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Compressive Strength Of Fly Ash Based Geo-Polymer Concrete

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Abstract - Concrete is the world's most versatile, durable & reliable construction material. The production of Portland cement contributes at least 5 to 7% of carbon dioxide which polluted the atmosphere. We try to reduce the pollution by the usage of industrial waste products. We use the fly-ash as a replacement of cement but not used as total replacement which is used as a 10%, 20%, 30%. Alkaline material used as binding material which is sodium hydroxide (NaOH) and sodium silicate with different molarities i.e. 8M, 10M, 12M are taken to different mixes. The cube sizes of 15 × 15 × 15 *cm* are for compressive strength of geo-polymer concrete. The specimen tested after 7, 14, 28 days. The result shows that strength of geo-polymer concrete is increasing with increase of molarity of alkaline material. The use of Portland cement in concrete construction is under critical review due to high quantum of carbon dioxide gas released to the atmosphere during the product of cement. In recent times, attempts to increase the application of cover ash to incompletely replace the use of Portland cement in concrete are gathering instigation. Utmost of this by product material is presently ditched in tips, creating a trouble to the environment. Fly ash was chosen as the introductory material to be actuated by the geo-polymerization process to be the concrete binder, to completely replace the use of Portland cement. The binder is the only contrast to the usual Portland cement concrete. To spark the Silicon and Aluminium content in cover ash, a combination of sodium hydroxide result and sodium silicate result was used.

***Key Words*: Polymer concrete, fly ash, compressive strength, tensile strength, Temperature.**

I. INTRODUCTION

For the construction of any structure, Concrete is the main material. Concrete usage around the world is second only to water .The main ingredient to produce concrete is Portland cement. On the other side global warming and environmental pollution are the biggest menace to the human race on this planet today. The production of cement means the production of pollution because of the emission of CO2 during its production [1]. There are two different source of CO2 emission during the cement production. Combustion of fossil fuels to operate the rotary kiln is the largest source and other one is the chemical process of calcimine limestone into lime in the cement kiln also produces CO2 In India about 2,0679,738 thousands of metric tons of CO2 is emitted in the year of 2010. The cement industry contributes about 5% of global carbon dioxide emissions. And also, the cement was manufactured by using the raw materials such as lime stone, clay and other minerals. Quarrying of these raw accoutrements is so causes environmental declination. To produce 1 ton of cement, about 1.6 tons of raw materials are required and the time taken to form the lime stone is much longer than the rate at which humans use it. So to overcome this problem, the concrete to be used should be environmental friendly [2].

After wood, concrete is the most frequently used material by the community. Concrete is conventionally produced by applying the ordinary Portland cement(OPC) as the direct binder. The environmental issues associated with the product of OPC are well known. The quantum of the carbon dioxide released during the manufacture of OPC due to the calcination of limestone and combustion of reactionary energy is in the order of one ton for every ton of OPC produced. In addition, the quantum of energy needed to produce OPC is only coming to sword and aluminum[3].

On the same side, the cornucopia and vacuity of cover ash worldwide produce occasion to use this by- product of burning coal, as partial relief or as performance enhancer for OPC. Fly ash in itself doesn't retain the list parcels, except for the high calcium or ASTM Class C fly ash. still, in the presence of water and in ambient temperature, cover ash reacts with the calcium hydroxide during the hydration process of OPC to form the calcium silicate hydrate(C-S-H) gel. This Pozzolana action happens when cover ash is added to OPC as a partial relief or as an amalgamation. The development and operation of high volume cover ash concrete, which enabled the relief of OPC up to 60- 65 by mass, can be regarded as a corner in this attempt. In another scheme, Pozzolana similar as blast furnace sediment and fly ash may be actuated using alkaline liquids to form a binder and hence completely replace the use of OPC in concrete[4].

In this scheme, the alkalinity of the activator can exist tropical to soft orhigh. In the first case, with low to medium alkalinity of the activator, the main contents to actuated are silicon and calcium in the by- product material similar as blast furnace sediment. The main binder produced is a C- S- H gel, as the result of a hydration process. In the after case, the main ingredients to be actuated with high alkaline result are substantially the silicon and the aluminum present in the by- product material similar as low calcium fly ash. The binder delivered in this case is due to polymerization. Geo-polymers, and stated that these binders can be produced by a polymeric conflation of the alkali actuated material from geological origin or by- product accoutrements similar as cover ash and rice cocoon ash [5][6].

II. MATERIALS

Cement

The cement used for experimental purpose is Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 grade (Ultra Tech OPC) conforming to IS: 8112-1989 is used. The cement is in dry powdery form with the good quality chemical compositions and physical characteristics. multiple tests were supervised on cement; some of them are special earnest, thickness tests, setting time tests, compressive strengths, etc. [1].

Fine Aggregate

Fine aggregate are basically sand which can be found from land or marine environment. It consist sand or crust stone which passing from 4.75 mm sieve. The specific gravity 2.87and fineness modulus 8.77 is use as fine aggregate.

Coarse Aggregate

Crushed stone were used as coarse aggregates; the fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse sum totals from crushed Basalt gemstone, agreeing to IS 383 are utilized. The Flakiness Index and Elongation Index were maintained well below 15%.

Water

Water is an major component of concrete as it truly participates in the chemical response with cement. Since it helps to from the strength presenting cement gel, the amount and quality of water is needed to be made into veritably precisely. Water which is straight and secure for drinking aim is operated and water cement proportion was0.42 for design blend M30.

Fly Ash

Fly ash is composed of the non-combustible mineral portion of coal. Particles are smooth, round „ball bearings" finer than cement particles. Sizes of particle are 0.1Gm-150 Gm. It is a Pozzolana material which reacts with free lime in the presence of water, converted into calcium silicate hydrate (C-S-H) which is the strongest and tough portion of the paste in concrete. The fly ash for testing purpose is collected from industrial area near Surat. Fly ash is a by- output of the combustion of did in coal, generally from coal- blasted power plants1. Fly ash solidifies in the exhaust feasts and is re-collected by electrostatic precipitators or sludge bags. According to American Concrete Institute ACI 116R fly ash is " the finely parted debris that results from the combustion of ground or crushed coal and that's packed by conduit treats from the combustion part to the flyspeck dumping network. " Due to upped mindfulness of all ill goods of pollution, perversion and secure scrapping of cover ash at thermal power shops has come an instant and laborious task. Fly ash is needed in many civil engineering applications because it provides better strength at later stages than the ordinary Portland cement concrete of plain concrete.

The types and relative quantities of non-combustible matter in the coal determine the chemical composition of cover ash. The chemical composition is substantially composed of the oxides of silicon (SiO_2), aluminium (Al_2O_3), iron (Fe_2O_3), and calcium (CaO), whereas magnesium, potassium, sodium, titanium, and sulphur are also present in a lower quantum. The major influence on the cover ash chemical composition comes from the type of coal [4]. The combustion of sub-bituminous coal contains further calcium and lower iron than fly ash from bituminous coal. The physical and chemical characteristics depend on the combustion styles, coal source and flyspeck shape. The chemical compositions of colourful cover ashes show a wide range, indicating that there's a wide variations in the coal used in power shops each over the world[5].

Fly ash that results from burning sub-bituminous coals is appertained as ASTM Class C fly ash or high calcium cover ash, as it generally contains further than 20 present of CaO. On the other hand, fly ash from the bituminous and anthracite coals is appertained as ASTM Class F fly ash or low calcium cover ash. It consists of substantially an alumina silicate glass, fineness and uniformity. MnO is a dimension of burnt carbon remaining in the ash. Fineness of cover ash substantially depends on the operating conditions of coal clinchers and has lower than 10 present of CaO. The colour of cover ash can be tan to dark slate, depending upon the chemical and mineral ingredients[1][2].

Table-1: Composite of fly ash

Composition	Batch-1 (% by mass)	Batch-2 (% by mass)
SiO_2	53.2	54.1
Al_2O_3	26.0	25.4
Fe_2O_3	7.95	6.18
Na_2O	0.29	0.77
K_2O	2.59	2.98
TiO_2	1.38	2.36
MgO	0.97	0.71
CaO	3.57	4.88
MnO	0.04	0.04

The typical cover ash produced from Australian power stations is light timid-grey in colour, analogous to the colour of cement greasepaint. The maturity of Australian cover ash falls in the order of ASTM Class F fly ash, and contains 80 to 85 of silica and alumina.

Away from the chemical composition, the other characteristics of cover ash that generally considered are Magnesium Oxide (MnO), fineness and uniformity. MnO is a dimension of burnt carbon remaining in the ash. Fineness of cover ash substantially depends on the operating conditions of coal clinchers and the grinding process of the coal itself. Finer gradation generally results in a further reactive ash and contains lower carbon.

Alkaline Solutions

In this project the compressive strength of geo- polymer concrete is examined for the mixes of varying molarities of sodium hydroxide (8M and 10M). The molecular weight of sodium hydroxide is 40. To prepare 8M i.e. 8 molar sodium hydroxide solutions, 320g of sodium hydroxide flakes are weighted and they can be dissolved in distilled water to form 1 litter solution. For this, volumetric flask of 1 litter capacity taken, sodium hydroxide flakes are loaded slowly to distilled water to prepare 1 litter solution. The weight add to get required molarity are given in table.

- The solution of sodium hydroxide and sodium silicate are used as alkaline solution in the present study.

- Sodium hydroxide is available in market in various forms as flakes, pellets, and in powder forms. In the study, commercial grade sodium hydroxide in flakes form (97%-100% purity) is used.

- Sodium hydroxide is accessible in demand in multicolored casts as flakes, bullets, and in greasepaint forms

- Na_2O - 7.5%-8.5%

SiO_2 - 25%-28%
Water - 67.5%-63.5%

III. METHODS

Concrete Mix Design: In the study, M30 grade with combine of ingredient as per IS 10262 was used.

Mix design is known as the selection of mix ingredients and their proportion required concrete mix In the current study system for composite design is the Indian Standard Method. The mix design involves to other calculation of the amount of cement, fine aggregate, and course aggregate in addition to other related parameter dependent on the properties of constituent material [5].

Table-2: Data use for Concrete mix design

Description	Value
Grade of designation	M30
Type of cement	OPC 53
Maximum nominal size of aggregate	20 mm
Minimum cement content	300 kg/m3
Maximum water cement ratio	0.55
Workability in terms of slump	75 mm
Exposure condition	Mild
Method of concrete placing	Manual
Type of aggregate	Angular
Type of chemical admixture	NaOH(8M & 10M)
Specific gravity of cement	3.15
Specific gravity of course aggregate	2.84
Specific gravity of fine aggregate	2.87

The current system applied in the timber of common concrete is embraced to ready geo- polymer concrete. First, the fly-ash, course aggregate are mixed in dry condition for 3-4 minutes and then the alkaline solution which is sodium hydroxide added to the dry mix. The mixing is done about 6-8 minutes for proper bonding of all the materials. After the mixing, the cubes are casted with the mixes GP1 to GP3 by giving proper compaction.

Compressive strength of concrete is defined as the resistance to failure under the action of compressive force. Especially for concrete, compressive strength is an important parameter to determine the performance of the material during service condition. The compressive strength of concrete 1s most important property of concrete to most Structural applications, Generally to determine compressive strength of concrete cube used dimensions 150 x 150 x 150 mm were cast for M30 grade of concrete. In each cycle of casting there are three concrete cubes would be casted. And their average value determined. The compressive strength was calculated as follows, compressive strength (MPa) = Failure load / cross sectional area.

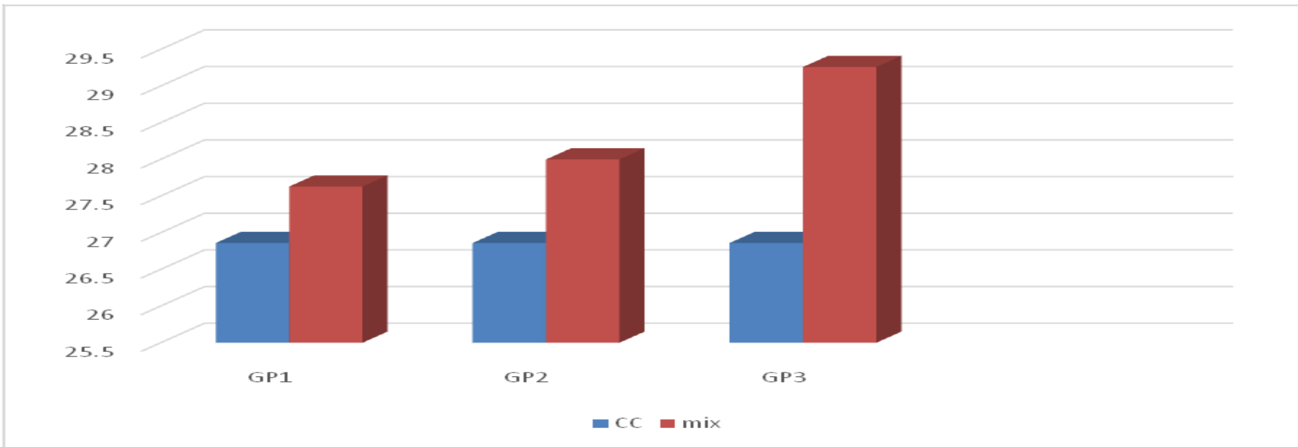

Figure-1: Compressive strength of specimen at the age of 7 days

The net effect is that advanced the water content of the admixture advanced is also the Na_2O-to-SiO_2 molar rate. It's intriguing to note that an increase in the Na_2O-to-SiO_2 rate has insignificant effect on the compressive strength of hardened concrete (Figure 1). Another important specific of fresh concrete state is the setting time. Our laboratory showed that fresh fly ash grounded geo- polymer concrete could be handled at least up to 120 twinkles after mixing, without any sign of setting, and without any declination in compressive strength [3].

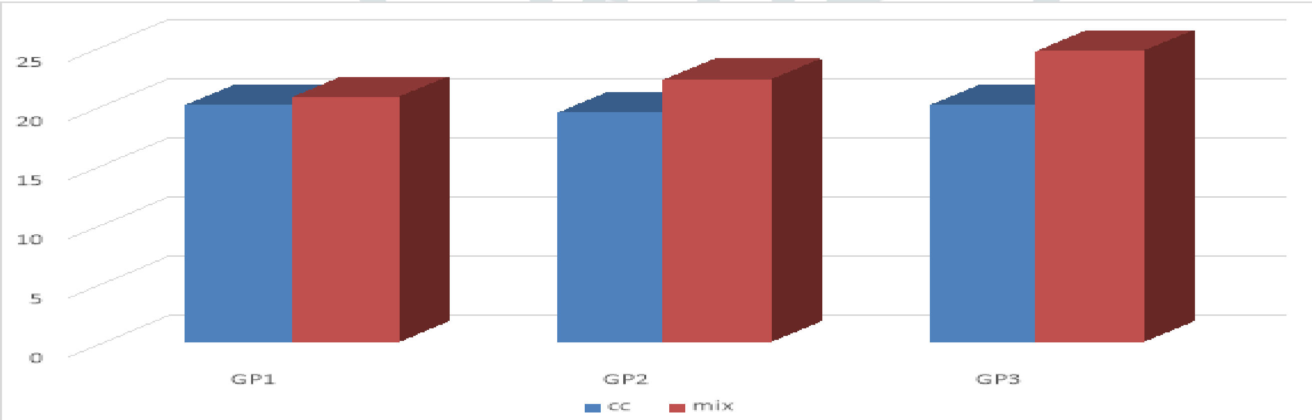

Figure-2: Compressive strength of specimen at the age of 14 days

With regard to hardened concrete, the molar proportion of H_2O-to-Na_2O significantly influences the compressive strength of fly ash grounded geo-polymer concrete. An increase in this proportion decreases the compressive strength. To measure the elastic constants of cover ash grounded geo-polymer concrete, four different fusions were prepared to gain four different compressive strengths in the range of 40 to 90 MPa.20 The elastic parcels, Young's modulus and Poisson's rate, were measured in agreement with the Indian Standard. The Young's modulus was determined as the secant modulus, measured at a stress position equal to 40 percentage of the compressive strength of concrete. (Figure 2)

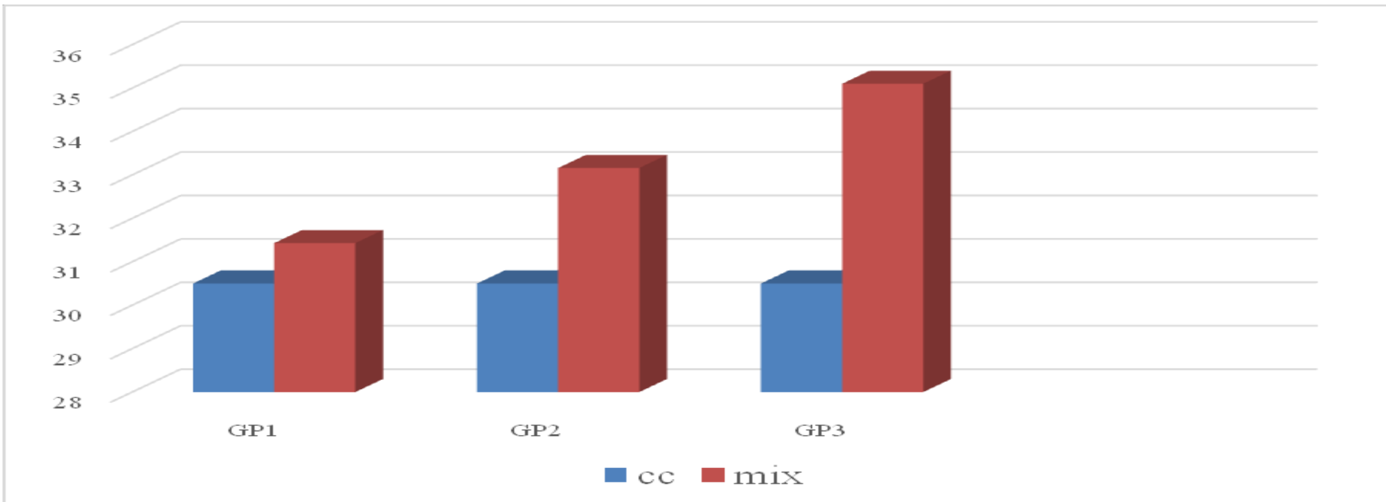

Figure-3: Compressive strength of specimen at the age of 28 days

The test results colluded in Figure 2 is recast in Figure 3 in terms of geo-polymer solids to water rate by mass versus compressive strength. For a given geo-polymer concrete, the total mass of water in the admixture is taken as the sum of the mass of water in the sodium silicate result, the mass of water in the sodium hydroxide result, and the mass of redundant water, if any, added to the admixture. The mass of geo-polymer solids is the sum of the mass of cover ash, the mass of sodium hydroxide flakes, and the mass of sodium silicate solids Again, this relation is an amorous to the relationship between the water- cement rate and the compressive strength of Portland cement concrete.

Compressive strength of concrete is tested on cube at different percentage of marble dust content in concrete. The strength of concrete has been tested on cube at 7 days, 14 days and 28 days of curing. 7 days check has been conducted to see the gain in initial strength concrete. 28 days test provides the information of ultimate strength of concrete at 28 days curing [4]. Compression testing machine is used for testing the compressive strength test on concrete. At the time of testing the cube is taken out of water and dried then tested keeping the smooth faces in higher and lower part. Other important factors that impact the parcels of hardened cover ash- grounded geo-polymer concrete are the curing temperature and the curing time. Advanced the curing temperature advanced is the compressive strength. On the effect of curing duration, fly ash- based geo-polymer concrete cured for longer ages of duration, shows an increase in its compressive strength, at least up to 48 hours.

IV.RESULTS AND DISCUSSION

Mix GP1 showed the loftiest water permeability measure of any other concrete. Again, GP3 displayed the smallest measure. Except for GP1 and GP2, the final water permeability portions of other composites were slightly analogous. Void content was attained during the water permeability test by measuring the difference between the dry and logged weights of concrete samples. From Table- 5 it can be seen that the void varied from8.2 to 13, which also confirms that all concrete has an “average” quality. There exists a nonlinear relation between the water permeability measure and the void content, since GP1 with a low void content has the loftiest permeability measure. Pore durability another aspect of porosity was seen to be more influential in this inflow rate dimension. Water permeability is told by severance connectivity in the concrete paste. The severance development of concrete is dependent on parameters similar as water content, binder content and the curing system. This is also the case for cover ash geo-polymer concrete. The lower water permeability therefore observed for GP3 is attributed to the thick paste and lower severance interconnectivity. The increase in total content of GP4 contributes to a drop in capillary pores volume and the water permeability measure. There exists a good correlation between the water permeability measure and compressive strength. As the compressive strength increases, the permeability measure also increases. It can be seen that water permeability portions from former exploration were lower than the former study. This may be due to the geo-polymer admixture composition and the types of water permeability test used by both experimenters.

V. CONCLUSION

Based on the Experimental work reported in this study, the advanced attention (in terms of molar) of sodium hydroxide result results in advanced compressive strength of cover- ash & chase grounded geo-polymer concrete. The fresh cover ash grounded geo-polymer concrete is fluently handled up to 120 twinkles without any sign of setting and without any declination in compressive strength. The blend GP3 gives advanced compressive strength as it has high molarity of NaOH. We observed that the compressive strength is increased with increased in the molarity of the sodium hydroxide. After three days of curing the increase the compressive strength isn't sufficient. The geo- polymer concrete shall be effectively used for the ray column junction of the concrete corroborated structure. Geo-polymer concrete shall also be sued structure workshop. In addition to that cover- ash shall be effectively used and hence no tips are needed to leave the fly-ash.

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