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To Study the Strength Characteristics of Concrete by Replacement of Coarse Aggregate with Coal Mill Reject

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Abstract - *Everyday many thousand tons of coal mill reject are generated during the thermal production. This reject is currently not being used as construction material except lands filling in rail, roads embankments and dumping in low laying areas. These applications of utilizations are small or part only and the huge quantity of material is dumped as a waste. This study has been done to reduce the accumulation of coal mill reject and provide an alternative material as coarse aggregate in concrete.*

Introduction and Statement of the Study

The utilization of industrial waste or secondary materials will encourage the production of economical concrete in the area of construction fields. The by-products and waste materials are being generated by various industries. Transporting and disposal of waste materials consumes lot of cost, valuable space and manpower. On the other hand, it creates environmental and health hazard problems. Therefore, the use of waste materials in concrete production will be a good solution in construction industry. For many years, the by-products such as fly ash, silica fume, red mud and blast furnace slag were considered as waste materials. Few of these materials are being used to prepare concrete with added qualities like cement manufacturing, improvement in workability and durability of concrete. Over decades intensive research studies it could be possible to uses of these materials. Construction waste such as blast furnace slag(steel slag), coal fly ash and bottom ash have been widely accepted as alternate materials for use in construction works.

Coal-mill reject is an industrial waste product produced from coal during ball mill grinding mostly in thermal power plants. Every day in a plant of capacity 500 MW about 40,000 tons of coal is used for making powder by ball mill for use in firing of boilers to produce steam. Out of this about 2% coal is very hard which remains ungrounded. This product is called coal mill reject and normally used in filling of low laying grounds or stacking as waste dump. It has been estimated that in India approximately 25.8 million tons of coal mill reject is generated from thermal power plants in a year.

A project study was conducted considering coal mill reject as waste material and being hard enough. During the study, its characteristics were studied to confirm, whether coal mill reject could replace the stone aggregate used as coarse aggregate in producing cement concrete. It is observed that ball mill reject has a number of favorable mechanical properties to use as aggregate, such as excellent soundness characteristics, good flakiness index, good elongation index etc.

The use of coal mill reject in the concrete industry may be a replacement of stone aggregate with advantages like; saving natural environment, removing waste dumps, saving in dumping spaces and construction cost reduction.

Objective and Principles

The objective of this study is to investigate the strength of concrete using coal mill rejects an industrial waste product as coarse aggregate. The variables considered in the study include the replacement of coarse aggregate with coal mill rejects were:

- Comparative concrete compressive strengths
- Comparative Impact Value of aggregates
- Fineness modulus of aggregates

Replacement of the stone aggregate by coal mill rejects in concrete has the following advantages;

After testing of concrete it was found that the properties of coal mill rejects are almost similar to that of stone aggregate.

Aim of the Study

The main aim of this research work was to investigate effective replacement of aggregate by coal mill reject in concrete. To achieve this, an extensive study has been carried out to investigate the following using coal mill reject.

1. To find the optimum proportion of coal reject that can be used as a replacement material for aggregate
2. To evaluate compressive strength of concrete using coal mill reject.
3. To evaluate compressive strength of concrete using coal mill reject.
4. To find out the various test values to compare with normal aggregate.

Future Scope

The government of India has targeted the year 2020 and 2021 for providing housing for all. Such large scale housing construction activities require huge amount of money. Out of the total cost of house construction, building materials contribute to about 70 percent costs in developing countries like India. Therefore the need of hour is to replace the costly and scarce conventional building materials with innovative, cost effective and environment friendly materials.

Since, coal mill reject concrete showed a good mechanical performance, it can be used as a building raw material. Therefore in this investigation, possibilities of using coal mill reject for various purposes were examined and being reported.

Advantages of Coal Mill Reject use in Concrete

- Reduces the construction cost due to saving in material cost.
- Reduces the pores of concrete, because it has irregular size and shape of material, which helps in grading of aggregate.
- Reduces permeability.
- Reduces the use of primary natural resources.

Research Methodology and Materials

The research methodology for performing this research is given below:
1. Material collection
2. Finding material characteristic used in the studies by sieve analysis, fineness modulus etc.
3. Testing the material (coal mill reject) and compare it with normal aggregate
3. Making cement concrete blocks using coal mill reject and normal concrete blocks
4. Testing on concrete blocks
5. Analyzing the result and concluding.

Materials

1. Pozzolana Portland cement
2. Coarse aggregate: natural crushed stone of size 20mm graded.
3. Fine Aggregate: clean river sand
4. Coal mill reject
5. Water: normal tap water

Equipment: The equipment and setups we used are listed blow;
1. Sieve analysis equipment containing sieves of size
4.75 mm, 10 mm, 20 mm and 40mm
2. Impact Testing Machine.
3. Moulds for cubes, cylinders and tempering rod.
4. Compression testing machine.

Test on coal mill reject.
Test on cube shape mould-compressive strength.

Sieve Analysis

Sieve Analysis for 20 mm coal mill reject aggregate
5 kg sample taken

Test 1

S.No.	Sieve no.	Mass of retain	%of Retain	Cumulative % retain	Passing %
1	40mm	0	0	0	100
2	20mm	624gm	12.48%	12.48%	87.52%
3	10mm	4102gm	82.04%	94.52%	5.48%
4	4.75	230gm	4.6%	99.12%	0.88%
5	Dust	44gm	-	-	-
				206.12%	

Test 2

S.No.	Sieve no.	Mass of retain	%of Retain	Cumulative % retain	Passing %
1	40mm	0	0	0	100%
2	20mm	840gm	16.8%	16.8%	83.2%
3	10mm	3952gm	79.04%	95.84%	4.16%
4	4.75mm	166gm	3.32%	99.16%	0.84%
5	Dust	42gm	-	-	-
				211.8%	

Test 3

S.No.	Sieve no.	Mass of retain	%of Retain	Cumulative % retain	Passing %
1	40mm	166gm	3.32%	3.32%	96.68%
2	20mm	1176gm	23.52%	26.84%	73.16%
3	10mm	3508gm	70.16%	97%	3%
4	4.75mm	114gm	2.28%	99.28%	0.72%
5	Dust	36gm	-	-	-
				226.44	

Sieve Analysis for 20 mm stone aggregate
5 kg sample taken

Test 1

S.No.	Sieve no.	Mass of retain	%of Retain	Cumulative % retain	Passing %
1	40mm	0	0	0	100%
2	20mm	242gm	8.06%	8.06%	91.94%
3	10mm	2650gm	88.33%	96.39%	3.61%
4	4.75	30gm	1%	97.39%	2.61%
5	Dust	66gm	2.2%	99.59%	0.41%
				301.43%	

Test 2

S.No.	Sieve no.	Mass of retain	%of Retain	Cumulative % retain	Passing %
1	40mm	0	0	0	100%
2	20mm	438gm	14.6%	14.6%	85.4%
3	10mm	2520gm	84%	98.6%	1.4%
4	4.75mm	30gm	1%	99.6%	0.4%
5	Dust	0gm	-	-	-
				212.8%	

Fineness Modulas of coarse Aggregate

Fineness modulus of coarse aggregates represents the average size of the particles in the coarse aggregates by an index number. It is calculated by performing sieve analysis with standard sieves.

Fineness modulus of coal-mill rejects aggregates:

Test 1:
Fineness modulus = (206.12+500)÷100 = 7.06 %
Test 2:
Fineness modulus = (211.8+500)÷100 = 7.118%

Fineness modulus of stone aggregates:
Test 1:
Fineness modulus = (301.43+500) ÷ 100 = 8.01%
Test 2:
Fineness modulus = (212.8+500) ÷ 100 = 7.128%

Impact Value:

The aggregates impact value indicates a relative measure of the resistance of aggregates under sudden shock or an impact. It differs in some aggregates. Impact value assesses the regard to the toughness, for use in pavement construction. Hence, A test is necessary to evaluate the toughness of stones.

Impact test on Coal-mill Rejects:

Test 1: Coal-mill Rejects:
Weight of mould = 734gm

Sample weight = 316gm (w)
2.36 passing wt. = 94gm (w_1)
2.36 retain wt. = 222gm (w_2)
Impact value = (w_1/w)*100%
= (94/316)*100% = 29.7%

Test 2:(10mm above)
Sample wt. = 340gm
2.36mm sieve passing =101gm (w_1)
2.36mm sieve retain = 239gm (w_2)
Impact value = (w_1/w)*100%
= (101/340)*100 = 29.7%

Impact test on stone aggregates:

Test 1:
Wt. Of the mould = 734 gm
Sample wt. = 336 gm
2.36 retain = 262 gm
2.36 passing = 74 gm
Impact value = (74/336)*100 =22.02%

Test 2:
Wt. Of the mould = 734 gm
Sample wt. = 370 gm
2.36 retain = 294 gm
2.36 passing = 7+6 gm
Impact value = (76/370)*100 =20.54%

Bulk density of aggregates:

Bulk density of aggregates is the mass of aggregates required to fill the container of a unit volume after aggregates are batched based on volume.

Bulk density test for coal-mill rejects:
Sample wt. = 21720 gm = 21.72kg
Volume of container = 15 ltr.
Bulk density = 21.72 ÷ 15
= 1.448 kg/ltr.

Bulk density test for stone aggregates:
Sample wt. = 22.56kg
Volume of container = 15 ltr
Bulk density = 22.56 ÷ 15
= 1.504 kg/ltr

Cube Compressive Strength:

We prepared the cubes of M15 and M20 which has ratio of 1:2:4 and 1: 1.5:3 respectively. For that we first of all calculated the actual amount of all the ingredients that were used in concrete.

1) We used 28.92 kg (29kg approx. Having mix ratio of 60:40 greater than 10mm and less than 10mm) , sand of weight 14.46 kg and 7.3 kg of cement. The water cement ration taken as 0.7 (i.e. 5.15 ml of water) for M15 coal-mill rejects concrete and w/c ratio taken for normal concrete is 0.5.

2) For the M20 grade of concrete cube, we used 9.20kg of cement, 13.8kg of sand and 27.61 kg of coal-mill rejects as aggregates. The water cement ration taken as 0.65(i.e. 5.98 ml of water)

Observations:

Measured side of cube = 15cm x15cm x 15cm

	Coal-mill rejects concrete cube		Ordinary concrete cube	
	M15 (7 days curing)	M15 (28 days curing)	M15 (7 days curing)	M15 (28 days curing)
Weight of the cube	1) 7.356kg 2) 7.572kg 3) 7.282kg	4) 7.400kg 5) 7.488kg 6) 7.386kg	1) 8.282kg 2) 8.262 3) 8.236	4) 8.260kg 5) 8.102kg 6) 8.256kg

S.No.		Normal Concrete(M15)	Coal-Mill Rejects Concrete	
			M15	M20
1.	Cube 1	8.260kg = 346 ÷ 22.5 = 15.24 N/mm²	7.44kg =214.8÷22.5 =9.546 N/mm²	7.486kg =358÷22.5 =15.91N/mm²
2.	Cube 2	8.102kg =383 ÷ 22.5 = 17.02 N/mm²	7.488kg =226÷22.5 =10.044 N/mm²	7.489kg =338÷22.5 =15.02N/mm²
3.	Cube 3	8.256kg =337 ÷ 22.5 = 14.97 N/mm²	7.386kg 216÷22.5 =9.622 N/mm²	7.410kg 346÷22.5 =15.37N/mm²
	Average Compressive strength	=15.24+17.02+14.97 =47.23 =47.23÷3 =15.74 N/mm²	=9.546+10.044+9.622=29.212 =29.212÷3 =9.73 N/mm²	=15.91+15.02+15.37= 46.3 =46.3÷3 =15.43N/mm²

Conclusion:

The fineness modulus of coal mill reject is nearly equal to stone aggregate so we can replace the stone aggregate with coal mill reject.

The impact value of coal mill reject is in the range so it can be used in road construction and pavement construction.

The bulk density of coal mill reject is nearly equal to stone aggregate so replacement of aggregate can be done.

Coal mill reject concrete with nominal ratio 1:1.5:3 (1 cement: 1.5 coarse sand: 3 coal mill reject) is nearly equal to concrete with nominal ratio with stone aggregate 1:2:4 (1 cement: 2 coarse sand: 4 stone aggregate).

Applications:

Coal-mill rejects concrete for non-wearing surfaces such as footpath
Lean concrete in foundation base and under floors
Concrete blocks for masonry works
Concrete tiles for canal lining

Low height retaining walls
Concrete as sparsh to prevent scouring in the river banks
Concrete divider and curve stones
Almirah partitions
Base concrete of cement concrete roads

Future Scope of Study:

Making prototype and testing with dead and live load.
Testing of material on different locations and study spatial variations.
Testing of coal mill reject with imported coal which has superior quality.
Preparation of guidelines for field.

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BIOGRAPHIES

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