AN EXPERIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF FINE AGGREGATE WITH BOTTOM ASH AND QUARRY DUST

[1]PAMARTHI PURNA MUNINDRA, [2]PILLI NARENDRA BABU
[1]PG Scholar, Department of Structural Engineering, NRIIT, Agiripalli, Krishna, India
[2]Associate Prof, Department of Structural Engineering, NRIIT, Agiripalli, Krishna, India

Abstract— **Concrete is a composite material composed of fine and coarse aggregate bonded together with a cement paste that hardens over time. Several studies have been carried out to investigate the replacements for cement and aggregates. Now a day's erosion of rivers and their environmental issues cause a scarcity of river sand. The non-availability or shortage of river sand will affect the construction industry, hence there is a need to find the new alternative material to replace the river sand.**

In this study, fine aggregate in concrete mix has been replaced with Quarry dust and Bottom ash have been used to enhance the strength characteristics. M30 concrete have been used in this experimentation. The mix is prepared for various combinations of 0%, 10%, 20%, 30% and 40% replacement of sand by bottom ash and Quarry dust individually As well as we used both quarry dust and bottom ash for the weight of sand have been used. Mechanical properties of various materials have been studied and strengths are calculated by various standard tests like compressive strength, split tensile strength and flexural strength..

Keywords— **Conventional Concrete, Conventional Mix, Quarry dust, Bottom Ash. Compressive Strength, Split tensile strength, Flexural strength**

I. INTRODUCTION

Concrete is a composite construction material made primarily with aggregate, cement, and water. There are many formulations of concrete, which provide varied properties, and concrete is the most-used man-made product in the world. Concrete is widely used for making architectural structures, foundations, brick or block walls, pavements, bridges or overpasses, motorways or roads, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences and poles and even boats.

Concrete is a manmade material used in the building and construction industry and consists of aggregates which are bonded together by cement and water. The major constituent of concrete besides the cement is the aggregate. Various types of aggregates that may be used include sand, crushed-stone, gravel, slag, ashes, burned shale, and burned clay. Fine aggregates refer to the size of aggregate used in making concrete slabs and in providing smooth surfaces. Coarse aggregates are used for massive structures or sections of Concrete. Historically the word concrete comes from the Latin word "concretus" (meaning compact or condensed).

BOTTOM ASH

Bottom ash is a hazardous by-product from coal based thermal power plants. Direct use of this material with a large quantity, will provide a solution to dispose of this material, and the possibility as alternative materials in construction. The experimental investigations carried out to study the effect of use of bottom ash (the coarser material, which falls into furnace bottom in modern large thermal power plants and constitute about 20% of total ash content of the coal fed in the boilers) as a replacement of fine aggregates.

Health Effects

Coal ash - which includes bottom ash - can have a different chemical makeup depending on where the coal was mined. Broadly speaking, coal ash is a pollutant, and it contains acidic, toxic, and radioactive matter. This ash can contain lead, arsenic, cadmium, mercury and uranium. The EPA found that significant exposure to bottom ash and other components of coal ash increases a person's risk of developing cancer and other respiratory diseases.

Environmental Effects

When fly ash and bottom ash are disposed in lagoons, there are associated environmental effects. These wet lagoons can be an issue, because if they do not have proper liners to prevent leaking and leaching then groundwater contamination is much more common. Leaching is a process that occurs when coal ash is wet, and it simply means that the toxic components of the ash dissolve out and percolate through water.

OBJECTIVES:

- To determine the optimum content of bottom ash that can be replaced in fine aggregate to achieve maximum strength.
- To determine the maximum content of Quarry dust that can be replaced with fine aggregate to achieve maximum strength.
- To evaluate the strength of concrete formed with the combination of cement, fine aggregate, bottom ash, Quarry dust and coarse aggregate along with the addition metallic fibers.
- To evaluate the mechanical properties of concrete containing bottom ash and stone dust as partial replacements for fine aggregate.

QUARRY DUST:

How Quarry Dust Is Made:

A quarry is a place from which dimension stone, rock, aggregate, riprap, sand, gravel, or slate has been excavated from the ground. A quarry is the same thing as an open-pit mine from which minerals are extracted. The only non-trivial difference between the two is that open-pit mines that produce building materials and dimension stone are commonly referred to as quarries. The word quarry can also include the underground quarrying for stone, such as Bath stone.

Check Out The Benefits of Using Quarry Dust:

Strength When Needed:

Cement is availability is becoming challenging at reasonable price. In order not to compromise strength of building during construction, the dust come handy as an equal substitute without threat to quality at the same time rendering good strength to constructions.

Saves Cost:

Construction Projects that use quarry dust have proven to be cheaper than those that depend wholly on cement. The dust come at cheaper cost and lesser pressure on market demand for cement. Partial replacement of cement with this dust will make good concrete that is well desired in residential construction. The final product is strong bricks, slabs or tiles that are produced at lower cost compare to using cement.

Easily available:

As compared to cement, the quarry dust is easily available. It requires less processing and it being a by-product of quarrying, it is very accessible at large quantities for a cheaper cost. Many quarry owners dispose it at very low prices making it almost always available.

Quality maintenance:

Quality of construction is the most important aspect under consideration. The dust improves the mechanical properties of concrete as well as durability. Quarry dust has been proposed as an alternative to cement that gives additional benefit during construction.

Consumption reduces the pollution in environment:

In areas where constructors use this dust, there is a significant reduction of air pollution by the dust. Quarry dust is very volatile and its inhalation can cause respiratory problems. Inclusion of the dust in construction projects will solve the problem of disposal of this dust.

II. LITERATURE REVIEW

A. Selecting a Template (Heading 2)

[1]**TAHIR CELIK AND KHALED MARAR (1996)** concluded as concrete shows higher compressive strength after replacing fine aggregate by stone dust. So stone dust can be used as an additive in concrete preparation. Workability of concrete increases with the use of stone dust. Stone dust can be used as an alternate material of fine aggregate both in lean concrete as well as in high strength concrete.

[2]**H.A.F.DEWAH (2012)** reported as that stone dust increases the strengthen properties of concrete. However other parameters like temperature, humidity, climate conditions, air-entrapped etc. Also effects the same.

[3]**P.TANG** found that the compressive and flexural strength of concrete drain with augmentation of the bottom ash fines at the identical age, particularly after 3and 7 days. He used bottom ash fines as aggregate in high performance concrete.

[4]**K.SOMAN** investigated and concluded as the 30% replacement of sand with bottom ash has given a 28day compressive strength of 38.43 N/mm2. The result showed that bottom ash can be replaced up to 30%.

III. DESCRIPTION OF MATERIALS

Concrete is a composite of three raw materials. Cement, Fine aggregate and Coarse aggregate. These three raw materials play an important role in manufacturing of concrete. By varying the properties and amount of these materials, the properties of concrete will changes. The main raw materials used in this experimental work are cement, fine aggregate, Coarse aggregate.

CEMENT

Cement is the main ingredient in manufacturing of concrete. The characteristics of concrete will be greatly affected by changing the cement content. The cement used in this project is Ordinary Portland cement of 53 grade confirming to IS 12269-1987.

FINE AGGRIGATE

Aggregates of size ranges between 0.075mm-4.75mm are generally considered as fine aggregate. In this experimental work two types of Fine aggregate were used. They are River sand and Bottom ash. The Fine aggregates are selected as per IS-383 specifications.

River Sand

It is also called as natural sand. In this work a good quality of natural sand was used. The sand is medium sand and is confirming to zone-III as per standard specifications.

Bottom ash

Bottom ash is a waste material from the thermal power plants. The bottom ash that is used has been brought from Vijayawada thermal power station.

Chemical composition of bottom ash

The grains of bottom ash have an angular geometry.The colour of bottom ash ranges from medium brown to medium black.The chemical composition of bottom ash is as follows

S.NO	CHEMICAL COMPOUNDS	PERCENTAGE OF
1.	Loss of ignition	11.93
2.	Silica(SiO_2)	52.61
3.	Iron(Fe_2O_3)	29.16
4.	Titanium(TiO_2)	Nill
5.	Aluminum(Al_2O_3)	1.43
6.	Calcium(Cao)	0.67
7.	Magnesium (Mgo)	1.56
8.	Sodium (Na_2O_3)	0.23
9.	Potassium (k_2O)	0.36
10.	Sulpur (SO_3)	2.05

QUARRY DUST

Quarry dust is a by-product of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying activities, the rock has been crushed into various sizes; during the process the dust generated is called quarry dust and it is formed as waste.

S.No	Ingredients	Properties
1	Silicon dioxide	0.8694
2	Aluminum oxide	0.002
3	Iron oxide	0.001
4	Calcium oxide	0.3-2.2%
5	Magnesium oxide	0.2-0.6%
6	Sodium oxide	0.1-0.8%
7	Potassium oxide	2.1-2.30%

COARSE AGGREGATE

Aggregate of size more than 4.75mm are generally considered as Coarse aggregate. The maximum size of coarse aggregate used in this experimental work is 20mm. A good quality of coarse aggregate is obtained from nearest crusher unit. The coarse aggregate are selected as per IS-833 specifications.

PROPERTIES OF THE MATERIALS

1. CEMENT

S.No	Tests	Result
1	Consistency	32%
2	Fineness	92%
2	Initial Setting Time	62min
3	Final Setting Time	6.5hr
4	Specific gravity	3.11

2. SAND

S.No.	Test Conducted	Test Result
1	Sieve analysis of sand	Zone-III
2	Moisture content	2%
3	Bulk age of sand	8.33
4	Specific gravity	2.65

3. COARSE AGGREGATE

S.No.	Test Conducted	Test Result
1	Specific gravity of Coarse Aggregate 20mm	2.61
2	Water absorption coarse agg	0.5%

4. QUARRY DUST

S.No.	Test Conducted	Test Result
1	Fineness Modulus	2.53
2	Specific gravity	2.65

5. BOTTOM ASH

S.No.	Test Conducted	Test Result
1	Fineness Modulus	1.99
2	Specific gravity	2.65

IV. TESTS ON CONCRETE

A. RESULTS FOR COMPRESSIVE STRENGTH

% of REPLACEMENT	3 DAYS	7 DAYS	14 DAYS	28 DAYS
0% REPLACEMENT	17.96	29.05	38.41	40.31
10% REPLACEMENT	15.34	27.26	36.42	38.62
20% REPLACEMENT	15.76	27.69	36.62	38.77
30% REPLACEMENT	16.2	28.43	36.66	38.38
40% REPLACEMENT	14.86	26.99	35.78	37.94

Replacement of Fine Aggregate with Bottom Ash

% of REPLACEMENT	3 DAYS	7 DAYS	14 DAYS	28 DAYS
0% REPLACEMENT	17.96	29.05	38.41	40.31
10% REPLACEMENT	17.86	29.17	38.28	40.36
20% REPLACEMENT	18.23	29.35	38.56	40.75
30% REPLACEMENT	18.33	29.39	38.63	41.22
40% REPLACEMENT	19.02	29.93	39	41.57

Replacement of Fine Aggregate with Quarry Dust

B.A = BOTTOM ASH ; Q.D = QUARRY DUST)

% of REPLACEMENT	3 DAYS	7 DAYS	14 DAYS	28 DAYS
(0% B.A + 0% Q.D) 0% REPLACEMENT	17.96	29.05	38.41	40.31
(5% B.A + 5% Q.D) 10% REPLACEMENT	16.69	28	37.02	38.92
(10% B.A + 10% Q.D) 20% REPLACEMENT	16.81	28.2	36.72	38.92
(15% B.A + 15% Q.D) 30% REPLACEMENT	16.56	28.2	36.75	38.5
(20% B.A + 20% Q.D) 40% REPLACEMENT	16.23	27.89	36.2	38.18

Replacement of Fine Aggregate with Quarry Dust and Bottom Ash

(B.A = BOTTOM ASH ; Q.D = QUARRY DUST)

% of REPLACEMENT	3 DAYS	7 DAYS	14 DAYS	28 DAYS
(0% B.A + 0% Q.D) 0% REPLACEMENT	17.96	29.05	38.41	40.31
(5% B.A + 5% Q.D) 10% REPLACEMENT	16.69	28	37.02	38.92
(10% B.A + 10% Q.D) 20% REPLACEMENT	16.81	28.2	36.72	38.92
(15% B.A + 15% Q.D) 30% REPLACEMENT	16.56	28.2	36.75	38.5
(20% B.A + 20% Q.D) 40% REPLACEMENT	16.23	27.89	36.2	38.18

Replacement of Fine Aggregate with Quarry Dust and Bottom Ash

B. RESULTS FOR SPLIT TENSILE STRENGTH

% of REPLACEMENT	7 DAYS	28 DAYS
0% REPLACEMENT	2.77	3.82
10% REPLACEMENT	2.54	3.19
20% REPLACEMENT	2.33	3.11
30% REPLACEMENT	1.91	2.89
40% REPLACEMENT	1.63	2.78

Replacement of Fine Aggregate with Bottom Ash

% of REPLACEMENT	7 DAYS	28 DAYS
0% REPLACEMENT	2.77	3.82
10% REPLACEMENT	2.85	3.8
20% REPLACEMENT	2.91	3.81
30% REPLACEMENT	2.99	3.94
40% REPLACEMENT	3.01	3.98

Replacement of Fine Aggregate with Quarry Dust

(B.A = BOTTOM ASH ; Q.D = QUARRY DUST)

% of REPLACEMENT	7 DAYS	28 DAYS
(0% B.A + 0% Q.D) 0% REPLACEMENT	2.77	3.82
(5% B.A + 5% Q.D) 10% REPLACEMENT	2.56	3.28
(10% B.A + 10% Q.D) 20% REPLACEMENT	2.59	2.83
(15% B.A + 15% Q.D) 30% REPLACEMENT	2.6	2.82
(20% B.A + 20% Q.D) 40% REPLACEMENT	2.6	2.74

Replacement of Fine Aggregate with Quarry Dust and Bottom Ash

C. RESULTS FOR FLEXURAL STRENGTH

% of REPLACEMENT	7 DAYS	28 DAYS
0% REPLACEMENT	3.16	4.45
10% REPLACEMENT	3.07	4.24
20% REPLACEMENT	3.01	4.04
30% REPLACEMENT	2.79	4.00
40% REPLACEMENT	2.60	3.73

Replacement of Fine Aggregate with Bottom Ash

% of REPLACEMENT	7 DAYS	28 DAYS
0% REPLACEMENT	3.16	4.45
10% REPLACEMENT	3.12	4.49
20% REPLACEMENT	3.15	4.52
30% REPLACEMENT	3.19	4.56
40% REPLACEMENT	3.21	4.61

Replacement of Fine Aggregate with Quarry Dust

% of REPLACEMENT	7 DAYS	28 DAYS
(0% B.A + 0% Q.D) 0% REPLACEMENT	3.16	4.45
(5% B.A + 5% Q.D) 10% REPLACEMENT	3.12	4.15
(10% B.A + 10% Q.D) 20% REPLACEMENT	3.05	4.04
(15% B.A + 15% Q.D) 30% REPLACEMENT	2.93	3.9
(20% B.A + 20% Q.D) 40% REPLACEMENT	2.71	3.75

Replacement of Fine Aggregate with Quarry Dust and Bottom Ash

V. CONCLUSIONS

The concept of adding both bottom ash and quarry dust in M_{30} grade of concrete increases the compressive strength and flexural strength. From adding these replacement to the concrete, the compressive strength, split tensile strength and flexural strength will increase in high manner. Thus reduces the burden of the strength of concrete in construction management.

From the study of the literature review it is noticed that the quarry dust and bottom ash has significant effect on the strength and durability of concrete. This may produces the high strength motors and concrete at lower cost.

For Bottom Ash:

- From above investigation we found that the **maximum** compressive strength of mix proportion is 17.96 N/mm^2, 29.05 N/mm^2, 38.41 N/mm^2 and 40.31 N/mm^2 at 3 days, 7 days, 14 days and 28 days respectively at **no replacement** of bottom ash in concrete while the **minimum** compressive strength is found 15.76 N/mm^2, 27.69 N/mm^2, 36.62 N/mm^2 and 38.77 N/mm^2 is at 3 days, 7 days, 14 days and 28 days respectively when **20% replacement** of bottom ash in concrete.
- The **maximum** flexural strength of concrete is found 3.16 N/mm^2 and 4.45 N/mm^2 at 7 days and 28 days respectively at **no replacement** of bottom ash in concrete while **minimum** flexural strength of concrete is found 3.07 N/mm^2 and 4.24 N/mm^2 is at 7 days and 28 days respectively when there is **10% replacement** of bottom ash in concrete.
- The **maximum** split tensile strength of concrete is found 2.77 N/mm^2 and 3.82 N/mm^2 at 7 days and 28 days respectively at **no replacement** of bottom ash in concrete while **minimum** flexural strength of concrete is found 2.54 N/mm^2 and 3.19 N/mm^2 is at 7 days and 28 days respectively when there is **10% replacement** of bottom ash in concrete.

For Quarry Dust:

- From above investigation we found that the **maximum** compressive strength of mix proportion is 19.02 N/mm^2, 29.93 N/mm^2, 39.00 N/mm^2 and 41.57 N/mm^2 at 3 days, 7 days, 14 days and 28 days respectively at **40% replacement** of Quarry dust in concrete while the **minimum** compressive strength is found 17.96 N/mm^2, 29.05 N/mm^2, 38.41 N/mm^2 and 40.31 N/mm^2 is at 3 days, 7 days, 14 days and 28

days respectively when **no replacement** of Quarry dust in concrete.

- The **maximum** flexural strength of concrete is found 3.21 N/mm^2 and 4.61 N/mm^2 at 7 days and 28 days respectively at **40% replacement** of Quarry dust in concrete while **minimum** flexural strength of concrete is found 3.16 N/mm^2 and 4.45 N/mm^2 is at 7 days and 28 days respectively when there is **no replacement** of Quarry dust in concrete.
- The **maximum** split tensile strength of concrete is found 3.01 N/mm^2 and 3.98 N/mm^2 at 7 days and 28 days respectively at **40% replacement** of Quarry dust in concrete while **minimum** flexural strength of concrete is found 2.77 N/mm^2 and 3.82 N/mm^2 is at 7 days and 28 days respectively when there is **no replacement** of Quarry dust in concrete.

For Both Bottom Ash and Quarry Dust:

- From above investigation we found that the **maximum** compressive strength of mix proportion is 17.96 N/mm^2, 29.05 N/mm^2, 38.41 N/mm^2 and 40.31 N/mm^2 at 3 days, 7 days, 14 days and 28 days respectively at **no replacement** of Bottom ash and Quarry dust in concrete while the **minimum** compressive strength is found 16.81 N/mm^2, 28.2 N/mm^2, 36.72 N/mm^2 and 40.31 N/mm^2 is at 3 days, 7 days, 14 days and 28 days respectively when **20% replacement** of Bottom ash and Quarry dust in concrete.
- The **maximum** flexural strength of concrete is found 3.16 N/mm^2 and 4.45 N/mm^2 at 7 days and 28 days respectively at **no replacement** of Bottom ash and Quarry dust in concrete while **minimum** flexural strength of concrete is found 3.12 N/mm^2 and 4.15 N/mm^2 is at 7 days and 28 days respectively when there is **10% replacement** of Bottom ash and Quarry dust in concrete.
- The **maximum** split tensile strength of concrete is found 2.77 N/mm^2 and 3.82 N/mm^2 at 7 days and 28 days respectively at **no replacement** of Bottom ash and Quarry dust in concrete while **minimum** flexural strength of concrete is found 2.59 N/mm^2 and 2.83 N/mm^2 is at 7 days and 28 days respectively when there is **20% replacement** of Bottom ash and Quarry dust in concrete.

A. Scope of the work

- To increase the speed of construction, enhance green construction environment we can uselightweight concrete.
- The possibility exists for the partial replacement of coarse aggregate with bottom ash aggregate to produce in thermal power plants waste materials.
- Bottom ash is compatible with the cement.
- Uses and applications of bottom ash and quarry dust as fine aggregate can reduce the cost of construction Materials and it is useful in environmental protection also..

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