AN EXPERIMENTAL STUDY ON STRENGTH PARAMETERS OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH COAL DUST AND FINE AGGREGATE WITH IRON SLAG

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Abstract

Due to growing environmental awareness, as well as stricter regulations on managing industrial waste, the world is increasingly turning to researching properties of industrial waste and finding solutions on using its valuable component parts so that those might be used as secondary raw material in other industrial branches.

Concrete a composite material made from cement, water, fine aggregate and coarse aggregate. But present researchers are in interest of finding new cement materials by waste materials or waste products produced from industries which are harmful to environment.M30& M25 grades of concrete has been chosen as the reference concrete specimen. This project deals with partial replacement of cement with coal dust (0%, 10%, 20% and 30%) and fine aggregates with iron slag (0%, 40%, 50% and 60%). In this study, workability, compressive and flexural strength of concrete was evaluated to investigate the optimal use of coal dust as cement and iron slag as fine aggregates in concrete.

Keywords - Compressive strength, flexural strength, workability, Iron slag, Coal dust, M30 & M25 grades of concrete.

1 Introduction

Concreteistheworld'smostconsumedman-madematerial.Toproduce1ton ofPortlandcement,1.5tonsofrawmaterialsareneeded.Thesematerialsincludegoodquality limestone and clay. Therefore, to manufacture 1.5 billion tons of cement annually, at least 2.3 billion tons of raw materials are needed. Over 5-million BTU of energy is needed to produce one tone of cement. In the year 1914, India Cement Company Ltd started cement production inPorbandarwithanoutputof10,000tonsand aproductionof1000 installed capacity.At the timeofindependence1947,theinstalledcapacityofcementplantsinIndiawasapproximately 4.5 milliontonsandactualproductionaround3.2milliontonsperyear.Thepartialdeepcontrolin 1982 prompted various industrial houses to set a setup new cement plants in the country, capacitywasnearly30milliontons,whichhasnow,increasetonearly120milliontonsduring aperiodof20years.Thefulldecontroloncementindustryin1988furtherprovidedmomentum forthegrowth. India is the second largestproducer of cementon the globe after China. In total, India manufactures251.2MillionTonsofcementperyear.ThecementindustryinIndiahasreceived a great impetus from a number of infrastructure projects taken up by the Government of India likeroadnetworksandhousingfacilities.WhiletheIndiancementindustryenjoysa phenomenalphaseofgrowth,expertsrevealthatitispoisedtowardsahighlyprosperousfutureover the very recent years. The annual demand for cement in India is consistently growing at8-10%. National Counsel for Applied Economic Research (NCAER) has estimated after anextensive study that the demand for cement in the country is expected to increase to 244.82million tons by

2012. At the same time, the demand will be at 311.37 million tones if theprojectionsofthe roadandhousingsegmentsaremetinreality

1.2 Coal Dust

Coal is a heterogeneous, carbonaceous rock formed by the natural decomposition of plantmatteratelevatedtemperatureandpressureintheearth'scrust.Thesubjectofthismonographis'c oaldust,itselfaheterogeneousby-productoftheminingandusecoal.

1.3 Iron Slag

Theprimarycomponentsofironslagarelimestoneandsilica.

Physicalproperty(colour)ofIronslagisblack.

2.MATERIAL PROPERTIES

2.1 Cement

Ordinary Portland Cement (OPC) is the cement best suited to general concreting purposes. OPC 53 grade confirming with IS: 8112-2007 is used. The cement is kept in an airtight container and stored in the humidity controlled room to prevent cement from being exposed to moisture.

2.2 Aggregates:

Aggregates are the important constituents in concrete. They give body to theconcrete,reduceshrinkageandeffecteconomy.

Aggregatesoccupy70to80percentofvolumeofconcrete.Aggregatesareobtainedeithernaturallyorartifi cially.Aggregatescanbeclassifiedonthebasisofsizeasfineaggregate andcoarseaggregate.

2.2.1 Fine Aggregates (Sand)

The size of the fine aggregate is below 4.75mm.Fine aggregates can be naturalor manufactured. The grade must be throughout the work. The moisture content or absorptioncharacteristics must be closely monitored. The fine aggregate used is natural sand obtainedfromtheriverGodavariconformingtogradingzone-IIoftable3ofIS:10262-2009.The experiment was conducted as per IS:2386-1963andthe value is2.66

2.2.2 Coarseaggregate:

ThematerialwhoseparticlesareofsizeareretainedonISsieveofsize4.75mmis termed as coarse aggregate and containing only so much finer material as is permitted forthe varioustypesdescribedinIS:383-1970isconsideredascoarse aggregate.Aggregatesshould beofuniformqualitywithrespect toshapeandgrading.Thesizeofcoarseaggregateddependsuponthenatureofthework.Thecoarseaggrega teusedinthisexperimental investigation is 20mm and 10mm size, crushed and angularin shape.

Theaggregatesarefreefromdustbeforeusedintheconcrete. The specific gravity of the coarse aggregate is 2.8

2.2.3Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acid, alkalis, salts, organic materials or other substances they may be deleterious to concrete portable water is used for mixing as well as curing of concrete as prescribed in IS: 456 – 2000.

2.2.4Coal Dust

Coal is a heterogeneous, carbonaceous rock formed by the natural decomposition of plantmatteratelevatedtemperatureandpressureintheearth'scrust.Thesubjectofthismonographis'c oaldust,itselfaheterogeneousby-productoftheminingandusecoal. The specific gravity of the coal dust is 3.004

1.2.5 Iron Slag

Theprimarycomponentsofironslagarelimestoneandsilica.

Physicalproperty(colour)ofIronslagisblack. The specific gravity of iron slag is 2.017

2. EXPERIMENTAL PROGRAM

3.1 Parametersformixdesign

Table3.1 DesignedValuesofMaterialsM30

S.No	Itemname	As per mixeddesign(kg/m3)
1	Cement	437.3
2	Fineaggregates	666.6
3	Coarseaggregates	1128
4	water	197

Table3.2:DesignedValuesofMaterialsM25

S.No	Itemname	Aspermixed design(kg/m3)
1	Cement	448.6
2	Fineaggregates	752.71
3	Coarseaggregates	1064.65
4	water	197.4

3.2 Mixeddesign

3.2.1 proportionsForM25

- In this research work 15 Standard cubic specimens of size 150mm (nine sample foreach percentage partial replacement of cement with coal dust and fine aggregates withiron slag) were casted for the compressive strength of concrete and it was kept undercuring for 7, 14 days & 28 days of age. Total cubes for compressive strength testingwas36(9cubes *4proportions).
- In this research work 10 standard beams of size (three sample for each percentagepartial replacement of cement with coal dust and fine aggregates with iron slag) werecasted for flexural strength of concrete andit was keptunder curingfor 28 days ofage.Totalcubesforflexuralstrengthtesting was12 (3beams* 4proportions).
- Massofingredientsrequiredwillbe calculatedfor9no'scubesassuming25%wastage
- Volumeofthe Cube=9*1.25*$(0.15)^3$=0.037969m^3
- Mass of ingredients required willbe calculated for3 no's beams assuming 20%wastage
- VolumeoftheBeam=3*1.20*($(0.10)^2$*(0.50))=0.018m^3

Table3.3:MaterialProportionsforM25(Cubes)

replacement %ageofcoaldust &ironslag	0%-0%	10%-40%	20%-50%	30%-60%
Cement (Kgs)	17.0328	15.32952	13.62624	11.92296
Coaldust(Kgs)	0	1.70328	3.40656	5.10984
coarseaggregate(Kgs)	40.4236	40.4236	40.4236	40.4236
water(lit)	7.495	7.495	7.495	7.495
fineaggregate(Kgs)	28.579	17.1474	14.2895	11.4316
Ironslag(Kgs)	0	11.4316	14.2895	17.1474

Table3.4: MaterialProportionsforM25(beams)

replacement %ageofcoaldust &ironslag	0%-0%	10%-40%	20%-50%	30%-60%
Cement (Kgs)	8.0748	7.26732	6.45984	5.65236
Coaldust(Kgs)	0	0.80748	1.61496	2.42244
coarseaggregate(Kgs)	19.1637	19.1637	19.1637	19.1637
water(lit)	3.5532	3.5532	3.5532	3.5532
fineaggregate(Kgs)	13.548	8.1288	6.774	5.4192
Ironslag(Kgs)	0	5.4192	6.774	8.1288

3.2.2 ForM30

- In this research work 15 Standard cubic specimens of size 150mm (nine sample foreach percentage partial replacement of cement with coal dust and fine aggregates withiron slag) were casted for the compressive strength of concrete and it was kept undercuring for 7, 14 days & 28 days of age. Total cubes for compressive strength testingwas36(9cubes *4proportions).
- In this research work 10 standard beams of size (three sample for each percentagepartial replacement of cement with coal dust and fine aggregates with iron slag) werecasted for flexural strength of concrete andit was keptunder curingfor 28 days ofage.Totalcubesforflexuralstrength testing was12 (3beams* 4proportions).
- Massofingredientsrequiredwillbe calculatedfor9 no’scubesassuming25%wastage
- Volume ofthe Cube = $9*1.25*(0.15)^3=0.037969m^3$
- Mass of ingredients required willbe calculated for3 no’s beams assuming 20%wastage
- Volumeofthe Beam=$3*1.20*((0.10)^2*(0.50))=0.018m^3$

Table3.5:MaterialProportionsforM30(cubes)

replacement %ageofcoaldust &ironslag	0%-0%	10%-40%	20%-50%	30%-60%
Cement (Kgs)	16.6038437	14.94344	13.28308	11.62269
Coaldust(Kgs)	0	1.66038	3.32076	4.981153
coarseaggregate(Kgs)	42.829032	42.829032	42.829032	42.829032
water(lit)	7.479893	7.479893	7.479893	7.479893
fineaggregate(Kgs)	25.3101354	15.18608	12.6550677	10.1240554
Ironslag(Kgs)	0	10.124054	12.6550677	15.18608

Table3.6:Material ProportionsforM30(beams)

replacement %ageofcoaldust &ironslag	0%-0%	10%-40%	20%-50%	30%-60%
Cement (Kgs)	7.8714	7.08426	6.29712	5.50988
Coaldust(Kgs)	0	0.78714	1.57428	2.36142
coarseaggregate(Kgs)	20.304	20.304	20.304	20.304
water(lit)	3.546	3.546	3.546	3.546
fineaggregate(Kgs)	11.9988	7.19928	5.9994	4.79952
Ironslag(Kgs)	0	4.79952	5.9994	7.19928

3.3 Compressive Strength

Compressive strength or crushing strength is the main property observed in testing the cubes. The cubes of size 150 x 150 x 150mm were casted. After 24 hours, the specimens are removed from the moulds and subjected to curing for 28 days in portable water. After curing, the specimens are tested for compressive strength using compression testing machine of 2000 KN capacity (IS: 516 – 1959). Cubes are tested to calculate Compressive strength by applying gradual loading in Compression Testing Machine. The maximum load at failure occurs on the top of the machine. For M30 grade concrete, Atotalof54cubeswerecastforthefivemixes.i.e.,foreachmix9cubeswereprepared.Testing of the specimens was done at 7 days, 28 days and 90 days, at the rate of three cubesfor each mix on that particular day. The average value of the 3 specimens is reported as thestrengththatthatparticularage

Compressive strength = ultimate compressive load/cross sectional area

= P/A

= load/area N/mm2

3.4 Flexuralstrengthtest:

In the flexural strength test theoretical maximum tensile stress reached at thebottomfibresofthetestbeamisknownasthemodulusofrupture.Whenconcreteissubjectedtobending stress,compressiveaswellastensilestressesaredevelopedattopandbottomfibresrespectively.Thestren gthshownbytheconcreteagainstbendingisknownasflexuralstrength.The standardsizeofspecimenis100mm×100mm×500mwithaspanof600mm. The flexural strength of the specimen is expressed as the modulus of rupture '**fb**' which, if 'a'equalsthedistancebetweenthelineoffractureandthenearestsupportmeasuredonthecentrelineofthet ensilesideofthespecimen,incm,iscalculatedtothenearest0.05Mpaasfollows

fb=PL

bd^2

3. RESULTS

4.1 Compressivestrength

Thecompressive strength test was performed on the cubes of size 15 cm x 15 cm x 15 cm tocheck the compressive strength of rubberized concrete and the results obtained are given inTable4.1&4.2.

Table4.1:CompressivestrengthforM25grade

S.No	CoalDust(%)	Ironslag(%)	Avg.Strength(N/mm²) 7days	Avg.Strength(N/mm²) 14days	Avg.Strength(N/mm²)28 days
1	0	0	20.78	27.11	31.56
2	10	40	20.67	27	31.89
3	20	50	22	32.22	33.85
4	30	60	19.67	25.77	30.55

Table4.2:CompressivestrengthforM30grade

S.No	CoalDust(%)	Ironslag(%)	Avg.Strength(N/mm²) 7days	Avg.Strength(N/mm²) 14days	Avg.Strength(N/mm²)28 days
1	0	0	21.22	27.88	32.78
2	10	40	21.67	28.22	33.22
3	20	50	22.78	30	35.11
4	30	60	19.67	25.78	31.56

4.2 FlexuralStrengthTest

The Flexural test was performed on the beams of size 50 x 10 x 10 cm to check the flexuralstrengthoftherubberizedconcreteandtheresultsobtainedwhileperforming theflexuraltestonUTM aregiveninTable4.3&4.4.

Table4.3:FlexuralstrengthforM25grade

S.No	CoalDust(%)	Ironslag(%)	Avg.Strength(N/mm²)7days	Avg.Strength(N/mm²)14days	Avg.Strength(N/mm²) 28days
1	0	0	4.5	4.9	5.2
2	10	40	5	5.5	5.89
3	20	50	5.2	5.6	6.1
4	30	60	4.9	5.4	5.78

Table4.4:FlexuralstrengthforM30grade

S.No	CoalDust(%)	Ironslag(%)	Avg.Strength(N/mm²)7days	Avg.Strength(N/mm²)14days	Avg.Strength(N/mm²) 28days
1	0	0	5.42	5.8	6.05
2	10	40	6.86	7.03	7.63
3	20	50	7.32	7.85	8.33
4	30	60	6.2	6.4	6.90

5. Conclusions

The strength and durability characteristics of concrete mixtures have been computed in thepresent work by replacing 10%, 20% and 30% coal dust with the cement and iron slag withsand.Onthe basisofpresentstudy,followingconclusions are drawn.

1. The compressive strength of cubes were increased with addition of coal dust and iron slagup to 20% & 50 % respectively by weightin place of cement and sand, further any additionofcoaldustandironslagthe compressivestrengthdecreases.

2. TheworkabilityoftheconcretewithAluminiumdrossdidnotshowappreciablechangesascomparedtothecontrolmix.

3. The Coal dust and iron slag waste can be utilized in concrete and hence solve a potentialdisposalproblem.

4. The use of coal dust and iron slag in concrete might be cost effective because this materialisavailable athalfthe rateofsandandcementrespectively.

5. In M25 grade of concrete, the maximum compressive strengthis obtained at 28 days forthemixproportionof20%CoalDust&50%IronSlag.Thestrengthisincreasedby1.96%ascompar etothecontrolmix.

6. Similarly, In M30 grade of concrete, the maximum compressive strength is obtained at 28daysforthemixproportionof20% CoalDust&50%IronSlag.Thestrengthisincreasedby 1.55%ascomparetothecontrolmix.

7. InM25 gradeofconcrete,themaximumFlexuralstrengthisobtained at28daysforthemixproportionof20%CoalDust&50%IronSlagis6.1N/mm2.

8. InM30 gradeofconcrete,themaximumFlexuralstrengthisobtained at28daysforthemixproportionof20%CoalDust&50%IronSlagis8.33N/mm2.

9. Useofcoaldustinconcrete cansavethecoal&thermalindustrydisposalcostsandproduce agreenerconcreteforconstruction.

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