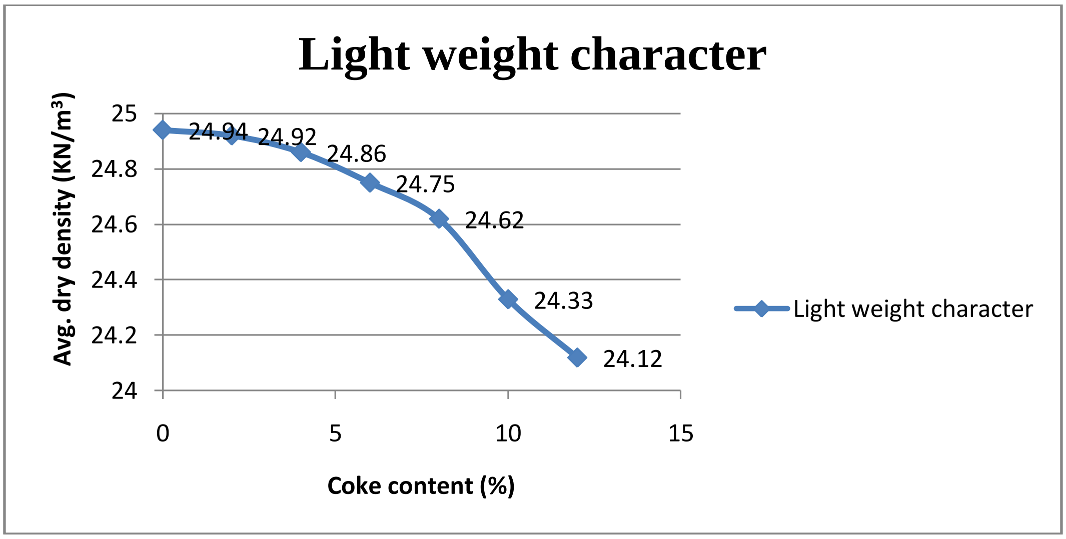

Figure 7: Variation of Avg. dry density with Coke content.

V. Conclusion

On the basis of results obtained, following conclusions are presented:

1. By introducing carbon based conductive materials i.e, coke powder in concrete the flow of electronic current is observed. The conductivity of concrete increases continuously with the increase in coke content which proves useful in providing the conductive flow path for high voltage electric current to deeper depths safely. 8% replacement of cement by coke is regarded as the optimum value for the purpose, above this value hazardous effects are seen.
2. At 8% replacement of cement by coke powder show appreciable decrease in C.S. 34.7% decrease in compressive strength at 3 days, 15.3% decrease in compressive strength at 7 days and 18.9% decrease in compressive strength at 28 days.
3. Workability of concrete mix decreases continuously with increase in coke content due to high specific surface area of coke , therefore needs suitable plasticizers or super-plasticizers.
4. Temperature rise may prove beneficial in De-Iceing, heating purposes etc.
5. With increase in coke content, average weight decreases by 3.28% for mixture with 12% coke content thus making waste glass concrete light weight.
6. Use of coke in concrete will eradicate the disposal problem of waste coke and prove to be environment friendly thus paving way for greener concrete, thus make concrete construction industry sustainable.

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