Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 8, July 2021: 4658-4678

An Experimental Investigation On Strength Characteristics Of Concrete With The Partial Replacement Of Fine Aggregate By Coal Bottom Ash

[1] Dr. K. SURESH, [2] Dr. M. VENKATESHWARLU, [3] B. LAKSHMI NARAYANA

[1] PROFESSOR & HOD, [2] PROFESSOR, [3] PG STUDENT
Dept of CIVIL ENGINEERING
CMR COLLEGE OF ENGINEERING & TECHNOLOGY, HYDERABAD
[1]hodcivil@cmrcet.ac.in, [2] drmvenkateshwarlu@cmrcet.ac.in, [3] narayan109109@gmail.com

ABSTRACT: The natural resources of the sand are becoming depleted gradually. Mining of sand leads to various environmental hazards. The demand for the protection of the natural environment and the ban on mining in some areas is further making a problem (aggravating) to river sand. Using a partial replacement of sand by coal bottom ash, the work is assisted to developing a better understanding on strength characteristics of concrete. Bottom ash is a byproduct of burning of pulverized coal. It is also one of the major solid wastes coming from power plant or thermal power plants industries; it is composed mainly of silica, alumina, calcium, magnesium sulphate and iron. The paper presents the experimental investigation administered to review the effect of use of coal bottom ash as a partial replacement of fine aggregate. An experimental program is planned in which controlled concrete grade M30 is used. Fine aggregate is replaces with bottom ash by 0%, 10%, 20%, 30%, 40% and evaluating its Compressive strength, Split tensile strength, Flexural strength. Test results show that bottom ash is often used as an efficient replacement of fine aggregates. Workability decreases with the rise of bottom ash content. The compressive strength, tensile strength, flexural strength was effective up to 30% replacement level. Therefore 30% of the fine aggregates maybe replaced with Coal bottom ash effectively.

KEYWORDS: Coal bottom ash, concrete, Compressive strength, Split tensile strength, flexural strength.

I.INTRODUCTION

1.1 General:

Concrete is extensively used in a variety of building projects. Because the demand for the use of fine aggregate is growing, researchers are attempting to replace sand with alternative materials from an economic standpoint as well as to reduce air pollution by either preserving or improving characteristics utilising waste resources. The goal of this research is to examine the various engineering characteristics of concrete produced with fine aggregate substituted by power plant trash (Bottom ash). The fine aggregates used in the manufacture of concrete assembly were natural river sand, which has now surpassed water as the most extensively used natural resource on the planet. Sand usage in the globe is projected to be 1 crore and 50 lakh tonnes per year. Sand has become a vital material for our contemporary economy during the past two centuries. As a result of their preservation and conservation of natural resources, the development industry is looking for new component materials for concrete. There is a need to replace sand with other building materials to prevent environmental impacts and reduce natural dangers. As a result, the fine aggregate is replaced with (bottom ash). This ash is dark grey in colour and about the size of sand. This ash is collected in a water-filled hopper at the furnace's rock bottom and washed away by high-pressure water jets. It's put in a collecting pond and then kept for eventual disposal or recycling. This massive quantity of trash has become a global problem that requires immediate action from nations who rely on coal as a source of electricity. The value of creating additional landfill areas, transportation, and operating reclamation facilities will rise substantially as the amount of bottom ash accumulates. As a result, plant managers started to cooperate with academics and businesses in order to fully use the massive quantity of bottom ash that had collected.

Over 72 percent of India's energy is generated via the burning of fossil fuels, with almost half of it coming from coal-fired power plants or thermal power plants, which emit approximately 1500 mega tonnes of bottom ash each year. It's dumped in open areas and dumped in huge numbers near water bodies. This results in environmental hazards; to avoid these types of environmental effects, alternative utilisation materials must be used in a variety of processes, such as road pavements, construction practises, and cement factory production, among others, which aids in the reduction of ash content and reduces the use of natural resources.

An experimental study on the strength properties of concrete with the partial replacement of sand by coal bottom ash, as well as the impact of using coal bottom ash, is presented in this article.

1.2 Definition:

Bottom ash is a by-product of coal combustion collected at the furnace's bottom. The majority of bottom ash is generated by thermal or coal-fired power plants. When pulverised coal is burnt in a bottom boiler, the flue gas catches most of the unburned particles, which is collected as fly ash. Bottom ash accounts for up to ten percent to twenty percent of this ash. It's grey in colour and approximately the size of a grain of sand. In other words, huge quantities of ash, as well as carbon dioxide and other gases, are produced during coal burning. Bottom ash refers to fine particle ash that does not rise and is referred to as coal bottom ash collectively.

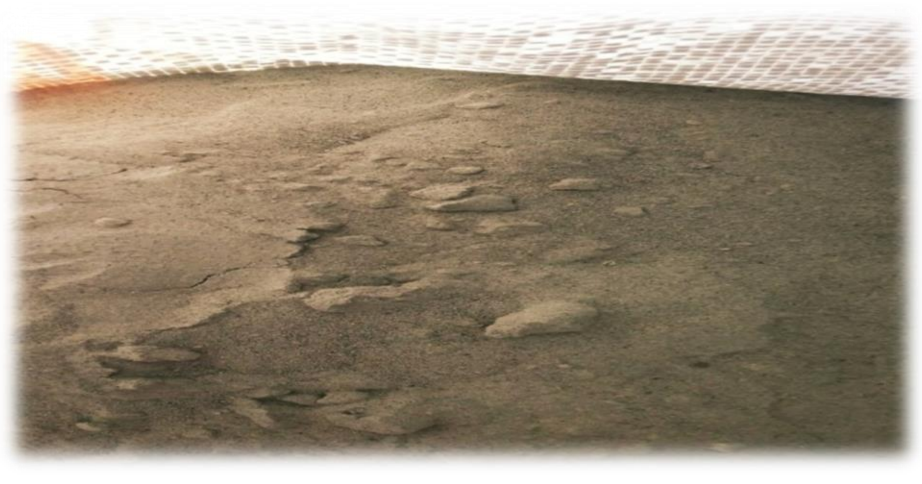


Fig: 1.1.Coal Bottom ash

1.3 Application of Bottom ash:

According to the literatures examined in order to gain information about the use of bottom ash as a building material and in other civil engineering sectors, the following uses have emerged: It is used in a variety of ways, in construction and for other environmental purposes:

1. Bottom ash is utilised in artificial reefs, roadways, and liners as a building material.

2. It's utilised in abandoned mines as structural fill or land fill.

3. Use as a soil amendment in agriculture.

4. Concrete masonry blocks, as well as lightweight and partial aggregate replacement.

5. Use in concrete and school running tracks as a component element.

6. As a railroad fill material and abrasive blasting grit, it's widely utilised.

7. As a top layer for unpaved roads and as cinders for snow-covered roads.

1.4 Necessity of Coal Bottom ash:

Thermal plant by-products such as bottom ash must be reused in order for coal-fired electricity production to be sustainable. However, by reducing energy and raw material consumption, coal bottom ash (CBA) utilised as a Portland cement component portion would aid in more predictable cement manufacturing.

1.5 Objective study:

This research aims to investigate the different engineering characteristics of a concrete produced using power plant trash in lieu of fine aggregate (Bottom ash). Traditional concrete tests such as compressive strength, split tensile strength, and flexural strength are included in the experimental studies.

The goal of this project is to create concrete that is both strong and long-lasting. This necessitates the utilisation of various thermal power plant waste products, such as Bottom ash. As a result, the following experimental programme will be implemented:

- To determine whether or not thermal power plant waste material (bottom ash) can be used effectively to meet the desired requirements.
- Determine the best superplasticizer dosage for maximum workability in M30 grade concrete.
- Obtaining the best percentage of Bottom ash with a proportionate concrete dosage
- Research concrete's strength characteristics (compressive, split tensile, and flexural strength).
- Results comparison/evaluation.

1.6 Scope of the work:

- Several concrete mixtures were created. Compressive strength, split tensile strength, and flexural strength are the primary characteristics investigated.
- The mechanical characteristics of this concrete were compared to those of traditional concrete. The current research utilised replacement percentages of 0 percent, 10 percent, 20 percent, 30 percent, 40 percent, and 50 percent of Bottom ash with fine aggregate for each replacement of fine aggregate.
- Concrete specimens were produced to evaluate mechanical characteristics.
- Cubes' compressive strengths differ from cylinders' tensile strengths and prisms' flexural strengths (Beams).
- After 7, 14, and 28 days of curing, the outcomes of the specimens were discovered.

II.METHODOLOGY

2.1 Introduction:

It is essential to extract information from all of the materials used in the concrete production process. Ordinary Portland cement (OPC), fine aggregate, coarse aggregate, thermal power plant by-product (Bottom Ash), and water are the components used in this project. In this project, admixture (sp-45 super plasticizer) is also utilised. All of the materials utilised in the research were subjected to rigorous testing in line with Indian regulations.

2.2 Materials used and their specifications:

2.2.1 Cement

Cement is a binding substance that holds all of the materials together. Deccan ordinary Portland cement of grade 53 according to IS: 12269-1987 was utilised in this research.

Fig: 2.1.Cement

Table-2.1 physical properties of cement

S. No	Property Name	Test Result
1.	Specific gravity	3.10
2.	Fineness	4.5%
3.	Standard consistency	31.3%
4.	Initial setting time	36min.
5.	Final setting time	548min.

2.2.2 Fine aggregate

The purpose of fine aggregate is to help fill voids and achieve mix homogeneity. Natural river sand is often utilised in this research, with only as much coarser than is allowed by specification passing through a 4.75mm IS sieve.

According to the source, fine aggregate is:

• Aggregate formed by natural disintegration of rock and deposited by streams or glacial forces

• Sand is classified as coarse, medium, or fine sand based on size. The fine aggregate utilised was zone-II compliant according to IS: 383-1970.

Fig: .2.2 Fine aggregate

Table- 2.2 Physical properties of Fine aggregate

S. No	**Property Name**	**Test Result**
1.	Specific gravity	2.64
2.	Fineness modulus	3%
3	Water absorption	1.34%
4.	Bulk density	1560kg/m^3
5.	Grading zone	Zone-II

2.2.3 Coarse aggregate

As coarse aggregate, crushed granite stone from the area is utilised. It must be devoid of contaminants and clean. The course aggregate confirmed to single sized aggregates of nominal size 20mm as per IS 383-1970, according to the sieve analysis. It decreases the shrinkage effect in concrete and provides it strength, toughness, and hardness. It takes up almost half of the concrete in the mix.

Fig: 2.3. coarse aggregate (20mm)

Table- 2.3 Physical properties of Coarse aggregate

S. No	Property Name	Test Result
1.	Specific gravity	2.76
2.	Fineness modulus	7.42%
3	Impact value	20.10%
4.	Bulk density	1610kg/m^3
5.	Crushing value	19.69%

2.2.4 Water

Water is an essential component of Mortar because it aids in the chemical interaction between cement and water. Because it contributes to the strength of the cement paste, the amount and quality of water must be carefully considered.

Both mixing and curing were done using potable water in the experiments. In the study, the water cement ratio derived from the design mix (w/c=0.45) was utilised. It also acts as a lubricant in cement and fine aggregate mixtures.

2.2.5 Admixture (super plasticizer)

Roofplast SP-45 is a super plasticizer used as a chemical additive to aid in the manufacture of high-quality concrete. It is also a water lowering agent for cement concrete, allowing for a lower water-to-cement ratio while increasing the concrete's compressive strength and workability. Hari Karthika Engineering Pvt Ltd. at Chikadapally, Hyderabad, provided it.

- Roofplast-SP45 has a few benefits, including:
- It enhances concrete's flow and workability.
- Chloride-free materials are resistant to corrosion.
- Concrete with a high density, low permeability, and a smooth surface finish with low porosity.
- It achieves great strength by adjusting the water cement ratio.

Fig:2.4 Admixtures (sp-45)

Table- 2.4 Physical properties of Admixture

S. No	Property Name	Test Result
1.	colour	Light brown liquid
2.	Sp. gravity	1.220to1.228 at 30 deg. C
3.	Chloride content	Nil according to IS:456
4.	Air entrainment	1%

2.2.6 Bottom ash

Bottom ash is a by-product of the thermal power plant sector; it is dark grey in colour and about the same size as sand. It comes from the Kothagudem Thermal Power Station in Paloncha, Telangana, which has a capacity of approximately 1750 MW.

Fig: 2.5. Bottom Ashes

Table- 2.5 Physical properties of Bottom ash

S. No	Property Name	Test Result
1.	Colour	Grayish
2.	Specific gravity	2.1

3.	Fineness	2.61%
4.	Water absorption	1.6%

Table- 2.6 chemical composition of Bottom ash

S. No	Chemical name	Formula	Percentage (%)
1.	Silicon dioxide	SiO_2	57.03
2.	Aluminum oxide	Al_2O_3	25
3.	Calcium oxide	CaO	1.03
4.	Magnesium oxide	MgO	0.85
5.	Sulfur trioxide	SO_3	6.15
6.	Ferric oxide	Fe_2O_3	2.18
7.	Titanium dioxide	TiO_2	0.17

2.3 Material Tests:

2.3.1 Specific gravity of cement

The weight of a certain volume of material divided by the weight of the a same amount of water Kerosene is used to measure the specific gravity of cement since it does not react with it.

The goal is to use a specific gravity bottle to measure the specific gravity of cement.

Apparatus: 100ml specific gravity bottle, capacity balance with 0.1gm accuracy.

Procedure:

- Clean and dry the specific gravity container before using the stopper to weigh it (W1).
- Fill at least half of the specific gravity container with cement sample and weigh with stopper (W2).
- Fill the kerosene-filled specific gravity container holding the cement with kerosene (no water) and weigh it (W3).
- Do not allow any air bubbles to remain in the specific gravity container while performing the above.

- The bottle must be washed and dried once it has been weighed. Then add new kerosene and weigh it with a stopper (W4).
- Empty the bottle of kerosene and replace it with a full bottle of water, weighing it with the cork (W5).
- All of the above weighing should be done at a temperature of 27°C + 10°C.
- Kerosene has a specific gravity of 0.79.

Calculation: Specific Gravity of cement = $W_2 - W_1 \times (W_4 - W_1) / (W_4 - W_1) - (W_3 - W_2) \times$

$$(W_5 - W_1)$$

2.3.2 Normal consistency of cement

In this test, the Vicat plunger should penetrate to a position 5 to 7 mm from the bottom of the Vicat mould. The quantity of water is given as a percentage [by weight] of dry cement. Normal consistency is another name for standard consistency.

A certain minimum amount of water must be mixed with cement in order to complete the chemical reaction between water and cement. If there is less water than this, the chemical reaction will not be completed, resulting in reaction strength. If there is more water, the water cement ratio will increase, reducing the strength. As a result, the proper w/c ratio is needed.

IS: 4031 (Part-4) - 1988, IS: 5513-1976,

Aim: To find out how much water is needed to make a standard consistency cement paste that may be utilised in other experiments.

Apparatus:

1. Vicat apparatus with plunge, I.S. Sieve No. 9, Measuring jar, weighing balance, stopwatch

Procedure:

- A D-frame with a moveable rod makes up the vicat apparatus. The moveable rod is equipped with an indicator that displays the penetration on a vertical scale.
- To determine the usual consistency of cement, a plunger with a diameter of 10 mm and a length of 50 mm is connected to the moveable rod.
- Add 30 percent by weight (90 ml) water to 300 gm of cement sieved using I.S. Sieve No. 9. In 3 to 4 minutes, fully mix water and cement on a non-porous surface.
- The vicat mould is filled with cement paste, and the top surface is smoothed with a trowel. The full mould, together with its bottom non-porous plate, should be put on the vicat apparatus's base plate, centrally below the moveable rod. The plunger is pushed into the paste rapidly. The plunger's settlement is recorded. The water supplied is correct if the penetration is between 33 mm and 35 mm from the top (or 5 mm and 7 mm from the bottom). If the penetration is less than

desired, the procedure is repeated using various water percentages until the desired penetration is achieved.

- The findings were presented as a percentage..

III.MIX DESIGN&EXPERIMENTAL PROGRAMME

Concrete mix design is the process of choosing appropriate concrete components and calculating their relative quantities with the goal of creating a concrete with the necessary strength, durability, and workability as cheaply as feasible.

Bottom ash is utilised as a partial substitute for fine aggregate in concrete in an experimental programme, and examples were cast, cured, and evaluated for fresh concrete and hardened concrete using different additive liquid to bottom ash ratios.

3.1 Experimental Investigation:

M30 Concrete design mix as per IS: 10262-2009, obtained mix proportions are:

1:1.7241:2.5178

Table- 3.1 Quantities of M30 concrete design mix

S.No	Material Name	Quantity (kgs/m^3)
1.	Cement	429.3707
2.	Fine aggregate	740.2787
3.	Coarse aggregate	1081.0610
4.	Bottom ash	93.035 kgs for 5mix ratios
5.	Water	193.22
6.	Admixture(super plasticizer)	2

Table- 3.2 Quantities of percentage replacement with various different ratios

S.No	%Replacements	Cement (kgs)	Fine aggregate (kgs)	Coarse aggregate (kgs)	Water (liters)	Bottom ash (kgs)	Admixture (ml)
1.	0%	35.960	62.010	90.540	16.139	0	330
2.	10%	35.960	55.089	90.540	16.139	6.201	330

3.	20%	35.960	49.608	90.540	16.139	12.402	330
4.	30%	35.960	43.407	90.540	16.139	18.603	330
5.	40%	35.960	37.206	90.540	16.139	24.804	330
6.	50%	35.960	29.185	90.540	16.139	31.005	330
Total		**215.760**	**276.505**	**543.240**	**96.834**	**93.015**	**1980**

3.3.1 Preparation of specimens:

Before the concrete is poured into the moulds, the moulds are cleaned and treated with mineral oil on both sides. On a typical level platform, the moulds are positioned. Immediately after mixing, the well-mixed concrete is poured into the moulds in three or more layers, compressed with hand strokes. Excess concrete was troweled away, and the top surface level was completed and smoothed off in accordance with IS 516- 1969.

• Cubes

For M30 grade concrete, standard cube size of 150150150mm constructed of cast iron were utilised to determine compressive strength for each cube.

Fig: 3.1 Cube moulds

- **Cylinders**

The typical cylinder dimensions are 300mm and 150mm. For the M30 grade of concrete, cast iron was utilised to determine split tensile strength of each specimen.

Fig: 3.2. cylindrical moulds

- **Prism's (beams)**

The beam is 700150150mm in length and is constructed of iron. M30 grade concrete was utilised to provide flexural strength for each cylinder.

Fig: 3.3. Beam moulds

3.3.2 Mixing:

Cement mixing may simply be described as the "full blending of the ingredients needed for the creation of a homogenous mix that yields homogeneous concrete."

The manual technique of mixing was used in this thesis, using the following hand mixing procedure:

- Clean the earthen platform that was utilised for concrete mixing.
- On the mixing platform, spread out the necessary coarse aggregate.
- Evenly distribute fine aggregate and bottom ash on top of the coarse aggregate layer. This is used to fill spaces.
- Using a consistent spread of cement over coarse and fine aggregates will provide a proper mix at each layer and create bonding between the components.

- Then, three or four times at a level of mix, combine all ingredients.
- Make a depression in the centre of the mixture and gently pour water into it. Mix it thoroughly with a trowel and shovel until it achieves a homogeneous mix, as well as adding various additional admixtures to improve concrete workability and decrease water flow ability.
- Once you have it, you may use it to make the concrete specimens you need.

Fig: 3.4. concrete mixing progress

3.3.3 Casting and compaction of specimens:

The standard moulds were installed with no gaps between the plates of the moulds. Small holes were repaired with plaster of Paris if necessary. After that, the moulds are lubricated and kept ready for casting. The wet mix is poured in three stages into the moulds, with each layer receiving 25 tamping rod blows. Is the process of removing entrapped air in new concrete and packing all aggregate elements together to form a connection between them in order to improve the concrete's durability and strength. To guarantee a top uniform surface, the top surface was planed using a trowel at the conclusion of the casting process. Each specimen may be identified by identification on top, bottom, or sides using a waterproof paint or any other ink after 2-3 hours of casting.

Cubes: sizes are 150×150×150mm

Fig: 3.5.Casting and Compaction of Cubes

Cylinders: 300mm height×150mm diameter

Fig:3.6 Casting and Compaction of Cylinders

Beams: sizes are 700mm×150×150mm:

Fig: 3.7. Casting and Compaction of Beams

Overall testing was done on 3 cubes, 3 cylinders, and 3 beams in each ratio/batch.

3.3.4 Demouding:

Between 16 and 24 hours after being produced, test cubes should be demoulded. If the concrete has not reached a sufficient strength to allow demoulding without destroying the cube after this time, Take the mould apart entirely before removing the concrete cube from it. Take care not to scratch the cube since any breaking would decrease the compressive strength.

Fig: 3.8. De-moulding of specimens

3.3.5 Curing:

After all of the specimens had been cast and demoulded, they were maintained in the same environment for 24 hours, with a temperature of 272°C and a relative humidity of 90%. The specimens were taken out of the mould and placed in fresh water until they were ready to be tested. The water in which the cubes were submerged was kept at a constant temperature of 27 2 C. The specimens were cured for seven, fourteen, and twenty-eight days, respectively.

Fig: 3.9 curing tank

IV.RESULTS AND DISCUSSION

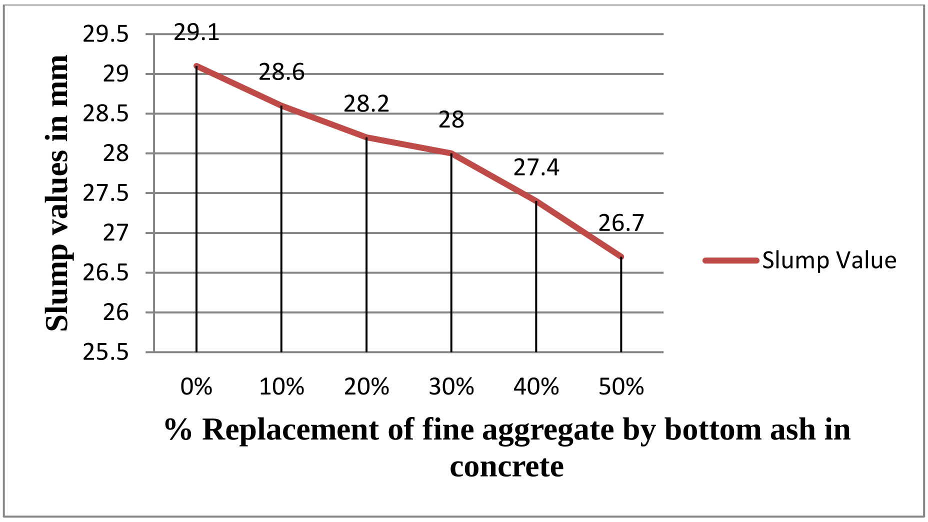
4.1 Workability Test Results

IS: 456-2000 is the Indian standard code. The slump value is determined by the placement circumstance (Type of structure). According to the findings, It is utilised in mass concrete, weakly reinforced sections in slabs, beams, columns, and floors with a slump of 25-75.

The findings of the slump cone tests for conventional and bottom ash concrete are described below.:

Table-4.1 Slump cone test results

S.No	**w/c ratio**	**Percentage replacement of fine by bottom ash**	**Type of slump**	**Slump value in (mm)**
1.	0.45	0%	True Slump	29.1
2.	0.45	10%	True Slump	28.6
3.	0.45	20%	True Slump	28.2
4.	0.45	30%	True Slump	28
5.	0.45	40%	True Slump	27.4
6.	0.45	50%	True Slump	26.7



Graph No. - 1 Slump cone test results

From the graph above, it can be seen that the slump value falls somewhat when the proportion of bottom ash in concrete is increased.

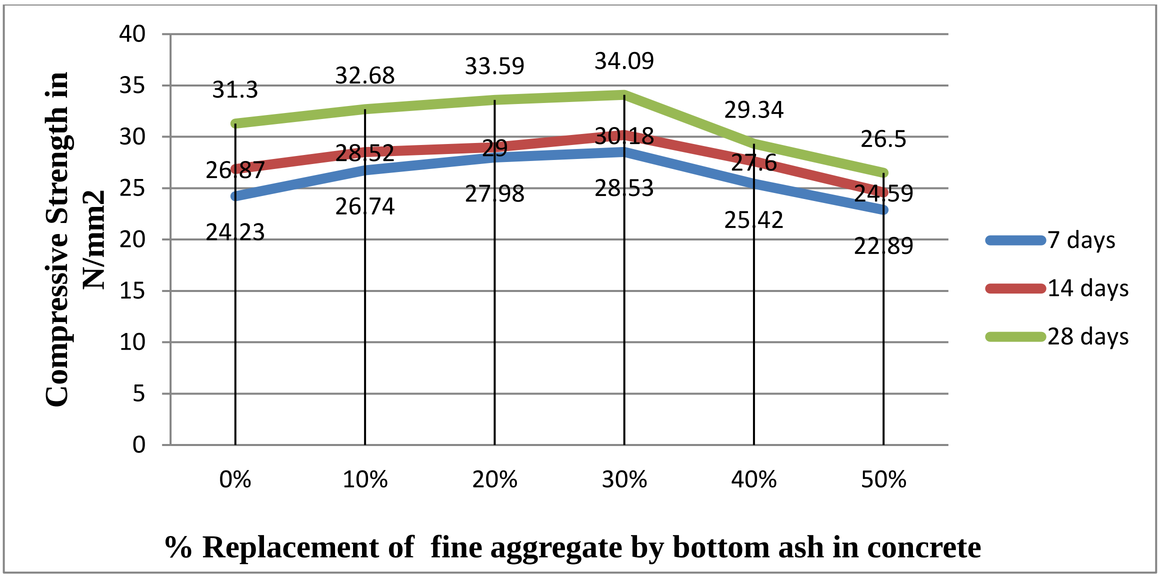
4.2 Compressive Strength Test Results:

A compression testing equipment is used to determine the compressive strength of concrete cubes. 150*150*150mm is the typical concrete cube size. After a seven-day, fourteen-day, and twenty-eight-day curing time, the tested cubes are chosen, and the compressive test results are given below:

Table-4.2 compressive strength test results

S. No	Percentage Replacement of Fine aggregate by Bottom ash in concrete (%)	Compressive strength (N/mm^2)		
		7 days	14 days	28 days
1.	0%	24.23	26.87	31.30
2.	10%	26.74	28.52	32.68
3.	20%	27.98	29.00	33.59
4.	30%	28.53	30.18	34.09
5.	40%	25.42	27.60	29.34
6.	50%	22.89	24.59	26.50

Graph No. - 2 Compressive strength test results



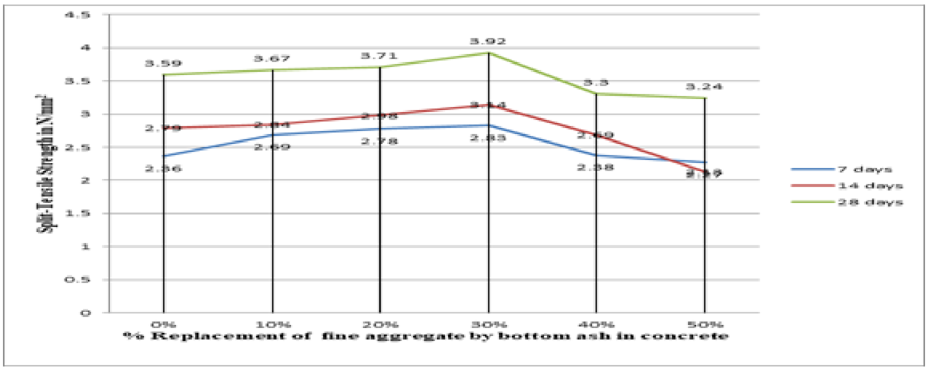
The test results of compressive strength test are improving the compressive strength characteristics of partial replacement 30 percent of bottom ash by fine aggregate in concrete, as shown in the graph above.

4.3 Results of the Split-Tensile Strength Test:

Compressive testing machines are used to determine the split-tensile strength of concrete cylinders. The dimensions of a typical concrete cylinder are 300mm h150mm dia. After a curing time of 7, 14, and 28 days, the tested cylinders are chosen, and the split-tensile test results are given below.:

Table-4.3 Split-tensile strength test results

S. No	Percentage Replacement of Fine aggregate by Bottom ash in concrete (%)	Split-tensile strength (N/mm^2)		
		7 days	14 days	28 days
1.	0%	2.36	2.79	3.59
2.	10%	2.69	2.84	3.67
3.	20%	2.78	2.98	3.71
4.	30%	2.83	3.14	3.92
5.	40%	2.38	2.69	3.30
6.	50%	2.27	2.13	3.24



Graph No. – 3 Split-Tensile strength test results

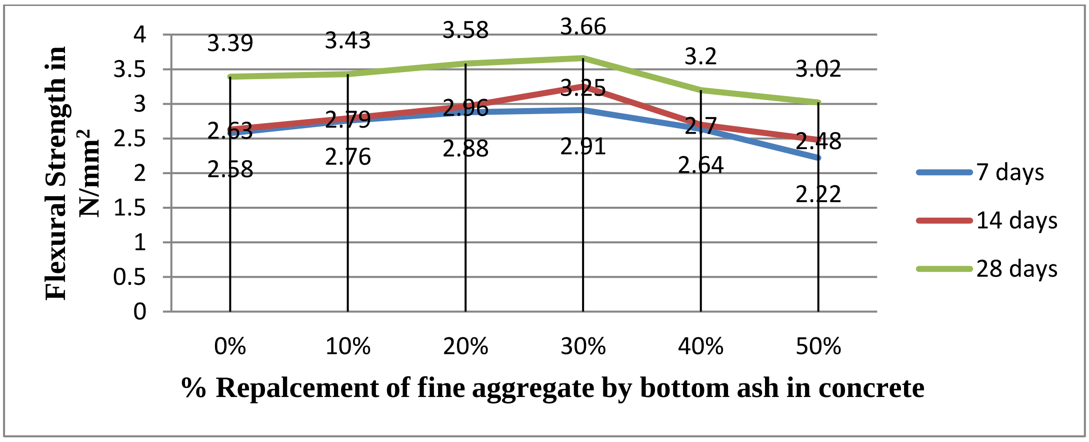
The test results of the Split-tensile strength test are improving the Split-tensile strength features of partial replacement 30 percent of bottom ash by fine aggregate in concrete, as shown in the graph above.

4.4 Results of the Flexural Strength Test:

Flexural testing equipment is used to determine the flexural strength of concrete beams. The dimensions of a typical concrete beam are 700*150*150mm. After a curing time of 7, 14, and 28 days, the tested beams are chosen, and the Flexural test results are given below.:

Table-4.4 Flexural strength test results

S. No	Percentage Replacement of Fine aggregate by Bottom ash in concrete (%)	Flexural strength (N/mm^2)		
		7 days	14 days	28 days
1.	0%	2.58	2.63	3.39
2.	10%	2.76	2.79	3.43
3.	20%	2.88	2.96	3.58
4.	30%	2.91	3.25	3.66
5.	40%	2.64	2.70	3.20
6.	50%	2.22	2.48	3.02



Graph No. – 4 Flexural strength test results

The test results of Flexural strength test are improving the Flexural strength characteristics of partial replacement 30 percent of bottom ash by fine aggregate in concrete, as shown in the graph above.

V. CONCLUSIONS

Apart from the kind of drawbacks, bottom ash offers a lot of applications since the coin always has two sides. High applicability in building goods, clean manufacturing, and CO2 emission and waste stabilisation are only a few of the main benefits. The most significant drawback is a lack of knowledge about the presence of bottom ash.

• The compressive strengths for 7,14, and 28 days were raised up to 0-30 percent replacement of fine aggregate by bottom ash in concrete, then compressive strengths were reduced for further replacement based on experimental work.

• Bottom ash is often utilised as a fine aggregate substitute.

• When compared to ordinary concrete, the densities of hardened concrete dropped linearly when the replacement percentages of bottom ash were raised beyond 30%. Bottom ash has a lower relative density than fine aggregates, which contributes to the problem.

• The workability of new concrete as measured by the slump cone test is progressively diminishing as the amount of bottom ash in the concrete increases, as is the case with the rise in water demand.

• Furthermore, after 30 percent replacement of bottom ash, the strength progressively deteriorates.

• When comparing the compressive strength of bottom ash replacement concrete to ordinary concrete, the findings are promising.

• For a period of 28 days, the highest compressive strength achieved was 34.09N/mm2.

• For a period of 28 days, the highest flexural strength achieved was 3.66 N/mm2.

• For a period of 28 days, the highest split-tensile strength achieved was 3.92 N/mm2.

• After 28 days, the strength differences between bottom ash concrete and ordinary concrete will go away.

Based on the above, it's been determined that the best use of Bottom ash in concrete as a fine aggregate substitute is 0-30 percent to encourage a substantial design mix.

REFERENCES

1. Abdu's Salaam Cadersa, (2014): "Assessing the Durability of Coal Bottom Ash as Aggregate Replacement in Low Strength Concrete", Journal of Emerging Trends in Engineering and Applied Sciences (ISSN: 2141-7016) 5(5): 344-349.
2. IS: 10262-2009 'Recommended Guidelines for Concrete Mix Design. 'Bureau of Indian Standards, New Delhi, India.
3. Ranapratap P (2016): "Effect of replacement fine aggregate with bottom ash in M40 grade of concrete with OPC-53 grade cement". International of Research in Engineering and Technology.
4. Soman K., Divya Sasi, Abu baker K.A. (2014) 'Strength properties of concrete with partial replacement of sand by bottom ash' International Journal of Innovative Research in Advanced Engineering, Volume .1 Issue 7 (August 2014), pp.223-227.

5. P. Aggarwal, Y. aggarwal, SM Gupta. “Effect of bottom ash as replacement of bottom ash as replacement of fine aggregates in concrete. Construction and building materials.”Asian Journal of Civil Engineering, 8(1), 49-62 (2007).
6. IS: 456-2000, ‘Indian Standard Code for Practice for Plain and Reinforced Concrete’ Bureau of Indian Standards, New Delhi, India
7. IS: 12269-1987 ‘Specifications for 53-Grade Portland Cement’ Bureau of Indian Standards, New Delhi, India.
8. M.P.Kadam, Y.D. Patil.“Effect of coal Bottom ash as sand Replacement on The Properties of Concrete with different W/S Ratio ” International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 - 5161.(2013).
9. M.S Shetty, S.Chand (2013) ‘Concrete technology, theory and practice’ Tata McGrah Hill Company Ltd, New Delhi.
10. Abhishek Sachdeva, Gobind khuran, (2015): “Strength Evaluation of Cement Concrete Using Bottom Ash as a Partial Replacement of Fine Aggregates”. (IJSET), Volume 3, Issue 6.
11. Vikas R Nadig. (2015). “Bottom Ash as Partial Sand Replacement in Concrete –A Review”. Journal of Mechanical and Civil Engineering, Volume 12, Issue 2.
12. M30 Design mix was considered as per ISR guidelines IS:10262-2009 and by taking reference of virtual labs@ NITK surathkal & Concrete Technology text book (Ms.shetty)
13. IS: 516-1959 ‘Indian Standard Code for Practice- Methods of Test for Strength of Concrete’ Bureau of Indian Standards, New Delhi, India.
14. Bai Y and Basheer P.A.M. (2003) Influence of furnace bottom ash as fine aggregate on properties of concrete. Structures and Buildings Vol. 156, No. 1, pp 85-92.
15. Remya Raju, Mathews M. Paul and K. A. Aboobacker, “Strength Performance of Concrete using Bottom Ash as Fine Aggregate”, International Journal of Research in Engineering & Technology (IJRET), ISSN (e): 2321-8843, ISSN (p): 2347-4599, Volume 2, Issue 9, September 2014, pp.111-122.
16. IS 516- 1959 Method of Tests for Strength of Concrete, BIS, New Delhi.
17. IS 5816 – 1970 Methods of test for split-tensile strength of concrete for cylinders, BIS, New Delhi.