STUDY ON STRENGTH OF GREEN CONCRETE

Nune Swamy
Undergraduate Student of Civil Engineering
Mepco Schlenk Engineering College, Sivakasi, India
Email – swamychowdary1@gmail.com

Abstract: *Utilization of coal combustion products in the concrete to reduce environmental pollution such as air, land, air and water pollution. On the other hand, natural resources such as limestone, clay, crushed stone, river sand is decreasing and as a result the price of these materials which have been used in construction is increasing rapidly. Keeping this in mind, this experimental investigation was carried out to replace cement with fly ash, fine aggregate with bottom ash and coarse aggregates with fly ash aggregates. Density of concrete with these replacements was found less than the normal concrete and compressive strength for M30 grade was around 20 N/mm^2. Modulus of elasticity, splitting tensile strength and flexural strength was increasing with the age of curing. The design of the concrete with fly ash, bottom ash and fly ash aggregate for M30 grade were found to be 20 N/mm^2 which can be used for normal construction practice. This will result sustainability in concrete and can also result in green concrete.*

Key Words: *fly ash, bottom ash, fly ash aggregate, green concrete, sustainable concrete*

1. INTRODUCTION:

As our society ages many of the natural resources became and will become a memory in the future. Using recyclables, replacement of materials has become the necessity not the choice. New construction methods and practices will lead to the sustainable development and can prevent the environmental pollution. Coal are burnt for the generation of electricity. The annual production of Coal combustion product (CCP) is approximately 108 million tonnes in India. These CCP are being dumped in the land which creates environmental hazard by polluting air, land and water. On the other hand, there is a scarcity of natural resources due the growing population, since the demand for the electricity exponentially increasing due to the growing population coal is being used for generation of electricity for supplying the demand. These made the civil engineers, scientists and researchers to think for the sustainable development. All these paves the way for the utilization of the CCP for the construction practices. The CCP are preferable materials offering significant technical and commercial advantages in the architecture, engineering construction, agriculture and other manufacturing industries. Coal combustion product mainly includes fly ash, bottom ash, boiler slag. Among these fly ash is already used as a partial replacement of cement in most of the big construction projects. Studies are going on to use bottom ash and fly ash as a replacement of sand and cement respectively.

1.1 Types of Fly ash:

Two major classes of fly ash are specified in ASTM C 618 on the basis of their chemical composition resulting from the type of coal burned; these are designated Class F and Class C. Class F is fly ash normally produced from burning anthracite or bituminous coal, and Class C is normally produced from the burning of sub-bituminous coal and lignite. Class C fly ash usually has cementitious properties in addition to pozzolanic properties due to free lime, whereas Class F is rarely cementitious when mixed with water alone.

1.2 Necessity to replace cement with fly ash in concrete:

Fly ash is one of the residues generated in combustion and comprise of fine particles that rise with the flue gases. They are generally dumped as waste products in landfills. Fly ash contains high content of heavy metals, organic compounds and chlorides and so it is very harmful to our environment. And also because of the shortage of landfill there is no other proper disposal method of fly ash. It is also found that fly ash is generally finer than cement and consist mainly of glassy-spherical particles as well as residues of hematite and magnetite, char and some crystalline phases formed during cooling. Fly ash is also cheaper and available at large quantities in coal-combustion factories. So using fly ash gives both economic and ecological benefits. In addition to it, use of fly ash in concrete improves its workability, reduces segregation, bleeding, heat evolution and permeability, inhibits alkali aggregate reaction, and enhances sulphate resistance.

1.3 Necessity to replace sand with bottom ash in concrete:

Concrete is the most important component in construction field. Sand is one of the major raw materials used in concrete. Sand is an important natural resource, but its excessive use has led to its scarcity and increase in its cost. With the increase in scarcity of sand as a natural resource, Indian government has put a restriction on collecting sand at a large amount from sea shores as well as river bed. So, there is a need to replace sand with some other material which has similar properties as that of sand. Bottom ash is found to be a good alternative of it. Bottom ash is one of the major waste product in coal-combustion industries where it sticks to the hot side wall of the coal-burning furnace. These bottom ashes are generally dumped in landfills which eventually causes pollution. So by using bottom ash as a replacement of sand we are solving two problems. First we are using cheaper alternative of sand and second, we are overcoming the disposal problem of bottom ash.

1.4 Necessity to replace coarse aggregate with fly ash aggregate in concrete:

The aggregates are vital elements in concrete. The usage of enormous quantities of aggregates results in destruction of hills causing geological and environmental imbalance. The environmental impacts of extracting river sand and crushed stone aggregates become a source of increasing concern in most parts of the Country. Pollution hazards, noise, dust, blasting vibrations, loss of forests and spoiling of natural environment are the bad impacts caused due to extraction of aggregates. Landslides of weak and steep hill slopes are induced due to unplanned exploitation of rocks. Considering the depletion of natural sources and the effect on environment, the disposal problems involved in disposing fly ash, light weight characteristics of fly ash aggregates with good mechanical properties (Compressive strength and Flexural strength), a particular attention may be focused on the usage of fly ash aggregates in concrete.

1.5 Objectives:

- To study the effectiveness of concrete by partial replacement of cement by fly ash.
- To study the effectiveness of concrete by partial replacement of fine aggregate(sand) by Bottom ash.
- To study the effectiveness of concrete by partial replacement of coarse aggregate by fly ash aggregate.
- To find out the strength of CCP replaced mix by finding out compressive strength, Density, modulus of elasticity, split tensile strength and flexural strength.

2. MATERIAL:

Cement: Ordinary Portland cement of grade 53 confirming to IS 12269-2013.

Fine aggregate: Sand passing through 4.75 mm and retained on 150 micron confirming to IS 383-1970.

Coarse aggregate: 12 mm and 20 mm coarse aggregate confirming to IS 383-1970 were used.

Fly ash: Class C fly ash was used which has usually cementitious properties in addition to pozzolanic properties due to free lime.

Bottom ash: This is the non-combustible residue obtain from the thermal power plants.

Table No. 1: Properties of material:

1	Properties of cement	
	• Specific gravity	3.13
	• Fineness of cement	4%
	• Initial setting time	45 Min
	• Normal consistency	27%
2	Properties of fly ash	
	• Specific gravity	2.46
	• Fineness modulus	1%
3	Properties of fine aggregate	
	• Specific gravity	2.8
	• Fineness modulus	2.8
	• Bulking	27.10%
4	Properties of Bottom ash	
	• Specific gravity	2.42
5	Properties of coarse aggregate	
	• Specific gravity (12 mm)	2.3
	• Specific gravity (20 mm)	2.6
	• Water absorption (12 mm)	0.33%
	• Water absorption (20 mm)	1%
	• Crushing value (12 mm)	16.80%
	• Crushing value (20 mm)	22.32%
	• Fineness modulus	7.22
6	Properties of fly ash aggregate	
	• Specific gravity	1.98
	• Crushing value	39.74%

3. EXPERIMENTAL PROCEDURE:

CCP in various proportions were mixed in M30 grade concrete and designated as 31, 32, 33 and 34 for experimental purpose as shown in below:

Table No. 2: Proportions of CCP

S. No	Designation	Fly ash(%)	Bottom ash(%)	Fly ash aggregate (%)
1	31	20	30	25
2	32	20	60	25
3	33	30	30	25
4	34	30	60	25
5	Control	0	0	0

The specimen of standard cubes, prisms and cylinders were used to determine the compressive strength, modulus of elasticity, split tensile strength and flexural strength of concrete.

Table No. 3: Specimen casting details

S. No.	Type of Mould	No. of Moulds	Dimensions(m)
1	Cubes	15	0.1×0.1×0.1
2	Prism	6	0.5×0.1×0.1
3	Small Cylinder	6	D=0.2 & H=0.2
4	Big Cylinder	6	D=0.15 & H=0.3
5	Plastic Shrinkage	1	0.5×0.25×0.07

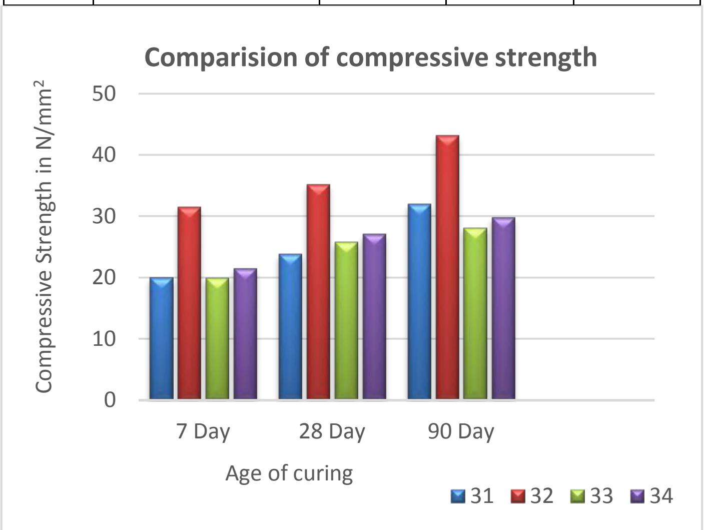
4. TEST RESULTS AND DISCUSION:

4.1 Compressive Strength test:

The following test results were obtained when the cubes were tested in the Compression Testing Machine at different age of curing.

Table No. 4: Results of compressive strength test

S. No.	Designation	7 Day	28 Day	90 Day
1	31	20.03	23.8	32.03
2	32	31.5	35.23	43.23
3	33	19.93	25.83	28.13
4	34	21.46	27.1	29.8
5	Control	29.4	40.1	NA



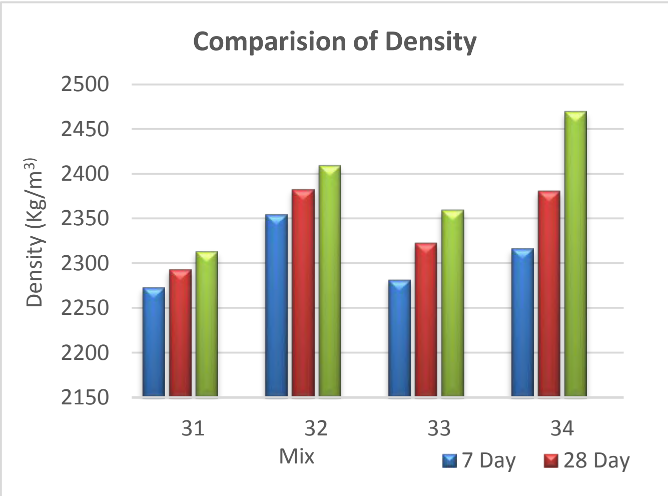
The 28 days' compressive strength of the control mixture is 40.10 N/mm^2 but for the mixture replaced with fly ash, bottom ash, and fly ash aggregates the values are lesser than the control but as the age of curing increases the compressive strength increases. The results of the compressive strength clearly show that it can be used for concrete where 20N/mm2 is required.

4.2 Density:

The following results were obtained when density of the cubes were calculated by weighing the cubes at different age of curing.

Table No. 5: Density of specimens

S. No.	Mix	7 Day	28 Day	90 Day
1	31	2273.33	2293.33	2313.33
2	32	2354.67	2383	2410
3	33	2281.67	2323.33	2360
4	34	2316.67	2381.33	2470



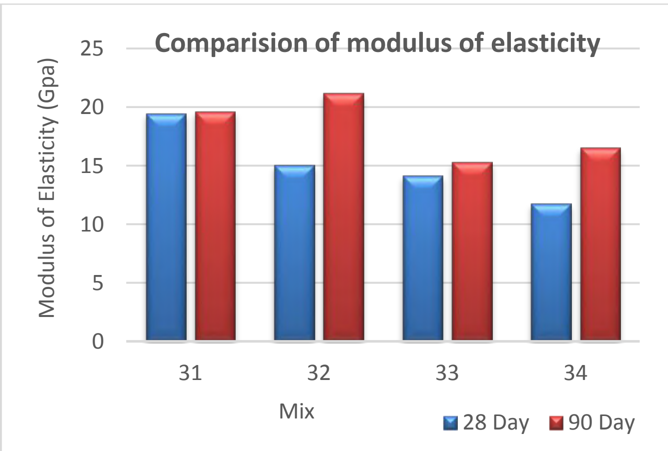
The density of the concrete is lower than 2400Kg/m^3 which show that it can be used as light weight concrete.

4.3 Modulus of elasticity (Gpa):

Modulus of elasticity of specimens were obtained at 28 days and 90 days

Table No. 6: Results of modulus of elasticity test

S. No.	Designation	Modulus of Elasticity (28 Day)	Modulus of Elasticity (90 Day)
1	31	19.49	19.64
2	32	15.08	21.2
3	33	14.17	15.29
4	34	11.79	16.56

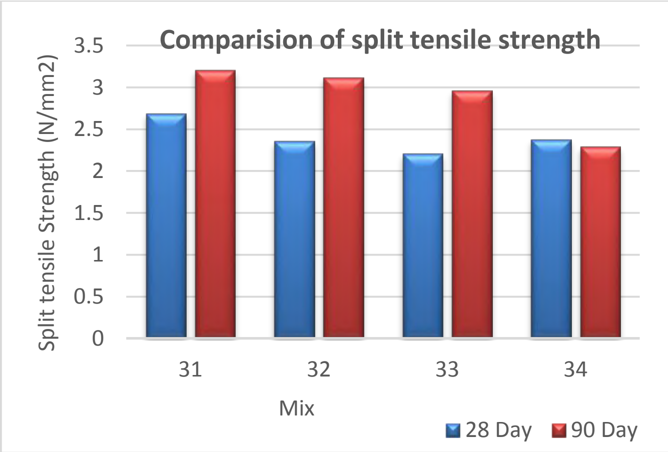


4.4 Split tensile strength:

The test was carried out confirming to IS 516 – 1959 to obtain flexural strength of concrete at the age of 28 & 90 days. The specimens were tested using Universal Testing Machine (UTM).

Table No. 7: Results of split tensile strength test

S. No.	Designation	28 Day	90 Day
1	31	2.69	3.21
2	32	2.36	3.12
3	33	2.21	2.96
4	34	2.38	2.29

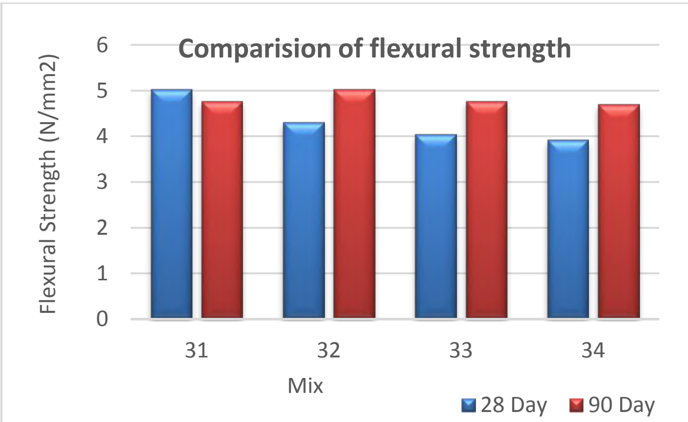


4.5 Flexural strength:

Three-point loading test (ASTM C 78) was conducted to obtain flexural strength of concrete at the age of 28 & 90 days.

Table No. 8: Results of flexural strength test

S. No.	Designation	28 Day	90 Day
1	31	5.03	4.77
2	32	4.31	5.03
3	33	4.05	4.77
4	34	3.92	4.7



Modulus of elasticity, splitting tensile strength and flexural strength was increasing with the age of curing.

5. CONCLUSION:

From the experimental investigation of coal combustion products such as fly ash, bottom ash, and fly ash aggregates on mechanical properties such as compressive strength, splitting tensile strength, flexural strength, and modulus of elasticity, and density the following conclusion are made

- The 28 days' compressive strength of the control mixture is 40.10N/mm^2 but for the mixture replaced with fly ash, bottom ash, and fly ash aggregates the values are lesser than the control but as the age of curing increases the compressive strength increases.
- The results of the compressive strength clearly show that it can be used for concrete where 20 N/mm^2 is required.

- The density of the concrete is lower than 2400 Kg/m^3 which show that it can be used as light weight concrete.
- With the usage of these coal combustion products from thermal power station in the concrete the usage of cement, river sand, and crushed stone that have been used for the construction can be minimized.
- Incorporation of fly ash, bottom ash and fly ash aggregates can not only save the natural materials such as lime stone, shale (for cement manufacturing), river sand (fine aggregate), crushed stone (coarse aggregate), but also the environmental pollution caused by the coal ash from thermal power station.

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