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EVALUATION OF STRENGTH OF CONCRETE ON PARTIAL REPLACEMENT OF CEMENT WITH COAL ASH

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Abstract:
We are aware that a lot of damage is done to environment in the manufacture of cement. It involves lot of carbon emission associated with other chemicals. The researches has shown that every one ton of cement manufacture releases half ton of carbon dioxide, so there is an immediate need to control the usage of cement, On the hand materials wastes such as coal ash is difficult to dispose which in return is environmental hazard, therefore the use of coal ash in concrete not only reduces the environmental pollution but also enhances the properties of concrete and also reduces the cost It makes the concrete more durable.
This study investigates the impact of partial replacement of cement with coal ash on the strength properties of concrete. Coal ash, a byproduct of coal combustion, has been increasingly considered as a supplementary cementitious material due to its pozzolanic properties and potential to mitigate environmental concerns associated with its disposal. The evaluation focuses on various mix proportions with different percentages of coal ash substitution, aiming to ascertain its effect on compressive strength, tensile strength, and flexural strength of concrete specimens.
This paper mainly deals with the replacement of cement with coal ash in fixed proportions. The concrete mix designed by varying the proportions of Coal ash for 10%, 20%, and 30% the Cubes, Cylinders and beams are been casted and cured and tested on 28days.The test result indicate that the strength of concrete increases up to 20% Coal ash replacement with cement. The findings provide insights into optimizing concrete mix designs to achieve desired strength characteristics while incorporating coal ash as a sustainable alternative to cement, thus contributing to the sustainable development of construction materials.

Keywords:
carbon emission, coal ash, pozzolonic properties, flexural strength.

1.Introduction:

The generation of fly ash in India has increased from 68.88 million tones to 163.56 million tones in 2012-2013 ,of which only 100.37 million tones was utilized. India has achieved a tremendous increase in its utilization from 9.63% in 1996-97 to 61.37% in 2012-13. Bottom ash is the coarse, granular, incombustible by-product of coal combustion that is collected from the bottom of furnaces. . When pulverized coal is burned in a bottom boiler, most of the un burned material is caught in the flue gas and captured as fly ash. Only about 10-20% of this ash is bottom ash. Although the total coal ash generation varies from year to year, (depending on the amount and ash content of the coal burned) the amount of coal ash has been increasing since 1996. 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, mercury, cadmium, 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. Bottom ash that is not to be recycled is discarded in landfills or storage lagoons. If the bottom ash goes to a storage lagoon, it is generally mixed with fly ash and referred to collectively as ponded ash.

Coal Classification:
Coal is classified into three major types namely anthracite, bituminous and lignite. However there is

no clear demarcation between them and coal is further classified as semi- anthracite, semi-bituminous and sub-bituminous.

- Class F is Coal ash produced from burning anthracite or bituminous Coal and Class C is produced from the burning of sub-bituminous coal and lignite.
- Class F is low in lime, under 15 % and contains a greater combination of silica, alumina and iron(greater than 70 %) than class C fly ash.
- Class F Coal ash comes from coals which produce an ash with higher lime content generally more than 15 % often as high as 30 %. Elevated CaO may give class C unique self-hardening characteristics.

Reusing coal ash can create many environmental , economic and product benefits including:

- Environmental benefits such as reduced green house gas emissions, reduced need for disposing in landfills and reduced use of other materials, improves performance and quality of concrete, reduces water demand, reduces segregation and bleeding, lowers heat of hydration and reduces permeability.
- Economic benefits such as reduced costs associated with coal ash disposal, increased revenue from the sale of coal ash and savings from using coal ash in place of other more costly materials.
- Product benefits such as improved strength, durability and workability of materials.

1.2 Objectives of the work

The objective of the work is to find the strength parameters of the conventional concrete, with addition of different percentages of Coal Ash replacement in the cement are studied after 28days of curing like compressive strength, flexural strength and splitting tensile strength tests are done.

1. A detailed investigation and collection of material is done.
2. Tests on physical properties of material to be used in concrete and then mix design for M30 grade concrete as per BIS Specifications.
3. Casting of cubes for different proportions of replacement of materials, finding the compressive strength for 28days.
4. Casting of beams and cylinders for different proportions of replacement of materials, finding the flexural strength and splitting tensile strength for 28days.comparing the results with normal cubes ,beams and cylinders.

2. Literature Review:

Introduction

Environmental friendly constructions place a major role in this era. In the present work, replacement of cement with coal ash in concrete is done and the results are interpreted. This chapter discusses about the literature on Evaluation of strength of concrete on partial replacement of cement with coal ash The literature review contains papers research by different authors

Navdeep Singh , Mithulraj M, Shubham Arya (2018) presented on " Influence of coal bottom ash as fine aggregate replacement on various properties of concretes**".** This paper concludes that utilization of Coal Bottom Ash (CBA) in concrete industry is one of the best feasible options to minimize the environmental concerns raised due to its presence. The present investigation has focused on reviewing some of the fresh, mechanical and durability properties of Normally Vibrated Concrete (NVC) and Self-Compacting Concrete (SCC) made with incorporation of CBA as replacement of fine aggregates. Most of the studies have described that the use of CBA lowers the overall performance of NVC/SCC, whereas few of them have reported its successful use in attaining similar/better performance to that of the concretes made without incorporation of CBA.

Khairunisa Muthusamy, Mohamad Hafizuddin Rasid , et.al .(2019) Presented on "Coal bottom ash as sand replacement in concrete". This paper concludes that coal ash is Being rich in silica, CBA has pozzolonic characteristic. Many experimental works revealed that CBA can be used in appropriate proportion to enjoy the benefits of workability, enhanced concrete strength and durability. Almost all the researchers promote the idea of turning variety of wastes to wealth to save valuable green area for better use rather than dumpsite and reduce high dependency on river sand mining supply to ensure the

sustainability of green river environment for prosperity of all the nations.
Diana Bajarea, Girts Bumanisb , LigaUpeniecec (2013) Presented on "Coal combustion bottom ash as microfiller with pozzolanic properties for traditional concrete ".This paper concludes that CCPs have chemical and physical properties that make them suitable for beneficial use in engineering and construction applications. Usage of CCPs in concrete industry also helps to reduce energy demand as well as CO2 emissions, for example, every ton of cement which is replaced by CCPs in the concrete production industry results in the decrease of CO2 emission in the amount of 0.7–1.2 tons. According to the presented results here is possible to decrease the price of concrete C30/37 by 10% due to usage of grinded coal combustion bottom ash and reduce amount of CO2 emission by 22.9%.
Mahdi Rafieizonooz, Jahangir mirza, et.al.(2016) Presented on "Investigation of coal bottom ash and fly ash in concrete as replacement for sand and cement" .This paper concludes that Concrete with bottom ash and fly ash added as replacement for sand and cement .Compressive, Flexural and tensile strengths of the concrete are determined .Pulse velocity ,drying shrinkage and micro-structural tests are performed. Relationship between mechanical properties and pulse velocity is discussed. Concrete specimens were prepared incorporating 0,20,50,75 and 100% bottom ash replacing sand and 20% of coal ash by mass as a substitute for ordinary Portland cement .Flexural and splitting tensile strength of the experimental mix containing 75% bottom ash and 20% fly ash exceeded much more than the controlled sample.
E.R. Teixeira , Camões , F.G. Branco , et .al (2019) Presented on "Recycling of biomass and coal ash as cement replacement material and its effect on hydration and carbonation of concrete". This paper focuses on the study of hydration and carbonation of cementitious pastes containing biomass fly ash and/ or coal fly ash by using thermo gravimetric analysis and X-ray diffraction analysis and by accelerated carbonation tests. The results show that incorporating biomass fly ash into construction materials has a similar carbonation behavior to coal fly ash. Biomass fly ash seems to give some extra alkalinity to the mixtures, and this may present benefits to the construction materials and for the ash management.

2.1 Conclusions on Literature Review

The present investigation has focused on reviewing some of the fresh, mechanical and durability properties of Normally Vibrated Concrete (NVC) and Self-Compacting Concrete (SCC) made with incorporation of CBA as replacement of fine aggregates But it is Being rich in silica, CBA has pozzolonic characteristic. Many experimental works revealed that CBA can be used in appropriate proportion to enjoy the benefits of workability, enhanced concrete strength and durability and the Usage of CCPs in concrete industry also helps to reduce energy demand as well as CO2 emissions. Flexural and splitting tensile strength of the experimental mix containing 75% bottom ash and 20% fly ash exceeded much more than the controlled sample. study of hydration and carbonation of cementitious pastes containing biomass fly ash and/ or coal fly ash by using thermo gravimetric analysis and X-ray diffraction analysis and by accelerated carbonation tests.

3. Tests on Materials:

For the experimental work, tests on cement were conducted such as fineness of cement, consistency, setting time, soundness, specific gravity and compressive strength test etc. Along with cement aggregate particle size distribution, water absorption, shape tests, bulking of sand test was conducted to perform the experiments.

Table 3.1: Physical properties of cement

S.No	Name of the test	Result obtained	Specification as per
1.	Fineness of cement	99%	IS: 4031 (part 1)-1996
2.	Consistency of cement	34%	IS: 4031 (part 4)-1988

3.	Setting time of cement a. Initial setting time of cement b. Final setting time of cement	45min 600min	IS: 4031 (part 5)-1988
4.	Soundness of cement	2mm	IS: 4031 (part 3)-1988
5.	Specific gravity of cement	2.74	IS:1199-1959
6.	Compressive strength of cement	24N/mm^2	IS: 4031 (part 6)-1988

Particle size distribution of aggregates

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS:2386(part-1) 1963. In this we use different sieves as standardized by the BIS specifications and then pass aggregates through them and thus collect different size particles retained over different sieves. In case of the coarse aggregates the test helps us to know maximum size of aggregates and in case of fine aggregates it helps us to know how much the material is finer and the zone in which it is classified. The tests performed and the results obtained as shown in table 4.2 and the grading curve is shown in figure 4.9.

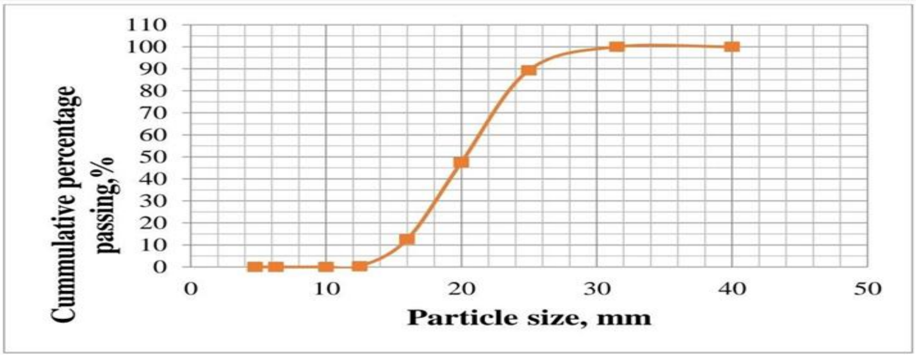

Figure 3.9 Particle size distribution curve for gravel

Table 3.2: Physical properties of aggregates

S No	Name Of The Test	Results	Specification
1	Water Absorption Coarse Aggregate	0.20%	IS:2386(part-III)-1963
2	a)Flakiness Index b)Elongation Index	7.68% 14.33%	
3	Sieve Analysis a)Fine Aggregate b)Coarse Aggregate	Zone –II 20mm	IS:2386(part-1)1963 IS: 383:1970
4	Bulking Of Sand	6%	IS:2386(part-III)-1963

4.Mix design

Table 4.1: Data for mix design

S.NO	Name	Stipulations
1.	Grade designation	M30
2.	Type of cement	PPC with flyash based

3.	Maximum nominal size of aggregate	20mm
4.	Min cement content	320 kg/m^3
5.	Maximum water cement ratio	0.45
6.	Workability	50mm
7.	Exposure condition	Severe
8.	Degree of supervision	Good
9.	Specific gravity a. Cement b. Coarse aggregate c. Fine aggregate	2.8 2.7 2.7
10.	Water absorption a. Coarse aggregate b. Fine aggregate	Nill Nill
11.	Surface moisture a. Coarse aggregate b. Fine aggregate	Nil Nil
12.	Sieve analysis a. Coarse aggregate b. Fine aggregate	20mm Zone-III

Table 4.2 Mix proportions

S.NO	% Replacement	Mix proportion	w/c Ratio
1	10	1:1.26:2.45	0.4
2	20	1:1.24:2.41	0.4
3	30	1:1.23:2.39	0.4

The mix design is performed accordance with 10262:2019.

5.Results and Discussions:

The tests are performed for M30 grade concrete at ages of 28days.The results obtained from the above tests are presented individually in the following tables and figures

Test Results of cubes

% Replacement of Coal Ash	Compressive Strength of Cube (Mpa)
0	51.25
10	45.5
20	38.56
30	32.03

Table 5.1 Test results of cubes

Test results of Cylinders

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% Replacement of Coal Ash	Split Tensile Strength of Cylinder (Mpa)
0	4.22
10	3.86
20	3.07
30	2.95

Table 5.2 Test results for Cylinders

Test Results of Beams

% Replacement of Coal Ash	Flexural Strength of Beam (Mpa)
0	5.94
10	6.01
20	5.87
30	5.8

Table 5.3 Test results for beams

6. Conclusions:

The work presented in this project tells about the physical tests performed to know the suitability of materials for concrete mix and comparison of strength for M30 between conventional concrete and Coal ash concrete(Replaced concrete) for 28 days and we performed compression test, flexural test and splitting tensile test.

- In this project PPC is used and prepared coal ash concrete by mixing coal ash with replacements of 0%, 10%, 20% and 30% by weight
- M30 grade concrete is used. Slump test has performed to check workability and performed results for 28days.
- The compressive strength of concrete reaches maximum when cement has replaced by 20% of coal ash.
- The split tensile strength is maximum when cement is replaced by 10% coal ash.
- The flexural strength obtained maximum when cement is replaced by 10% coal ash but the coal ash replacement can be added up to 30%.

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