EXPERIMENTAL INVESTIGATIONS ON CORROSION RESISTIVITY OF LOW CALCIUM FLY-ASH BASED GEOPOLYMER CONCRET

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ABSTRACT

This research presents experimental investigations conducted to assess the corrosion resistivity of low calcium fly ash-based geopolymer concrete. Geopolymer concrete is a sustainable alternative to traditional Portland cement-based concrete, as it significantly reduces carbon dioxide emissions and utilizes industrial waste materials. The study focuses on understanding the corrosion behavior of geopolymer concrete in aggressive environments, which is crucial for its practical application in various construction projects. The experimental program involves preparing different mixes of low calcium fly ash-based geopolymer concrete with varying proportions of activator solutions. Accelerated corrosion tests are conducted using chloride and sulphate exposure conditions to simulate aggressive environmental conditions commonly encountered in marine and industrial settings. The corrosion resistivity is evaluated by monitoring the corrosion rate, half-cell potential, and electrochemical impedance spectroscopy. The findings from this study reveal the influence of activator composition and exposure conditions on the corrosion behaviour of low calcium fly ash-based geopolymer concrete. The results indicate that certain mix designs exhibit superior corrosion resistance compared to traditional Portland cement-based concrete in aggressive environments. The research outcomes contribute to the understanding of geopolymer concrete's performance in corrosive conditions, aiding in its widespread adoption as a sustainable construction material.

Keywords: *Geopolymer Concrete, Low Calcium Fly Ash, Corrosion Resistivity, Accelerated Corrosion Tests, Sustainable Construction.*

I. INTRODUCTION

Geopolymer has been the subject of significant research and commercial interest over the past decade. The geo-polymerisation process provides an opportunity for by product materials to be used as a valuable product, although the variability in the source materials results in different performance levels of the geopolymer products. In the meantime, work is being carried out on the factors affecting geo-polymerisation, mechanical properties, mechanisms of the process, and some brief aspects of durability. The research carried out concluded that the concrete has superior engineering properties as a construction material. However, in the longer term, the exposure of this concrete in severe environments, such as seawater, is inevitable and greater knowledge about its durability is important. Some reports stated that geopolymer has good durability; however, these are very limited because of the use of different sources materials and activators, types of specimens and types of tests that were employed. The results of this research will provide scientific data and information about mixture optimization, strength development and durability of low calcium fly ash based geopolymer concrete that has been developed at Curtin University. Some important properties of concrete were used to determine its durability, namely water penetrability, seawater resistance and corrosion of steel reinforcement bar.

Objective:

a) To develop fly ash geopolymer concrete mixtures for reinforced concrete structures in seawater environments.

b) To assess the strength development, namely compressive strength, tensile strength, flexural strength, modulus of elasticity; water penetrability and drying shrinkage of the optimized mixtures.

c) To study the seawater resistance under continuous immersion and wetting-drying cycles by measuring change in mass, change in compressive strength, change in modulus of elasticity, change in effective porosity, and change in length of the optimum mixture's specimens. In addition, a chloride ion penetration is investigated.

d) To investigate the corrosion performance by half-cell potential measurement, an accelerated corrosion test under impressed voltage, and in a medium incorporating microorganism.

Fly ash:

Fly ash can be defined as a fine-grained product from bituminous hard coal combustion in power station furnaces. The product consists of oxides of silica, aluminum, iron and some calcium. Since it is created at high temperature, the fly ash is glassy and chemically stable. It can be used in fly ash geopolymer synthesis because it is rich in silica and alumina, two major sources of the geo-polymerization process. The activator is needed in this process to initiate reaction and hardening, given that fly ash cannot naturally harden in water. Fly ash from various sources is claimed to have different mineralogy and solubility that influence the reaction rate and finally the physical characteristics of the geopolymer. Clearly, the analytical calcium (CaO) content, glassy phase and particle size distribution were the main factors that distinguished the final geopolymer product. The high CaO content (more than 15%) could increase a setting time. Fly ash with the high content of glass phase and finer particles could increase a degree of reaction and reactivity, resulting in higher degree of geo-polymerisation and consequently higher compressive strength.

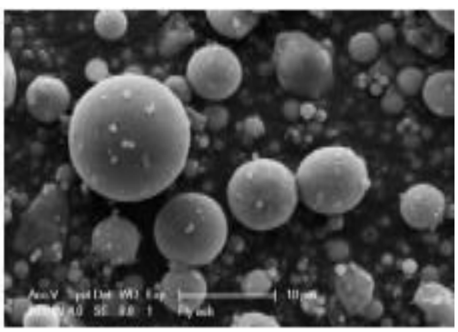

Figure 1 Raw Collie fly ash particles

Identified Problems:

Despite the superiority of geopolymer in some areas, particularly where the OPC concrete does not perform well, the actual in-situ casting for application of the fly ash geopolymer remains an issue. Some problems regarding in-situ casting were identified as follows: a) The mixture needs to have very low water content, thereby reducing workability. b) The mixture needs to be cured at a high temperature, which means finding an efficient technology to perform it. c) Safety procedure of handling the mixture due to caustic chemicals involved d) Efflorescence on the concrete surface that reduces the aesthetic appearance 6 e) Durability in application is still unproven, especially for corrosion of steel reinforcement bars in concrete structures.

II. LITERATURE REVIEW

[1] Morla P, Gupta R et al (2021) studied that geopolymer Concrete (GPC) is a potential sustainable solution that does not involve the use of cement as a binder. GPC is produced by mixing the alumina-silicate source materials such as fly-ash with alkali activators such as potassium hydroxide (KOH) and potassium silicate (K_2SiO_3). Unlike Ordinary Portland Concrete (OPC), the characteristics of GPC depend on the precursor materials and therefore vary for different mixes. Consequently, corrosion behaviour needs to be evaluated separately for individual mixes. This has narrowed the scope of existing published work on corrosion behaviour of GPC. In this study, GPC and OPC specimens were prepared and exposed to accelerated corrosion exposure. Half-cell potential and linear polarization resistance were used to evaluate the corrosion rate in GPC and OPC. Under accelerated conditions, the corrosion rate of the GPC specimens was between 10 µm/year and 20 µm/year exhibiting a moderate to high rate of corrosion. Meanwhile, the corrosion rate of the OPC specimens was between 40 µm/year and 60 µm/year indicating a very high corrosion activity. It can be concluded that GPC has a higher resistance to chloride-induced corrosion; with a low corrosion rate and lower mass loss percentage, compared to OPC.

[2] Prusty J.K and Pradhan B (2020) investigated the effect of GGBS on strength and corrosion performance of steel in chloride contaminated fly ash-GGBS based geopolymer concrete (GPC). Fly ash and fly ash-GGBS based GPC mixes were added with 0% and 3.5% of NaCl during the time of preparation. Corrosion potential measurement and corrosion 20 current density by linear polarization resistance (LPR) measurement were performed on reinforced cylindrical GPC specimens. Results indicated that the fly ash-GGBS based GPC showed higher compressive strength as compared to fly ash based GPC, due to formation of N-(C)-A-S-H and C-S-H gel in fly ash-GGBS based GPC which is evident from FESEM analysis. The chloride admixed GPC mixes achieved lower compressive strength than that of control (0% NaCl) GPC mixes. There was a higher probability of corrosion initiation and higher corrosion current density of steel reinforcement in NaCl added GPC as compared to the control

[3] GPC. Yang W, Zhu P et al (2021) study the sulfuric acid corrosion resistance of geopolymer concrete (GPC) with different binding materials and concentrations of sodium hydroxide solution (NaOH), metakaolin, high-calcium fly ash, and low-calcium fly ash were chosen as binding materials of GPC for the geo-polymerization process. A mixture of sodium silicate solution (Na_2SiO_3) and NaOH solution with different concentrations (8 M and 12 M) was selected as the alkaline activator with a ratio (Na_2SiO_3 /NaOH) of 1.5. GPC specimens were immersed in the sulfuric acid solution with the pH value of 1 for 6 days and then naturally dried for 1 day until 98 days. The macroscopic properties of GPC were characterized by visual appearance, compressive strength, mass loss, and neutralization depth. The materials were characterized by SEM, XRD, and FTIR. The results indicated that at the immersion time of 28 d, the compressive strength of two types of fly ash-based GPC increased to some extent due to the presence of gypsum, but this phenomenon was not observed in metakaolin-based GPC. After 98 d of immersion, the residual strength of fly ash-based GPC was still higher, which reached more than 25 MPa, while the metakaolin-based GPC failed. Furthermore, due to the rigid 3D networks of aluminosilicate in fly ash-based GPC, the mass of all GPC decreased slightly during the immersion period, and then tended to be stable in the later period.

[4] Zerfu K. and Ekaputri J (2016) studied that geopolymer concrete results almost up to 90% reduction in carbon dioxide (CO_2) emission to atmosphere. Mechanical properties of geopolymer concrete such as compressive strength, durability, sulphate resistance, early strength and low shrinkage are better than Portland cement concrete. In addition, the appropriate usage of one ton of fly ash earns one carbon-credit redemption value of about 20 Euros, and hence earned monetary benefits through carbon-credit trade. Therefore, this paper presents a review on the fly ash-based geopolymer concrete. The paper mainly covers

[5] Babaee M, Khan M.S et al (2018) investigated the carbonation of two low-calcium fly ash-based geopolymer concretes to assess the effect of alkali concentration in the activator, and the carbon dioxide concentration on the pH drop and passivity of the reinforcement. Chemical adsorption of carbon dioxide at different concentrations into an aqueous NaOH solution, as representative of the pore solution, is studied to predict the distribution of carbonate species and pH drop. pH profiles were obtained during the exposure period. X-ray diffraction (XRD) was conducted to identify the carbonate phases. Half-cell potential and polarization resistance of reinforced concrete samples were monitored to assess the passivity of embedded reinforcement. The carbonated binders remained rather highly alkaline during the accelerated carbonation test which was in agreement with the predicted values. No sign of passivation of reinforcement was observed, even for the lower strength grade concrete, during the long exposure time of 500 days to 1% carbon dioxide.

[6] Gunasekara C, Bhuiyan S. et al (2017) prepared a series of geopolymer concrete specimens containing a range of cast in chloride contents (0–5%) using three different low calcium (Class F) fly ashes obtained from Australian power stations. The corrosion potential (Ecorr), polarisation resistance (Rp) and corrosion current (Icorr) for steel embedded in the geopolymer concrete over the initial three months are reported in this paper. The geopolymer concrete is found to passivate steel reinforcement to a slightly lesser degree than a similar binder content PC concrete in this initial stage. In addition, the steel in the geopolymer displaying the highest compressive strength (Gladstone) was observed to display the most negative Ecorr and highest Icorr values in this period, indicating the greater susceptibility to corrosion.

[7] Fu Q, Xu W, Zhao X et al (2021) researched on the microstructure and durability of FABGC (Fly ash-based geopolymer concrete)to systematically summarize the results on its alkali-activated reaction, pore structure, and interface characteristics. The degradation mechanisms of FABGC in various corrosive environments are analyzed, and the factors that affect its microstructure and durability are discussed. It is observed that aluminosilicate gel produced by the alkali-activated process of FABGC has an optimizing effect on the pore structure and interfacial transition zone. Effective developments of the microstructure can 22 improve the durability of FABGC to a certain extent. At present, there is no consensus on the research conclusions on the microstructure and durability of FABGC. Therefore, further research is required.

[8] Nuaklong P, Sata V et al (2018) investigated the effects of metakaolin (MK) on the properties of a fly ash-based geopolymer concrete containing 100% recycled coarse aggregate from crushed specimens of laboratory. The MK was used as a partial replacement for high calcium fly ash (HCF) in geopolymer binders. The results showed that geopolymer concrete with MK has better strength, porosity, water absorption, and acid resistance. Increasing the use of MK leads to higher strengths in both natural and recycled aggregate geopolymer concrete. Furthermore, the high calcium fly ash blended with MK geopolymer concrete containing recycled aggregate is suitable for environment friendly construction and is comparable in terms of mechanical performance to a normal geopolymer concrete made with natural aggregate.

[9] Ganeshan M. and Venkataraman S (2021) discussed the effect of Fly ash blending on self-compacting geopolymer concrete (SCGC) in terms of durability and microstructure. 10% Class C fly ash was incorporated into Class F fly ash in self-compacting geopolymer, to alter the conventional methods of heat curing and aiming for commercialisation in concrete production. Geopolymer (GP) synthesis of low calcium fly ash was prepared using combination of sodium hydroxide and sodium silicate, to achieve M30 grade concrete. Tests such as acid resistance, sulphate resistance, water absorption, sorption test, chloride penetration and accelerated corrosion were performed on account of durability, and interstitial characteristics were diagnosed using SEM analysis. Results prove that the inclusion of Class C fly ash did not show any detrimental effects in SCGC, and are viable for use in hazardous environmental conditions.

[10] Jiao Z, Li X et al (2023) investigated the workability, mechanical performance, and chloride resistance of class C/class F fly ash-based geopolymer mortars . First, the effects of the water-to-fly ash ratio, class C fly ash content, and sand-to-ash ratio, on the fluidity, and mechanical properties of the geopolymers were examined. Second, based on the results, geopolymer mortars with three different strength grades were chosen for chloride resistance tests. After these were subjected to a NaCl solution, their weight change, ultrasonic flight-time, and compressive strength were determined. Moreover, corrosion products were evaluated by conducting micro structural analysis. The results indicated that a high-class C fly ash content, small water-to-fly ash ratio, and small sand-to-ash ratio led to low fluidity and a 23 high compressive strength of the specimens. The ultrasonic flight-time and the pore structures of the geopolymers were strongly related. Furthermore, after corrosion, the hydration products appeared as new crystalline zeolite phases in the low-strength samples. Compared with the high- and medium- strength mortars, the low-strength samples showed excellent chloride resistance.

III. CORROSION

Corrosion In recent decades, the construction industry has undergone a paradigm shift towards sustainable and eco-friendly materials to mitigate the environmental impact of conventional cement-based concrete. One such innovative approach is the utilization of geopolymers, a class of inorganic binders that exhibit remarkable potential for enhancing the durability and performance of concrete structures. Geopolymer concrete, synthesized from industrial by-products like low calcium fly ash, offers a promising alternative to traditional cement-based concrete due to its reduced carbon footprint and improved mechanical properties. The corrosion of reinforcing steel in concrete has been a persistent concern, leading to structural deterioration, increased maintenance costs, and compromised safety. Therefore, enhancing the corrosion resistivity of concrete is of paramount importance for ensuring the longevity and reliability of infrastructure. Geopolymer concrete has emerged as a potential solution to this challenge, with research indicating its superior resistance to corrosion compared to conventional concrete. Low-calcium fly ash, a waste product generated by coal combustion, serves as a suitable precursor for geopolymer synthesis. The utilization of fly ash not only diverts an industrial waste from landfills but also reduces the consumption of natural resources, making it an environmentally responsible choice. Fly ash-based geopolymers are formed through a chemical reaction between the fly ash and alkali activators, resulting in a three-dimensional polymeric network that exhibits excellent mechanical strength and durability. The focus of this study is to experimentally investigate the corrosion resistivity of low-calcium fly ash-based geopolymer concrete. By comprehensively evaluating its performance in aggressive environments, the study aims to contribute to the growing body of knowledge concerning the potential of geopolymer concrete to mitigate corrosion-related challenges in infrastructure.

Causes of Corrosion:

Corrosion in concrete arises from the interplay of various factors:

1. Moisture and Oxygen: The presence of water and oxygen provides the necessary conditions for the initiation and propagation of corrosion reactions. Moisture can infiltrate 16 concrete through cracks, pores, and imperfections, creating an environment conducive to corrosion.

2. Aggressive Chemicals: Corrosive agents like chlorides, sulphates, and carbon dioxide penetrate concrete and reach the embedded steel. Chlorides, often originating from de-icing salts or marine environments, are particularly detrimental as they break down the passive layer on the steel surface, accelerating the corrosion process.

3. Carbonation: Carbon dioxide from the atmosphere reacts with calcium hydroxide in concrete, resulting in a reduction of pH near the reinforcement. This phenomenon, known as carbonation, can compromise the protective alkaline environment surrounding the steel and hasten corrosion.

IV. METHODOLOGY

Geopolymer Concrete and Normal Concrete beams are tried for corrosion by utilizing the example of size(100 x 100 x 450mm). The mix designs pursued for Normal concrete were M20, M40, and M60. Also, the mix designs pursued for Geopolymer concrete are G20, G40 and G60.

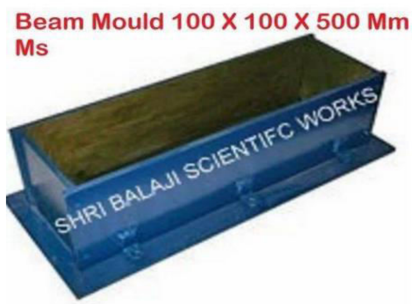

Figure 2 Beam mold of 100x100x450mm

Mixing:

In the wake of gathering every one of the materials in the required extents for example Cement, Fine aggregate, coarse aggregate, superplasticizer, and water for Normal concrete examples. What's more, Fly Ash, fine aggregate, coarse aggregate, sodium hydroxide, sodium silicate, superplasticizer, and additional water for Geopolymer concrete examples. They are mixed in the concrete mixer ceaselessly for a time span of 3 minutes.

Figure 3 Concrete mixer

Casting:

A total of 18 specimens were casted i.e. 9 beams of normal concrete and 9 beams of geopolymer concrete.

Curing:

The typical concrete solid shapes are put in water in a restoring tank for a complete time of 28 days in the wake of demoulding. The Geopolymer concrete molds are put in the Hot air 25 broiler for warmth restoring and afterward demoulded and set for encompassing relieving for the ideal time frame.

Testing:

The concrete specimens are tested for compressive strength and corrosion resistivity.

Test Results:

The results obtained are tabulated and analyzed.

Objective of the present investigation:

The primary target of the present trial examination is to analyze the corrosion resistivity of different evaluations of typical concrete and geopolymer concrete

V.MATERIALS

Cement:

Standard Portland cement of 53 grade, accessible in nearby market is utilized in the examination. The cement utilized for all tests is from a similar clump. The cement utilized has been tried for different properties according to May be: 4031-1988

- Grade: OPC 53
- Brand: Bharati Cement

Fine Aggregate:

Locally available RIVER SAND is used as fine aggregate and is tested for various properties required. The sand passing through IS sieve 2.36mm was taken.

Figure 4 2.36 mm sieved river sand

Coarse Aggregate:

The coarse aggregate utilized is locally accessible squashed rock stone of 20mm size. Tests are led to decide its physical properties. The aggregates going through IS 20mm strainer and holding on 12.6mm sifter were taken for the exploratory methods Size of aggregate: 20mm

Figure 5 Granite stone of 20mm size

Water:

Water used for mixing and curing is fresh potable water, conforming to IS: 3025 - 1964 part 22, part 23 and IS: 456 - 2000.

Fly Ash:

Fly ash is a byproduct of the combustion of pulverized coal in power plants. It is a fine, powdery material that is carried away by the flue gases produced during the combustion process. This substance consists mainly of spherical particles and contains various chemical components, making it a valuable resource with a wide range of applications. Fly ash is considered an environmentally friendly material due to its potential to reduce waste and its contribution to sustainable construction practices

Figure 6 fly ash

S.No.	Characteristics	Requirements (% by weight)	Fly Ash used (% by weight)
1	Silicon dioxide (SiO_2)plus aluminum oxide Al_2O_3 plus iron oxide Fe_2O_3	70 (minimum)	94.78
2.	Silicon dioxide (SiO_2)	35 (minimum)	66.81
3	Magnesium Oxide (MgO)	5 (max.)	2.55
4.	Total sulphur as sulphur trioxide (SO_3)	2.75 (max.)	0.87
5.	Loss on ignition	12 (max.)	1.8

Table 1 Chemical requirements of fly ash

Sodium silicate:

The Sodium Silicate liquid used in this study was provided in liquid form by Kiran Global Chems Limited, Chennai.

Figure 7 Sodium silicate

Sodium Hydroxide:

Sodium Hydroxide was provided by Genesynth Fine Chemicals, Hyderabad. The chemical was given in pellet/flakes form with 98% purity

Figure 8 Sodium Hydroxide

Super plasticizer

Naphthalene Sulphonate Formaldehyde (SNF) based super plasticizer was provided by BASF chemical company by the product name - Rheobuild - 920SH.

Figure 9 super plasticizer

VI. TESTS

Fineness test on cement:

The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence faster the development of strength.

- *RESULT:* Fineness of OPC 53 grade is 97%
- *IS LIMIT:* As per code Fineness of cement should be greater than 90% HENCE OK

Figure: 10 IS sieve no.9 of 90 microns size.

Specific Gravity of cement:

Specific gravity is normally defined as the ratio between the weight of a given volume of material and weight of an equal volume of water.

- *RESULT:* Specific gravity of OPC 53 grade is 3.1
- *IS LIMIT:* As per code specific gravity for OPC should be 3 HENCE OK

Figure 11 Specific gravity of Pycnometer

Standard Consistency of Cement:

The standard consistency of a cement paste is defined as that consistency which will permit the Vicat plunger to penetrate to a point 5 to 7mm from the bottom of the Vicat mould

- *RESULT:* Standard consistency of OPC 53 grade is 32% (P)
- *IS LIMIT:* As per code the value should be 30-32 HENCE OK.

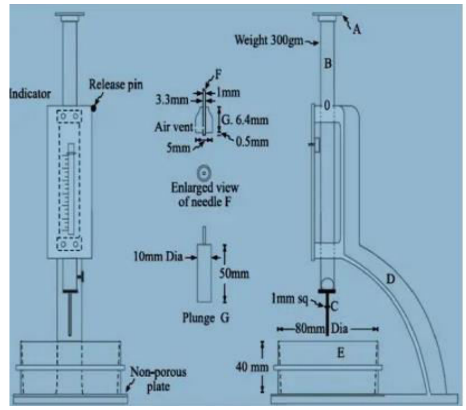

Figure 12 Vicat's apparatus

Initial Setting Time of Cement:

- *CODE:* IS 4031 Part-V
- *DESCRIPTION:* The final setting time is the point at which the set cement has acquired a sufficient firmness to resist a certain defined pressure.
- *WATERPERCENTAGE:* 0.85P % (weight of cement)
- *RESULT:* Final setting time of OPC 53 grade is 5hrs 50min
- *IS LIMIT:* As per code final setting time should be less than 10 hours HENCE OK

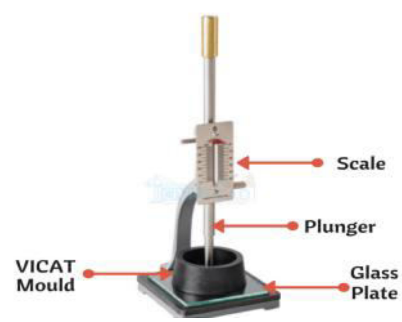

Figure 13 Vicat apparatus

Compressive Strength of Cement:

- *CODE:* IS 4031 Part-VI
- *DESCRIPTION:* Compressive strength is the capacity of a material or structure to withstand axially directed pushing forces. It provides data of force vs. deformation for the conditions of the test method.
- *CEMENT MORTAR:* 1:3 cement and sand WATER PERCENTAGE: (P/4 +3) %(weight of sample)
- *RESULT:* Compressive strength of OPC 53 grade for 3 days is 26Mpa

- *IS LIMIT:* As per code compressive strength of cement when tested shall be minimum 53Mpa (for 28 day)

Figure 14 Compressive testing machine

PHYSICAL PROPERTY TESTED	IS SPECIFICATIONS	RESULTS OBTAINNED
Fineness of cement	% Residue <10% % Fineness :- >90%	3% 97%
Specific gravity	3.15	3.1
Standard consistency	30-32%	32%
Initial setting time	>30 minutes	55 minutes
Final setting time	<600 minutes	350 minutes
Compressive strength test	53 MPa for 28 days	26 MPa for 3 days

Table 2 physical properties of cement

Specific gravity of fine aggregate:

Specific gravity test is used to find the specific gravity of fine aggregate sample by determining the ratio of weight of given volume of aggregate to the weight of equal volume of water. Aggregate specific gravity is needed to determine weight-to-volume relationships.

- *RESULT:* Specific gravity of fine aggregate is 2.50
- IS *LIMIT:* As per code specific gravity of fine aggregate has to range between 2.5-2.6 HENCE OK

SI no.	IS Sieve Size	Weight retained gm.	Cumulative Weight retained gm	Cumulative %Weight retained	Cumulative % Passing	Grading Limits IS 383- 1970 Zone II
1	10 mm	0	0	0	100	100
2	4.75mm	4	4	0.4	99.6	90-100
3	2.36mm	40	44	4.9	94.9	75-100
4	1.18mm	184	228	22.8	75.9	55-90
5	600microns	355	583	58.3	39.9	35-59
6	300 microns	310	909	90.9	8.9	8-30
7	150 microns	75	984	98.4	1.4	0-10
8	<150microns	14		—	-	-
9	Total	1000		275.7		

Table 3 Fineness Modulus of Fine Aggregate

PHYSICAL PROPERTY TESTED	IS SPECIFICATIONS	RESULTS OBTAINED
Specific gravity	2.5-2.6	2.55
Fineness modulus	2-4	2.7

Table 4 Physical properties of fine aggregate

Specific Gravity of Coarse Aggregate:

Specific gravity test is used to find the specific gravity of coarse aggregate sample by determining the ratio of weight of given volume of aggregate to the weight of equal volume of water. Aggregate specific gravity is needed to determine weight-to-volume relationships.

- *APPARATUS:* Pycnometer
- *RESULT:* Specific gravity of coarse aggregate is 2.62
- *IS LIMIT:* As per code specific gravity of coarse aggregate has to range between 2.6-2.7

  HENCE OK

Fineness Modulus of Coarse Aggregate:

Fineness modulus (FM) is defined as an empirical figure obtained by adding the total percentage of the sample of an aggregate retained on each of a specified series of sieves, and dividing the sum by 100. In general fineness modulus is defined as size of aggregate.

- *RESULT:* The fineness modulus of coarse aggregate is 7.1
- *IS LIMIT:* As per code the fineness modulus of coarse aggregate should range from 5.5-8

HENCE OK

SI. No	IS Sieve size	Weight retained gm.	%weight retained	Cumulative Percentage Weight retained
1	40 mm	0	0	0
2	20 mm	3550	63	63
3	10 mm	1450	37	100
4	4.75 mm	0	0	100
5	2.36 mm	0	0	100
6	1.18 mm	0	0	100
7	600 microns	0	0	100
8	300 microns	0	0	100
9	150 microns	0	0	100
	-			763

Table 5 Fineness Modulus Of Coarse Aggregate

PHYSICAL PROPERTY TESTED	IS SPECIFICATIONS	RESULTS OBTAINED
Specific gravity test	2.6-2.7	2.62
Fineness modulus	5.5-8	7.63

Table 6 Physical Properties Of Coarse Aggregate

Mix Design:

The mix designs taken in this examination were pursued from the mix designs created by Sri. K. Ramujee et al in his paper distributed in the Indian Concrete Institute (ICI) diary in 2013 [20]. Three examples were casted for every High, Standard and Ordinary evaluation mixes for Geopolymer concrete just as Conventional concrete. As on account of Portland cement concrete, the coarse aggregate and fine aggregate possess about 75% to 80% of the mass of Geopolymer concrete. This segment of Geopolymer concrete mixtures can be designed utilizing the instruments as of now accessible for Portland cement concrete. The compressive quality and usefulness of geopolymer concrete are affected by the extents and properties of the constituent materials that make the geopolymer glue. Three control mixes of M20, M40 and M60 of OPC concrete made by changing water cement ratio to accomplish a similar dimension of solidarity with Geopolymer concrete.

Grade ofGPC	G20	G40	G60
Fly ash	372	394.3	408.9
Fine Aggregate	672	646.8	554.0
Coarse Aggregate	1248	1201.2	1294.0
NaOH concentration	54.33(8M)	45.06(16M)	40.89(16M)
Na_2Si0_3	108.67	112.64	102.22
Extra water	22	24	24
Super Plasticizer		4	6
Ratio of Mixture proportions	1:1.80:3.35	1:1.64:3.04	1:1.35:3.16
Liquid/binder ratio	0.50	0.40	0.35

Table 7 Optimized mix proportions for various grades of GPC (Kg/m)

VII. PROCEDURE FOLLOWED

Mixing:

Intensive mixing is fundamental for the generation of uniform, brilliant concrete. Hence hardware and strategies ought to be able to do adequately mixing concrete materials containing the biggest determined aggregate to deliver uniform mixtures of the most reduced droop reasonable for the work. A concrete mixer is utilized for this reason.

Geopolymer Concrete Mixing:

The essential contrast between Geopolymer concrete and Portland cement concrete is the fastener. The silicon and aluminum oxides in the low - calcium flyash responds with the basic 43 fluid to from the geopolymer glue that ties the free coarse and fine aggregates and other unreacted materials to frame the geopolymer concrete. The Sodium Hydroxide chips are to be disintegrated in refined water in right amounts relying on the molarity required for each mix design. This NaOH arrangement is to be mixed and arranged 24hours before use. The fly fiery debris, coarse aggregate and fine aggregates are first mixed together in the mixer for three minutes or until the dry materials are altogether mixed together. The Sodium Hydroxide and Sodium Silicate arrangements are mixed together alongside the super plasticizer and water and after that additional to the dry materials in the mixer. The whole mixture is permitted to mix for four minutes. The crisp concrete is to be tried for droop in a droop cone mechanical assembly which has been appropriately lubed and fitted.

Casting Of Gpc Specimens:

After the sample has been mixed and tried for slump, fill the beam forms in the wake of applying oil to every one of the appearances. The concrete is to be poured in three layers and compacted with manual strokes by applying twenty-five hits to each layer with the assistance of a packing pole. While completing off the outside of the concrete, if the form is too full the abundance concrete ought not be evacuated by scratching off the top surface as this removes the cement glue that has made advances on the top and leaves the concrete shy of cement. The right route is to utilize a side of trowel and uncover a reasonable sample of the concrete all in all, at that point complete the surface by trowelling.

Figure 15 Gpc specimens

Opc Specimens:

After the sample has been mixed and tried for slump, fill the beam forms in the wake of applying oil to every one of the appearances. The concrete is to be poured in three layers and compacted with manual strokes by applying twenty-five hits to each layer with the assistance of a packing pole. While completing off the outside of the concrete, if the shape is too full the overabundance concrete ought not be evacuated by scratching off the top surface as this removes the cement glue that has made advances on the top and leaves the concrete shy of cement. The right path is to utilize an edge of trowel and uncover a reasonable sample of the concrete in general, at that point complete the surface trowelling

Demoulding:
The Conventional concrete beams ought to be demoulded between 20-24 hours after they have been made. The Geopolymer concrete beams are to be demoulded after proper warmth restoring has occurred. When expelling the block from the shape, dismantle the form totally. 45 Take care not to harm beam in such a case that any breaking is caused, the compressive quality might be diminished.

Curing:
Care must be taken to appropriately fix concrete, to accomplish best quality and hardness, during this period concrete must be held under controlled temperature and damp environment. Appropriately relieving concrete prompts expanded quality and lower penetrability and abstains from splitting where the surface dries out rashly. Ill-advised relieving can cause scaling, decreased quality, poor scraped area obstruction and breaking.

Curing Of Gpc Specimens:
After the Geopolymer concrete molds are casted, the specimens are restored at a temperature of 60°C for 24hours. Two kinds of restoring were connected, Heat relieving and Ambient restoring. For warmth restoring, the specimens werecovered with a polythene sheet andcured in a broiler and for Ambient relieving the specimens were left to air for wants period. Theheat relieved specimens were left to air-dry in the research center for another 24hours or until testing. It is to be noticed that the specimens are still in their molds during the 24hours time of Heat restoring. The specimens can be demoulded, after warmth relieving, and left for ambient restoring.

Curing Of Normal Concrete Specimens:
The beams must be restored before they are tried. The blocks ought to be put following demoulding in the restoring tank. The restoring temperature of the water in the relieving tank ought to be kept up at 27-30°C. Relieving ought to be proceeded for 28 days or up to the season of testing. So as to permit acceptable course of water, sufficient space ought to be given between the beams, and between the beams and the side of the tank.

Testing:
The beam specimens are to be tested for compressive strength in the Compressive Testing Machine (CTM) and then tested for Corrosion in Open Circuit Potential Method

VIII. ANALYSIS & DISCUSSION OF RESULT

Results of Portland cement & Geopolymer concrete mixtures: Based the Experimental examinations did on Ordinary, Standard and High quality geopolymer concrete and Conventional concrete (OPC), the compressive quality outcomes are exhibited in the accompanying tables

Grade of Concrete	M20	M40	M60
Compressive strength (7 days curing) N/mm^2	18.55	33.77	50.08
Compressive strength (28 days) N/mm^2	23.77	43.55	66.12
Workability (Slump)	Very stiff	High	Moderate

Table 8 Portland cement concrete mixtures

Grade of Concrete	G20	G40	G60
Compressive Strength (7 days) N/mm^2	27.55	40.88	62.22
Compressive Strength (28 days) N/mm^2	29.25	45.77	67.85
Workability (Slump)	High	High	Very stiff

Table 9 fly ash-based Geopolymer concrete mixtures

OCP test results
ASTM C 876-91 specifies the OCP values and corresponding corrosion conditions are given in the table.

(mV vs SCE)	(mV vs CSE)	Corrosion Condition
<-426	<-500	Severe corrosion
<-276	<-350	Eligh(<90% risk of corrosion)
-126 to-275	350 to - 200	Intermediate corrosion risk
>- 125	>-200	Low(10 % risk of corrosion)

Table 10 corrosion condition

The test outcomes got were contrasted and the values given by ASTM C 876-91 guidelines and the likelihood of reinforcement corrosion are anticipated. From the table, it tends to be seen that GPC carries on in a superior way contrasting and OPC for a similar chloride arrangement.

SET	Cement type	Specimen no.	Average open circuit potential values of 3 specimens (mV)	Corrosion condition
1	OPC	M20	-89	Intermediate
	OPC	M40	-122	intermediate
	OPC	M60	-169	High
2	GPC	G20	-84	Intermediate
	GPC	G40	-105	Intermediate
	GPC	G60	-155	Intermediate

Table 11 Corrosion Probability

The effect of corrosion on the tensile behavior of reinforcement under different rates of corrosion is compared. There is not much noticeable change in the yield strength. Long duration test may be required to analyze the strength of beams.

Set	Cement type	Specimen no.	Yield stress with corrosion	Ultimate stress with corrosion	Yield stress with out corrosion	Ultimate stress with out corrosion
1	OPC	M20	394.26	471.85	426	492.86
		M40	398.13	479.89	426	492.86
		M60	405.26	486.28	426	492.86
2	GPC	G20	402.96	476.94	426	492.86
		G40	406.09	481.58	426	492.86
		G60	412.23	489.18	426	492.86

Table 12 results of tension test

The table shows the influence of chloride content on OPC and GPC in the potential values which is the indication of corrosion. At all concentrations, GPC perform superior to OPC.

IX. CONCLUSION

In the present work, Open Circuit Potential(OCP) technique decided the corrosion action in the reinforced beams. The impact of corrosion on the tractable conduct of reinforcement under various rates of corrosion was looked at and the test outcomes uncovers that the Geopolymer concrete performs better than OPC concrete.

1. Geopolymer concrete acts like OPC concrete.
2. Water to geopolymer solids ratio and antacid fluid to flyash ratio are the administering factors for the advancement of geopolymer concrete.
3. The execution of geopolymer reinforced concrete beams presented to chloride condition is better than OPC reinforced concrete beams.
4. As the evaluation of concrete increment the corrosion opposition likewise increments; for both OPC and GP concretes
5. Yield pressure and extreme pressure values for OPC and GPC diminishes as for unexposed reinforced bar.

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