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Research Article

Maintenance of sustainable environments from industrial wastes by replacing cement concrete with nano silica and copper slag pavements

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ABSTRACT

In developing country like India every decade, the population growth has been increasing. Hence, the Indian government fulfills its basic needs like power and employment and at the same time, industrialization and urbanization are the requirement to lead their life. Though these are the necessity of the society, they are unavoidable. During the industrialization, huge measure of industrialized disposals has been generated. The wastes are created by various industrial processes. They are of composite distinctiveness and different chemical compositions, also affect health and environment. Hence, safe management and the disposal of waste are very important to maintain the sustainable environment. Only the concrete industries are responsible for utilizing these waste materials because, large quantity of natural resources is consumed in concrete and also some positive properties are also present in the industrial by-product.

Keywords: Nano Silica, Copper Slag, Rigid Pavement

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Introduction

Copper industries in India take as regards 3% of the entire world market of copper. Indian Copper companies - Sterlite Industries, Hindalco, and Hindustan have contributed to the production of major quantities of copper. Copper slag is delivered during pyro metallurgical creation of copper from copper metals, which contain significant measure of materials like iron, alumina, calcium oxide, silica and so forth. For each ton of metal creation, about 2.2 huge amounts of slag are produced [1-3]. At present, around 33 million tons of Copper Slag (CS) is produced yearly worldwide and among that, India contributes 6 to 6.5 million tons. Exceptionally little amount of copper is available in the copper slag and furthermore partition of copper from slag is an unpredictable cycle. Air-cooled copper slag has number of great mechanical properties to be utilized as total, including astounding adequacy qualities, great scraped area obstruction and great solidness than the granulated copper slag. Copper slag is utilized in the creation of concrete, mortar and cement as crude materials for clinker, partial replacement for concrete, coarse and fine aggregate, individually. [4-8]

In India, development area is feeling the squeeze to investigate option in contrast to the essential development material to fulfill the developing need of foundation requests as a result of expanding shortage of waterway sand and common totals the nation over. In certain conditions of our nation, sand mining in streams has been restricted, inferable from its tragic effect biology. And also, conservation of natural resources is very essential in any modern development due to industrialization, and the production of waste materials is also increased [9-10]. These waste materials must be utilized, due to the presence of positive properties similar to the aggregate. The strength of the concrete alone is not the prime importance because the concrete structures are constructed in hostile environment such as acidity, alkalinity and heavy industrial areas etc. Hence, every year large amount of money is spent to maintain the concrete structures. As a result, this research paves way to the meticulous examination on the mechanical, and durability properties of nano silica and copper slag in concrete [11-13]

M40 grade Concrete mix is designed as per IS: 10262-2009. Twenty-four mixes are prepared for each grade of

concrete by substitute cement by nano silica from 0%, 3%, 5% and 10%, with increment by huge and the excellent aggregate is restored by copper slag from 0% to100% with 20% increment by mass. Coarse aggregate and water cement ratios are maintained constant [14].

Slump and compaction factor tests are carried out for each mix. By using Destructive Testing (DT), compressive power, split tensile power and flexural power tests are accomplished. Compressive strength test has been accomplished on 288 cubes of size 150mm x150mm x 150mm at 3,7,14, 28, 56- and 90-days curing periods by means of solidity testing machine by means of the capability of 2000kN. Use of copper slag can save the natural resources like the sand which is very critical now a day as in most of the metros, artificial sand has been utilized for production of concrete. This operation serves not only for preventing the unenthusiastic ecological impact but also to protect and defend nature. Characterization of various sources of copper slag has been provided [15-17]

In India, manufacture sector is beneath marvelous pressure to search alternatives to the creation material, as the command of construction materials like river sand and natural aggregates has been increasing greatly across the country. In some states of our country, sand mining in rivers is prohibited, due to its terrible collision ecology Conservation of natural resources is very essential in any modern development. In addition, due to the scarcity of natural resources, the waste materials must be properly utilized to make the environment eco-friendly. Each waste material, with some specific properties is associated to natural materials and also the requirement of natural materials for concrete making is increased, due to the development of infrastructure in developing countries. Preparation of concrete consumes great amount of natural materials and large amount of energy. As a result, concrete industry is should take responsibility for reusing the waste materials in concrete. The use of results in concrete as substitution for fine total and coarse total or concrete lessens the ecological contamination as well as decreases the expense of solid creation. The utilization of mechanical strong waste to deliver concrete is earth neighborly on the grounds that, it reduces the consumption of natural assets. It likewise forestalls the natural contamination, a dangerous atmospheric deviation impact, wellbeing problems, scarcity of land for dumping the waste materials and the force utilization [18-21].

2 MaterialsUsed

NanoSilica:-Nano silica can be indistinct or glasslike, permeable or non-permeable (thick), anhydrous or hydroxylated, paying little heed to the normal or manufactured nature. It is commercially available in the market in colloidal form as a stable dispersion of solid silica particles. The nominal size of nano silica particles is 10 nm, 20 nm, 30 nm and 40 nm. Chemically, nano silica is composed mainly of pure silica (99%).

Table 1 Physical characteristics of Nano silica

S. No.	Property	Value
1.	Average Particle size (nm)	20
2.	Density (g/cm^3)	2.4
3.	Molar Mass (g/mol)	59.90
4.	Melting Point (°C)	1610
5.	Boiling Point (°C)	2225
6.	Specific gravity	1.31
7.	Specific Surface (m^2/g)	140

COPPERS LAG:-Copper slag from Vizag Chemicals Pvt Ltd from Vishakhapatnam Andhra Pradesh is utilized and its possessions are specified in Table 2

Specification	Results
Specific gravity	3.52
Fineness modulus	3.53
Bulk Density kg/m3	1750
Void ratio	0.8
Water absorption %	0.13

Table 2 Physical possessions of copper slag

Specification	Results
Specific gravity	2.75
Fineness modulus	7.6
Bulk Density kg/m3	1380
Void ratio	0.95
Grading Zone	Max size 31.5mm
Water absorption %	0.45

Table 3 Physical possessions of crude comprehensive

Cement: -Ordinary Portland cement (43 Grade) is utilized for the entire research, and it confirms the current specifications as described in IS8112 (part1):2013. The possessions of the cement are specified in the Table 4. The following tests have been accomplished in accordance with IS codes.

Table 4 Physical possessions of cement - OPC 43 grade

Physical Properties	**Test result**
Specific gravity	3.15
Normal consistency (%)	36%
Initial setting time (minutes)	90
Final setting time (minutes)	420

Physical Properties	**Test result**
Specific gravity	3.15

Normal consistency (%)	36%
Initial setting time (minutes)	90
Final setting time (minutes)	420

Fine Aggregate nearby accessible usual smooth of zone II by 4.75mm greatest size is utilized as fine aggregate that has satisfied the IS383-1970 average. The fine aggregate is first sieve during 4.75 mm sieve to eliminate the particle superior than 4.75mm. The results are specified in Table 3.3.

Table 3.3 Physical possessions of fine aggregate

Specification	Results
Type	River Sand
Specific Gravity	2.51
Fineness modulus	2.79
Grading zone	Zone II
Water Absorption	1.08%

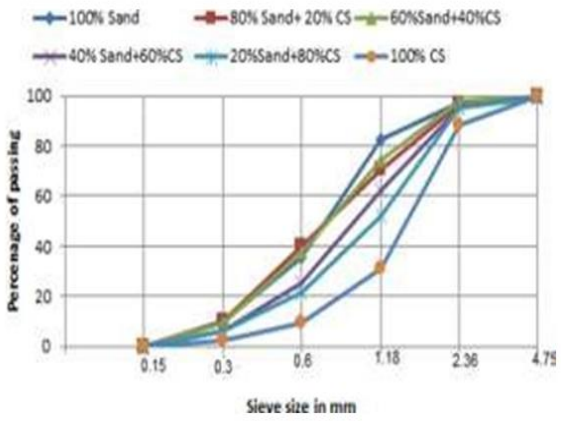

Figure 1 Grading curves

From these results, it is clear that copper slag has superior fineness modulus and mass solidity than the fine aggregate. Copper slag is substitute for fine aggregate by 0 to 100% at a 20% increasing. Here the element size allocation of the fineness modulus for fine aggregates are 2.8, 2.82, 2.83, 3.11,3.25 and 3.53, respectivelyfor0%, 20% 40% 60% 80% and 100% copper slag replacement for fine aggregates by this result, it is silent that the copper slag is coarser than the natural sand and surface area is less. Hence water requirement is decreases, when the quantity of copper slag is increased in concrete. The introduction of copper slag shifts the gradation curve towards right because the fineness modulus values are increased.

Mix Composition for M40Grade

Twenty four mix proportions are prepared with, cement is moderately restored by NS by 0% to 10% by increasing by mass and the fine aggregate is replace by CS by 0% to 100% with 20% growth by mass. Coarse aggregate and water cement ratio are kept constant as 1293 kg/m3 and 0.4. Totally twenty four concrete mix proportions are prepared and mix proportions of M40 grade.

CASTING OF SPECIMENS:-All the specimens are casted as per mix proportions given in Table 3.10. The required materials are mixed properly and ensure uniformity and water is added by steady water cement ratio of 0.4. Then they are mixed properly. The concrete is mixed using laboratory tilting drum mixer machine. All the moulds are properly oiled before casting the specimens. Before casting the specimen, fresh concrete property is carried out and then, the concrete is placed in standard size cast ion moulds with three equal layers. Compaction has been carried out by vibrating table. After 24-hours the specimens are demoulded, transferred to curing tank and tested at requiredage.

Experimental Tests &Results

Table.4. Test results of finess ofcement

S.NO	Experimental values	SAMPLE-1	SAMPLE-2
1	Sample taken in gm.	100	100
2	Passing through is:90mic. sieve	98.60	99.20
3	Retainedon is:90mic. sieve	1.40	0.80
4	Fineness (%)	1.40	0.80
5	Average	1.10	

Table.5. Consistency of Cement (IS:4031P-4-1988)

S.NO	Experimental values	SAM-1	SAM-2	SAM-3
1	Wt. Of Sample In gm.	350	350	350
2	Water Added In ml	101.5	103.25	105
3	Reading In Mm Of Apparatus	15	11	6
4	water % for consistancy	29	29.5	30
5	selected consistancy	30.00%		

Table.6. Setting Time OfCement

S.NO	Experimental values	Results
1	starting time in hrs	10.40 AM
2	initial setting time in hrs	12.55 PM
3	final setting time in hrs.	02.25 PM

Workability: -Increasing the quantity of nano silica in concrete, increases fines volume. Hence, requirement of water demand is expanded yet water request is diminished for CS amount expanded in concrete and subsequently, the seeping of cement is decreased.

Density of the Concrete: -In this study, density of concrete is higher than the normal density of concrete and less than the high density of concrete. Low density concrete is also undesirable, due to its relatively poor performance under reversed cyclic loading and so, this concrete may be suitable for earthquake prone areas.

Compressive Strength: -At the early age, nano silica exhibits strengthening cement value but at later ages, enlightened surplus lime resultant from hydration of strengthen reacts with NS and contribute significant power to the material. Target mean strength of M40 grade of concrete as per the mix design is 48.25N/mm2. At 28 days curing period optimum compressive strength has been reached 57.04N/mm2 at NS 5CS40. Most of the mix proportions satisfied the target mean strength.

Splitting Tensile and Flexural Strength

The results of the split tensile strength (150mm diameter x 300mm height) and flexural strength (100mm x 100mm x 500mm prisms) at 28 days are obtained in this study according to the procedures described in IS516- 1959. From the experimental results, it is illustrated that the splitting tensile and the flexural strength behave in similar manner. The optimum power is reach, when the concrete with 10%NS -60% CS substitute for cement and 40% CS replacement for fine aggregate. After that, strength profiles decline. The mix with up to 40% CS increases the tensile power of concrete. The reason for increased tensile power may be a strong interface bond between the CS and NS paste. Irregular surfaces of CS aggregate particles are filled with hydration products. As a result, they provide better bond strength and hence, the tensile strength is increased.

Durability Properties Of concrete:- After 90 days of water curing, the specimens are tested to determine the toughness properties such as Saturated Water Absorption(SWA), Porosity, Sorptivity, Co-efficient of permeability, Abrasion(28 days), Carbonation(150 days) Corrosion measurement of rebar by linear polarization resistivity (25 cycles of wetting and drying in 3.5% NaCl), Alkalinity (90 days curing period) tests are accomplished and micro structural studies such as SEM and EDAX are accomplished on the sample for the optimum compressive strength obtained at 28 and 90 days curing period.

Non Destructive Testing(NDT):- Non Destructive testing methods such as Ultrasonic Pulse Velocity (UPV) and Rebound Hammer tests are performed on the reinforced cement concrete beams before conducting flexural strength test. Uniformity of the concrete measured by the ultra sound measurements is performed through 20 paths (every150mm spacing) along the length of the beam by direct transmission method. The results are represented in the Table 5.10. From these results, it is clear that the uniformity of the concrete is varied in every placefrom 3.09 km/s to 4.79 km/s. Velocity of the concrete 4.79 km/s means that the quality of concrete is excellent and 3.09 km/s means the quality of the concrete is doubtful based on the IS 13311(Part 1):1992. In each rebound hammer test, 20 readings are taken and the hammer is vertically applied in all the readings. The surface hardness of the concrete is displayed in terms of compressive strength N/mm2and they are are 31.2, 34.51, 35.27,33.5 and 31, respectively for NS0CS0, NS0CS40, NS3CS40, NS5CS80 and NS10CS80.

Ultrasonic Pulse Velocity Test

The velocity of the propagation of ultrasound pulse is measured by direct transmission method using UX4600 ultrasound device. From these results, it is clear that UPV values of all the mix proportions vary from 4.0 km/s to 4.7 km/s. In this experiment, velocity obtained is higher. This indicates that the quality of the concrete in terms of density, homogeneity and uniformity is good. Based on the IS13311 (part 1) 1992, velocities of all concrete mixtures are indicated ‘excellent andgood’

CONCLUSIONS

Gradation of aggregates

As per the element amount allocation the fineness modulus value of CS is higher than the fine aggregates.

Copper slag has less surface area and hence, water requirement is decreased to attain the sufficient workability

Workability

Slump and compaction issue principles are enlarged by quantity of CS and NS is increased in concrete.

Based on the progression test, 100% normal sand is better in CS and as a result, the requirement of water is enlarged to reach average workability of concrete, due to increased surface area.

Water incorporation of copper slag is 0.13% evaluated whereas the water absorption of sand is 1.08%. Therefore, the workability of concrete increase considerably by increasing of copper slag content inconcrete mixture.

Based on the SEM images, both CS and NS have spherical particles. So, the workability of concrete is increased, because of ball bearing effects of NS andCS.

Density of Concrete

The density of concrete is increased, when the quantity of copper slagis increased in concrete. It happens because of high ferrous content present incopper slag. But, the density of concreteis

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