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AN EXPERIMENTAL STUDY ON EFFECTIVE UTILIZATION OF BOTTOM ASH (ENNORE) AS FINE AGGREGATE IN CONCRETE UNDER FLEXURE

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Abstract

Since the construction industry is developing very fast the requirement of concrete and their constituent materials are also increasing day by day. Hence the need becomes in evitable to find various alternate means for the aggregate and accordingly the researchers are going on in this way. But the availability of fine aggregate becomes difficult day by day. Hence the need arises to find alternative for the fine aggregate. The material which is known as bottom ash is available ash waste by-product material from the thermal power plants. In India most of the thermal power plants use wet system for disposal of ash. Bottom ash will be generated as a residue after burning pulverised coal at boiler cyclone and collected from bottom ash hopper located under boiler structure.
In this project work the material bottom ash is experimentally analysed and studied for its suitability as replacement as fine aggregate up to (0% to 50%). So far few researchers analysed its suitability as FA by finding the compressive strength of concrete. But in this project work the split tensile strength of concrete and flexural strength of concrete were analysed by replacing bottom ash as fine aggregate.

Keywords: Bottom Ash; Compressive; Split Tensile; Flexural Strength of Concrete.

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1. Introduction

Aggregates are the important constituents in concrete. They give body to concrete, reduce shrinkage and effect economy.

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About 75% of concrete comprises aggregates. The properties and quantities of aggregates influence the strength. These are the inert or chemically inactive materials which form the bulk of cement concrete. These aggregates are bound together by means of cement. Concrete can be considered in two phase materials. They are paste phase and aggregate phase. The analysis and study of aggregate paste is also important.

When the characters and properties of aggregates are changing the strength and the property of resulting concrete will also be changed suitably. The study of aggregates are best done as their classification, source ,size, shape, texture, strength, specific gravity and bulk density, moisture content, bulking factor, cleanliness, soundness, durability, sieve analysis and grading.

Since the volume of construction industry is growing day by day the requirements of concrete and its constituent materials such as cement, fine aggregate and coarse aggregate are also increasing day by day.

Since the availability of natural resources is limited it is difficult to get more aggregates according to the increased trend of construction industry. Usually river sand is used as fine aggregate. Quantity of river sand availability is limited one. In India some specified rivers are supplying river sand as fine aggregate for the concrete. So this limited availability of fine aggregate and the increasing trend of construction industry results in the compulsory need of identifying the alternate material for fine aggregate. Hence in order to safeguard the natural wealth of rivers and to meet the increased requirements of fine aggregate construction industry people and researchers are suggesting finding the alternate material for fine aggregate for concrete.

Bottom Ash

India's power generation has undergone a tremendous growth since independence. The production of ash has also increased from 17.06 million tonnes during 1990-1991 to 68.82 million tonnes in 1996-1997 and crossed 100 million tonnes in year 2000. The ash needs to be managed properly or otherwise it will cause land, air and water pollution. Hence it is a serious concern about utilizing it to the maximum extent.

In wet disposal system the bottom ash from the boilers and the fly ash from the precipitators are mixed together and pumped off in the form of slurry to lagoons, where water is drained off or recycled. The material is being referred as bottom ash. About 1000 million tonnes of such ash referred to as bottom ash is available in India, almost free of cost.

Fly ah collected through hoppers has been widely accepted as a pozzolona and is being used by the cement manufacturing industries. Bottom ash being coarser and less pozzolanic is not being used for cement manufacturing. By observing recent reports, it seems that France leads the world by utilized 50% of fly ash followed by west Germany and United Kingdom, while India utilized hardly 1% of the annual fly ash production of nearly 100 million tonnes. So far bottom ash is not at all used for any purpose anywhere in the country. It was dumped as a waste by product in almost all thermal power stations.

In this project bottom ash was collected in Ennore thermal power station at Chennai District. The collected bottom ash was grey in colour. It seemed as river sand while seeing. If the bottom ash is not to be used properly or disposed from the power station site there will be more problems due to the storage of wastage materials.

2. Materials and Methods

Materials

- Cement
- Fine aggregate
- Coarse aggregate
- Bottom ash
- Super plasticizer

Cement

Cement is a fine, grey powder. It is mixed with water and materials such as sand, gravel and cursed stone to make concrete. Cement and water form a paste that binds the other materials together as the concrete hardens.

1) The color of the cement should be uniform.
2) The cement should give uniform cool feeling when touched with hand. If a small quantity of cement is thrown in a bucket of water should sink.
3) The compressive strength after three days should not be less than 16 N / mm²
4) The compressive strength after seven days should not be less than 22 N /mm²
5) The tensile strength after 3 days should be 2.0 N / mm²
6) The tensile strength after 7 days should be 2.5 N / mm².

Fine Aggregate

Sand used for experimental program was locally procured and conformed to is:383-1970.the sand was first through IS 4.75 mm sieve to remove any particles greater than 4.75 mm and then was washed to remove the dust it tested per is :2386-1963.the sand belongs to grading zone II.

Table 1: Properties of Fine Aggregate

S.No	Properties	Observed Value
1.	Fineness modulus	2.94
2.	Specific gravity	2.60
3.	Water absorption	Nil

Coarse Aggregate

The material which was retained on BIS test size 4.75 mm was termed as Coarse aggregate the broken stone is generally used as Coarse aggregate. The nature of work decide the the maximum size of Coarse aggregate.

The maximum size of 20 mm was used in work the aggregate was washed to remove the dust and dried to surface dry condition it tested by using IS :2386-1963.

Table 2: Properties of Coarse Aggregate

S.No	Properties	Observed Value
1.	Fineness modulus	6.25
2.	Specific gravity	2.60

Bottom Ash

In wet disposal system the pond ash from the boilers and the fly ash from the precipitators are mixed together and pumped off in the form of slurry to lagoons, where water is drained off or recycled. This material is being referred as bottom ash. About 1000 million tonnes of such ash referred to as bottom ash is available in India, almost free of cost.

Table 3: Properties of Bottom Ash

S.No	Properties	Observed Value
1.	Color	Light grey
2.	Specific gravity	2.17
3.	Fineness Modulus	1.25

Super Plasticizer

These are the modern type of water reducing admixtures, basically a chemical or a mixture of chemical that imparts higher workability to concrete. It consists of formaldehyde.

It is the use of sp which has made it possible to use bottom ash as fine aggregate and particularly to give high workability to the concrete. Here super plasticizer used is **CHERA PLAST.**

Mix Design M-20

Mix Proportion

- **Bottom ash: 0% to 50%**
- **Super plasticizer: 0.5 dosages**

Table 4: Mix Proportion

Water	Cement	Fine Aggregate	Coarse Aggregate
186kg/m^3	389kg/m^3	766kg/m^3	1150kg/m^3
0.5	1	1.67	2.95

Material Preparation

The selection of aggregate, sand and cement were in proportion accordance with the mix design and current practice used in making OPC concrete.

Mixing, Placing and Compaction

For casting, all the moulds were cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Care was taken that here is no gaps left from where there is any possibility of leakage out of slurry. Careful procedure was adopted in the batching, mixing and casting operations.

Size of Mould

- Cube = 150 mm X 150 mm X 150mm
- Cylinder = 150 mm X 300mm
- Beam= 100mm X 100mm X 500mm

Specifications

- M20 concrete with 0% bottom ash.
- M20 concrete with 20% bottom ash
- M20 concrete with 30% bottom ash
- M20 concrete with 40% bottom ash
- M20 concrete with 50% bottom ash

Table 5: Mix Proportion for Cubes, Cylinders and Beams in kg/m^3

Content	Cement	Fine aggregate	Coarse aggregate	W/c ratio	Bottom Ash (0%)	Bottom Ash (20%)	Bottom Ash (30%)	Bottom Ash (40%)	Bottom Ash (50%)
Cube	3.89	7.66	11.50	1.86	0	6.12	5.36	4.59	3.83
Cylinder	6.22	12.25	18.40	2.97	0	9.80	8.57	7.35	6.12
Beam	5.83	11.49	17.25	2.79	0	9.19	8.04	6.89	5.74

3. Results and Discussions

3.1. Result of Cube

Table 6: Result for compressive strength of concrete

S.NO	DESCRIPTION	Cube (N/mm^2)		
	M20 concrete	**7 Days**	**28 Days**	**56 Days**
1.	**M20 concrete (0% cc)**	28.9	43.4	56.4
2.	**M20 concrete + 20% bottom ash**	28.8	42.9	52.7
3.	**M20 concrete + 30% bottom ash**	24.2	35.2	38.4
4.	**M20 concrete + 40% bottom ash**	23.1	31.4	35.8
5.	**M20 concrete + 50% bottom ash**	20.4	24.2	26.3

The compressive strength of Bottom Ash Concrete was carried by compression testing machine of capacity 2000KN and universal testing machine (UTM). The load is applied without shock and increase continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load be sustained. The size of 150 × 150×150 mm cube specimens was casted with mix ratio of 1: 1.67: 2.95, water cement ratio of 0.50.The maximum load applied to the specimen was recorded and the appearance of the concrete and any unusual features in this type of failure were noted. The test results of

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compressive strength of concrete for 7, 28 and 56 days as shown in table. Based on the results the compressive strength of concrete with partially replaced 20% bottom ash shows equal results compare to conventional concrete.

3.2. Result of Cylinder

Table 7: Result for Split Tensile Strength of Concrete

S.NO	DESCRIPTION	Cylinder (N/mm^2)		
	M20 concrete	**7Days**	**28Days**	**56Days**
1.	**M20 concrete (0% cc)**	1.6	2.3	2.2
2.	**M20 concrete + 20% bottom ash**	1.7	2.5	2.3
3.	**M20 concrete + 30% bottom ash**	1.6	2.1	2.0
4.	**M20 concrete + 40% bottom ash**	1.4	2.0	1.9
5.	**M20 concrete + 50% bottom ash**	1.3	1.6	1.3

Figure shows the split tensile strength of partially replaced bottom ash concrete respectively. The size of 150 × 300 mm cylindrical specimens was casted with mix ratio of 1: 1.67: 2.95 water cement ratio of 0.50. A tests result on concrete shows the different combination levels of percentage for partially replacement of bottom ash as shown in table. The test results of split tensile strength of concrete for 7, 28 and 56 days as shown in table. Based on the results the split tensile strength of concrete with partially replaced 20% bottom ash shows gradual increasing results compare to conventional concrete.

3.3. Results of Beam

Table 8: Result for Flexural Strength of Concrete

S.NO	DESCRIPTION	Beam (N/mm^2)		
	M20 concrete	**7Days**	**28Days**	**56Days**
1.	**M20 concrete (0% cc)**	6.4	11	10
2.	**M20 concrete + 20% bottom ash**	6.3	9.5	9.1
3.	**M20 concrete + 30% bottom ash**	6.2	9.1	9
4.	**M20 concrete + 40% bottom ash**	5.5	7.6	8.1
5.	**M20 concrete + 50% bottom ash**	5.1	6.5	6.7

Figure shows the flexural strength of Bottom Ash Concrete. The size of 500 × 100 × 100 mm beam specimens was casted with mix ratio of 1: 1.67: 2.95 water cement ratio of 0.50.. A tests result on concrete shows the different combination levels of percentage for partially replacement of bottom ash as shown in table. The test results of flexural strength of concrete for 7, 28 and 56 days as shown in table. Based on the results the flexural strength of concrete with partially replaced 20% bottom ash shows equal results compare to conventional concrete.

4. Conclusions & Recommendations

The following conclusions are drawn the observation of the compressive strength test, split tensile strength test and flexural strength test made by using the bottom ash as partly replacement for fine aggregate from 0% to 50%.

1) The density of concrete reduces with the increase in the percentage of bottom ash.
2) The compressive strength of concrete with bottom ash increases with increased curing period.
3) The split tensile strength of concrete with bottom ash increases with increased curing period.
4) While bottom ash is used the workability is reduced. For obtaining the required workability the super plasticizers are added while preparing the concrete. The more bottom ash we add the more super plasticizers are required to be added for obtaining the required workability.
5) With increasing replacement of fine aggregate with bottom ash, the average density of concrete shows a linear reduction due to its lower specific gravity.

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