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Different Chemical Reactions on Slag Based Geopolymer Concrete and Low Calcium Fly Ash

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ABSTRACT

Concrete is the most adaptable, long-lasting, and durable construction material. Concrete is the most often used fabric, necessitating massive amounts of Portland cement. Because the fundamental carbon dioxide generator pollutes the ecology, regular Portland cement manufacturing ranks second only to the automobile. Concrete is commonly delivered with the option of using normal Portland cement (OPC) as the binder. There are several environmental issues associated with the production of OPC, such as the release of 1 tonne of carbon dioxide for every 1 tonne of synthetic OPC. Geopolymer binders have been shown to be a green option for ordinary Portland Cement (OPC) in concrete production. Fly ash, a coal byproduct, got, which is available worldwide. Fly ash is high in silica and alumina, and when combined with an alkaline solution, it generates aluminosilicate gel, which serves as the concrete's binding fabric. Alkali liquids (usually a soluble steel hydro-oxide and alkali silicate) can be utilised to create binders by reacting with silica (SiO2) and alumina (Al2O3) rich natural resources, such as Metakaolin, or with commercial byproducts, such as fly ash. These binders are used with standard coarse and exceptional aggregates to create alkali-activated concrete or geopolymer concrete. With sodium silicate, sodium hydroxide, fly ash (magnificence-F), and a good and coarse combination, geopolymer concrete mixes will be powerful. The molarity of NaOH varies between (12M and 16M). The most crucial goal is to Examine the mechanical properties of GPC (G20 & G50) such as compressive, tensile, flexural, and affect electrical on dazzling molarities of NaOH (12M and 16M) and for one-of-a-kind curing procedures to get best outcomes of geopolymer concrete that can be utilised for regular advent. GPC NDT tests (Rebound Hammer and Pulse Velocity) will be studied, and the check results will be compared to controlled concrete of the same grade.

1. INTRODUCTION

Concrete is one in all the foremost wide utilized industrial substances; conjointly, it's related to hydraulic cement because the primary ingredient for building concrete. the requirement for concrete as a producing cloth is increasing. or else, as a results of warming, one in all the foremost serious environmental problems has become a high priority within the recent decade. warming is caused by the discharge of greenhouse gases, like CO2, into the atmosphere as a results of human action. CO2 provides around sixty fifth of worldwide warming among greenhouse gases. as a result of the assembly of 1 weight unit of hydraulic cement generates roughly one weight unit of CO2, the cement trade is liable for some 6 June 1944 of total CO2 emissions. the atmosphere Despite the actual fact that the utilization of hydraulic cement is important for the predictable future, many tries area unit being undertaken to cut back the utilization of hydraulic cement in concrete. These initiatives embrace the utilization of supplemental cementing materials like ash, oxide fume, coarse furnace dross, rice husk ash, and metakaolin, also because the identification of potential binders to hydraulic cement. to elucidate the zeolite-like polymers, Joseph Davidovits fictional the term "geopolymers" in 1972. Geopolymers area unit alumina-silicate polymers with amorphous and three-dimensional structures that result from the geopolymerisation of alumina-silicate monomers in base-forming solutions. Calcined clays (for example, metakaolin) or industrial wastes had been studied (e.g., ash or scientific discipline slag). Through the Davidovits technique, a chemical pathway connected to the polycondensation of orthosilicate ions (hypothetical monomer) is conferred.

According to studies, 3 methods inside the geopolymerisation process area unit supported: (1) dissolving in base-forming solution; (2) transcription and diffusion of dissolved ions with the event of little coagulated systems; and (3) polycondensation of soluble species to make hydrous merchandise.

Geopolymers area unit well-known for his or her superior properties as compared to regular hydraulic cement (OPC), that embrace high compressive strength, low shrinkage, and so on. they could be employed in producing engineering, fireproofing, biomaterials, waste treatment, and so on. all the same, new programmes area unit being thought of. The geopolymerisation technique varies from the OPC, whose producing involves the oxidation of rock at high temperatures, that consumes heaps of energy and emits heaps of greenhouse emission into the atmosphere. One weight unit of OPC synthesis produces roughly one weight unit of CO_2. As a result, there's a chance fabric turns into determined with a lot of less power consumption, and far less greenhouse gas (CO_2) emission and brought with nicely physic-mechanical homes to remedy the trouble raised through OPC production.

PROBLEM STATEMENT

After water, Portland cement concrete is the most widely used material on the planet. In actuality, aside from becoming one of the most widely used construction materials in the world, concrete has been proven over time to be extremely resistant to water, particularly salt water movement, when compared to other substances. As a result, it has become the major material used for constructions exposed to the sea environment. However, despite its ability to last for many years in a variety of packaging and to withstand environmental attacks from competitor marketers, it has been demonstrated that Portland cement concrete creates issues such as sturdiness and durability whether exposed to saltwater, sulfuric soils, or freezing temperatures, as well as carbon dioxide emissions Many concrete structures have demonstrated severe degradation much in advance of their intended provider lifetimes, particularly those erected in hostile environments (Mehta 1997). Because of its significant contribution to the amount, Portland cement has also prompted major concerns about its harmful effects on the environment.

OBJECTIVE OF THE WORK

The successful study addressed the manufacturing and durability properties of GGBS mixed fly ash-primarily based completely fully geopolymer concrete. The following are the key objectives of this observation:

- investigate the long-term properties of fly ash and slag-primarily based completely Geopolymer Concrete for oven-curing situations. Compressive energy, weight changes toward resistance to seawater, acids, and sulphate attack are among the properties.

To investigate the influence of various molarities of NaOH inside the binder on the iconic properties of geopolymer concrete in a competitive environment.

- comparing the sturdiness of geopolymer concrete findings with those of Portland cement concrete with equivalent electricity

2. LITERATURE REVIEW

This study provides associate analysis of the foremost recent analysis on Geopolymers and Geopolymer concrete, with a spotlight on low Ca fly ash-based Geopolymer paste and concrete applications. The energy and sturdiness of geopolymer concrete are lined well within the antecedently uploaded publications. many of them area unit offered here.

REVIEW OF WORKS ON GEOPOLYMER CHEMISTRY

Davidovits (1991, 1999) researched the Geopolymerization technique and discovered that it concerned a extremely fast chemical action between numerous alumino-silicate oxides and silicates beneath alcalescent conditions, giving chemical compound Si-O-Al-O linkages. During a chemical action, water is discharged from the Geopolymer matrix. it's important to grasp the role of water within the creation of Geopolymers. This water, that is discharged from the Geopolymer matrix throughout set and drying phases, leaves discontinuous nano-pores within the matrix, that improves the general performance of Geopolymers. It provides the foremost helpful workability to the mixture once managing and has no operate within the chemical action that happens, as compared to the chemical action that happens.

Van Jaarsveld et al. (1997) completed foundational analysis into the geology or par agenesis of the character minerals that comprise Geopolymers, in addition because the precise chemical processes chargeable for the dissolution and gel formation events in Geopolymer systems. once clays and ash were used, the dissolving of the start materials didn't end before the ultimate firm form was shaped. For the whole mixture to harden, the only little amount of silicon dioxide and corundum existing on particle surfaces needed to participate within the reaction. As a result, it became assumed that surface reaction was in control of attaching the unmelted waste particle into the final word Geopolymer kind.. Davidovits (2008) has established that the polymerisation system involved a fast chemical response below alcalescent conditions on element metal minerals that junction rectifier to a three-dimensional chemical compound chain and ring structure.

DURABILITY OF GEOPOLYMER CONCRETE

Bakharev (2005) investigated the soundness of Geopolymer compounds and planned the usage of sophistication F ash. As alcalescent solutions, soluble glass, hydrated oxide, and hydrated oxide activators were used and hydrothermally cured at 95oC. the weather were submerged in Na and Mg salt solutions. These tests are performed to work out Geopolymer compound resistance. The tests concerned immersing components in an exceedingly five-hitter concentration of {sodium salt|sodium sulfate|sulfate|sulphate} and Mg salt resolution and a five-hitter awareness of sulfate + five-hitter Mg sulphate resolution for five months. Weight, compressive electricity, deterioration, and microstructural changes within the specimens were conjointly investigated. large changes in electricity occurred within the sulfate resolution, with associate energy deficit of eighteen within the specimens. These tests are performed to work out Geopolymer compound resistance. The tests discovered that the specimens activated by soluble glass grew by sixty fifth, the specimens created employing a combination of hydrated oxide and hydrated oxide as activators grew by four-dimensional, and also the specimens activated by hydrated oxide grew by four-dimensional. within the Mg salt resolution, twelve-tone system and thirty fifth energy growth were detected in samples activated with hydrated oxide and a mix of Na and atomic number 19 hydroxides, severally, whereas pure gold strength reduction was measured in those activated with soluble glass alone. Monita Olivia et al. (2011) given the findings of their study on the sturdiness of fly ash-based Geopolymer concrete in an exceedingly marine setting. 3 distinct Geopolymer mixes and a changed blend were evaluated during this study to work out the powerful porousness, chloride particle penetration, and corrosion of steel reinforcement bars beneath electric circuit ability and increased corrosion testing. The Geopolymer paste includes a high chloride incursion.

3.MIX PROPORTION OF GEOPOLYMER CONCRETE

(Experimental Program)

3.1 MATERIALS

Materials used for preparation of Geopolymer Concrete are

Fly Ash (class F)
Ordinary Portland Cement -53 grade
Coarse aggregate
River sand (Fine aggregate)
GGBS (Ground Granulated Blast Furnace Slag)
Sodium silicate solution
Sodium hydroxide pellets
Water

Chemical Admixture Gelenium (B233)

Materials used for evaluating chemical resistance of Geopolymer concrete are

Hydrochloric acid

Sulphuric acid

Sodium Sulphate

Magnesium sulphate

3.1.1 FLY ASH

Low calcium (class F) dry fly ash collected from different places of Vijayawada is used as the source material to make geopolymer concrete.

Table 3.1 Chemical composition of fly ash (class F) as per XRF (mass %)

SiO2 – 47.8

SiO2	Al2O3	CaO	Cr	Fe2O3	K2O	MgO	Na2O	P2O5	SO3	TiO2	MnO	LOI
47.8	24.4	2.42	0.01	17.4	0.55	1.19	0.31	2	0.29	1.328	0.12	1.1

3.1.2 Ordinary Portland cement

Table No.3.1.2 Physical properties of Ordinary Portland Cement

S. No	Property	Test Method	Test Results	IS Standard
1.	Normal Consistency	Vicat Apparatus (IS: 4031 Part - 4)	25%	
2.	Specific gravity	Sp. Gr bottle (IS: 4031 Part - 4)	3.05	
3.	Initial setting time Final setting time	Vicat Apparatus (IS: 4031 Part - 4)	45 minutes 182 Minutes	Not less than 30 minutes Not less than 10 hours
4.	Fineness	Sieve test on sieve no.9 (IS: 4031 Part – 1)	1.0%	10%
5.	Soundness	Le-Chatlier method (IS: 4031 Part – 3)	2 mm	Not more than 10 mm
6.	Compressive Strength		51.8 N/mm2	

3.1.3 COARSE AGGREGATES

Locally available 10mm and 20mm uniform sized coarse aggregates are used in the preparation of Geopolymer concrete.

Table3.1.3: Physical properties of 20mm coarse aggregate

S.NO	Property	Method	Fine Aggregate
1.	Specific gravity	Pycnometer IS:2386 part 3-1986	2.536
2.	Flakiness Index	IS:2386 part 2-1986	--
3.	Elongation Index	IS:2386 part 2-1986	--
4.	Bulk density(compact)	IS:2386 part 3-1986	1711Kg/cum
5.	Bulk density(loose)	IS:2386 part 3-1986	1631Kg/cum
6.	Fineness modulus	Sieve Analysis (IS:2386 Part 21963)	3.06
7.	Bulking	IS:2386 Part 3-1986	4% wc
8.	Grading		Zone –V

3.1.4 FINE AGGREGATE

Best combination used turned into domestically to be had river sand with none natural impurities and the conforming to IS: 383 – 1970

Table No.3.3:Physical Properties of Fine Aggregate

S.NO	Property	Method	Fine Aggregate
1	Specific gravity	Pycnometer IS:2386 part 3-1986	2.84
2	Flakiness Index	IS:2386 part 2-1986	--
3	Elongation Index	IS:2386 part 2-1986	--

4	Bulk density(compact)	IS:2386 part 3-1986	1711Kg/cum
5	Bulk density(loose)	IS:2386 part 3-1986	1631Kg/cum
6	Fineness modulus	Sieve Analysis (IS:2386 Part 21963)	3.06
7	Bulking	IS:2386 Part 3-1986	4% wc
8	Grading		Zone –II

3.1.6 GROUND GRANULATED BLAST FURNACE SLAG

GGBS (additionally observed as GGBS or GGBFS) is created from furnace scum, a by-product from the manufacture of iron. GGBS is nonheritable with the help of mistreatment termination liquid iron furnace scum instantaneously in water or stream, to supply a glassy granular product this can be then dried and floor right into a good powder. it's AN terrific binder to supply excessive overall performance cement and concrete. These operate at a temperature of roughly one,500 stages centigrade and square measure fed with a cautiously managed combination of iron -ore, coke and rock. GGBS is actually thought-about one in all the "greenest" of production substances additionally to the environmental gain of employing a by-product, GGBS replaces some factor this can be made with the help of employing a implausibly energy -extensive method

Table No.3.2:Chemical Properties of GGBS

SiO2	32.78
Al2O3	22.4
Fe2O3	1.1
MgO	0.08
CaO	34.86
Na2O	-
LOI	0.62

3.2 CHEMICALS USED FOR DETERMINING DURABILITY OF GEOPOLYMER CONCRETE

Hydrochloric acid
Sulphuric acid
Sodium Sulphate
Magnesium Sulphate
Sodium chloride

3.2.1 HYDROCHLORIC ACID (HCl)

Hydrochloric acid is a solution to hydrogen chloride in water. Hydrogen chloride takes place as each a drab liquid with a hectic, stinky smell or a colour much less to slightly yellow gasoline which may be shipped as a liquefied compressed gas; quite soluble in water.

Melting point: -114.24°C
Boiling factor: -85.06°C
Specific Gravity: 1.2
Vapour Density: 1.268
1 ppm = 1.49 mg/m3

3.2.2 SULPHURIC ACID (H2SO4)

Sulphuric acid is intentional definitely through the oxidization of chemical compound minerals in rocks. Dilute sulfuric acid is additionally customary withinside the atmosphere through oxidization of dioxide (from the burning of fuels) withinside the presence of wet, sooner or later causative as `acid rain'.

sulfuric acid

$SO_3 + H_2O \rightarrow H_2SO_4$

Melting factor: 10 °C
Boiling factor: 337 °C
Precise Gravity: 1. 85
Vapour Density: 1. 84 g/ cm3

3.3.1 MIX DESIGN FOR CONTROLLED CONCRETE (M20)

The procedure for designing concrete mix of M20 grade concrete is adopted as per IS 10262: 2009 and IS: 456-2000.

Table No.3.3:Stipulations for Proportioning M20 Concrete Mix Design

M-20 CONCRETE MIX DESIGN		
AS per IS 10262-2009		
Stipulations for Proportioning		
1	Grade Designation	M20
2	Type of cement	Ultra Tech Opc 53 grade
3	Maximum Nominal Aggregate Size	20 mm
4	Minimum Cement Content	320 kg/m3
5	Maximum Water Cement Ratio	0.45
6	Workability	50-75mm(slump)
7	Exposure Condition	Normal

8	Degree of Supervision	Good
9	Type of Aggregate	Crushed Angular Aggregate
10	Maximum Cement Content	540 kg/m3

Target mean strength of concrete:
The target mean compressive strength (f'ck) at twenty eight days is given by
f'ck = fck + 1.65 S
I.e. 20 + 1.65 x 5 = 28.25 N/mm²
f'ck = target average compressive strength at twenty eight days,
f'ck = characteristic compressive strength at twenty eight days, and s = variance.

Selection of water-cement ratio:

From IS 456-2000
The water-cement quantitative relation needed for the target mean strength of 28.25 N/mm² is 0.45. Adopt W/C quantitative relation of 0.45

Selection of water content:

From Table a pair of (IS 10262: 2009), most water content =186 liter (for twenty five to fifty millimetre slump range) for twenty millimetre combination.

Calculation of cement content Water-cement quantitative relation = 0.45
Cement content = 186/0.45
= 413.33 kg/m³
Cement content 320 kg/m³< 413.33 kg/m³>540 kg/m³
As per clause eight.2.4.2 of IS 456:2000 (Cement content not together with ash and ground coarse furnace dross over 450 kg/m³ shouldn't be used)
Estimated water content =162.10 Lt
Cement Content = (162.10/0.45) = 362.64 Kg/m3

Proportion of volume of coarse combination and fine combination content
From Table 3(IS 10262: 2009),
volume of coarse combination reminiscent of twenty millimetre size combination and fine combination (Zone II) for water-cement quantitative relation of 0.50 =0.62.
Here water-cement quantitative relation is 0.45.

Therefore, volume of coarse combination is needed to be magnified to decrease the fine combination content. because the water-cement quantitative relation is lower by 0.10.
The proportion of volume of coarse combination is magnified by 0.02 (at the speed of -/+ 0.01 for each ± 0.05 amendment in water cement ratio).
Therefore, corrected proportion of volume of coarse combination for the water-cement quantitative relation of 0.45 = 0.62.
Therefore, volume of coarse combination = 0.62
Volume of coarse combination = 1- 0.62
Volume of fine aggregate= 0.38

Mix calculations

The mix calculations per unit volume of concrete shall be as follows:

- Volume of concrete = 1m³
- Volume of cement = mass of cement/ (Sp. Gravity of cement x1000)
  = 362.64 / (3.15*1000)
  = 0.104 m³
- Volume of water = mass of water / (Sp. Gravity of water x1000)
  = 162.10 / (1*1000)
  = 0.162 m³
- Volume of beat aggregates = one – (Volume of cement + Volume of water)
  = 1 – (0.104) = 0.734 m³
- Mass of coarse combination = Volume of beat combination x a thousand x Volume of coarse combination x relative density of coarse combination x a thousand

  =0.734*0.62*2.672*1000 = 1215.97m^2

- Mass of fine combination = Volume of beat combination x I 000 x Volume of fine combination x relative density of fine combination x a thousand

  = 0.734*0.38*2.84*1000
  = 792.13 Kgs

3.3.2 MIX DESIGN FOR GEOPOLYMER CONCRETE (G20)

Unit weight of concrete=2400Kg/m3
Mass of combined aggregate = 78.14% of unit weight of concrete
= ((78.14/100) *2400) = 1875.36 Kg/m3

Mass of fly ash and alkaline liquid = Unit weight of concrete – Mass of combined aggregate
= 2400 – 1875.36 = 524.64 Kg/m3
Considering Alkaline liquid to fly ash = 0.45
Calculation for mass of fly ash = ((Mass of fly ash and alkaline liquid)/ (1+Alkaline liquid to Flash ratio))
= ((524.64)/ (1+0.45)) = 361.82 Kg/m3
Calculation for Mass of Alkaline liquid = Mass of fly ash and alkaline liquid – Mass of fly ash
= 524.64 – 361.82 = 162.81 Kg/m3
Considering Na2SiO3 to NaOH ratio = 2.5
Calculation for Mass of NaOH= (Mass of alkaline liquid/ (1+ratio of Na2SiO3 to NaOH))
= (162.81/ (1+2.5)) = 46.51 Kg/m3
Calculation for Mass of NaOH for 12M (NaOH Solids) = (36.1/100) * Mass of NaOH
Where 36.1 = Number of moles for 12M
= ((36.1/100) * 46.51 = 16.79 Kg/m3
Calculation for Mass of Na2SiO3 = Mass of Alkaline liquid -Mass of NaOH
= 162.81 – 46.51 = 115.299 Kg/m3
Calculation for Mass of water = Mass of NaOH – Mass of NaOH solids for 12 = 46.51 – 16.79 = 29.72 Kg/m3

Table No.3.4: G20 Geopolymer Concrete Mix Design

Geopolymer Concrete (G20)		
1	Unit weight of concrete	2400
2	Mass of combined aggregate 78.14% of 2400	1875.36
3	Mass of fly ash and alkaline liquid	524.64
4	Considering Alkaline liquid to fly ash as	0.45
4(a)	Mass of fly ash	361.82Kgs
4(b)	Mass of Alkaline liquid	162.819
5	Considering Na2SiO3 to NaOH ratio	2.5
5(a)	Mass of NaOH	46.51
	For 12 Molarity (NaOH solids)	16.79
5(b)	Mass of Na2SiO3	116.3
6	Mass of water	29.72
7	From Na2SiO3	162.81
Mix Proportion		

3.3.3 MIX DESIGN FOR CONTROLLED CONCRETE (M50)

The procedure for designing concrete mix of M50 grade concrete is adopted as per IS 10262: 2009 and IS: 456-2000.

Table No.3.5: Stipulations for Proportioning M50 Concrete Mix Design

M-50 CONCRETE MIX DESIGN		
AS Per IS 10262-2009		
Stipulations for Proportioning		
1	Grade Designation	M50
2	Type of cement	Type of cement OPC 53 grade
3	Maximum Nominal Aggregate Size	20 mm
4	Minimum Cement Content	400kg/m3
5	Maximum Water Cement Ratio	0.45
6	Workability	50-75mm(slump)
7	Exposure Condition	Normal
8	Degree of Supervision	Good
9	Type of Aggregate	Crushed Angular Aggregate

Target mean strength of concrete:
The target mean compressive strength (f'ck) at 28 days is given by f'ck = fck + 1.65 S
i.e. 50 + 1.65 x 5 = 58.25 N/mm²
f'ck = target average compressive strength at 28 days, fck = characteristic compressive strength at 28 days, and s = standard deviation.

Selection of water-cement ratio:
From Table 5 of IS 456,
The water-cement ratio required for the target mean strength of 58.25 N/mm² is 0.45.
Adopt W/C ratio of 0.4
Selection of water content
From Table 2 (IS 10262: 2009), maximum water content =186 litre (for 25 to 50 mm slump range) for 20 mm aggregate.

Calculation of cement content
Water-cement ratio = 0.4

Cement content = 186/0.4

= 465 kg/m³

Cement content 320 kg/m3< 465 kg/m3

As per clause 8.2.4.2 of IS 456:2000 (Cement content not including fly ash and ground granulated blast furnace slag more than 450 kg/m³ should not be used)

Estimated water content =164.15

lts Cement Content = (164.15/0.4) = 409.36 Kg/m3

Proportion of volume of coarse aggregate and fine aggregate content

(IS 10262: 2009), volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II) for water-cement ratio of 0.50 =0.62. Here water-cement ratio is 0.4.

Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.10. the proportion of volume of coarse aggregate is increased by 0.02 (at the rate of -/+ 0.01 for every ± 0.05 change in water-cement ratio).

Therefore. corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.4 = 0.69.

Therefore, volume of coarse aggregate =0.69

Volume of coarse aggregate = 1- 0.69

volume of fine aggregate= 0.31

Mix calculations

The mix calculations per unit volume of concrete shall be as follows:

Volume of concrete = 1m³

Volume of cement = mass of cement/ (Sp. Gravity of cement x1000)

= 409.36 / (3.15*1000) = 0.12 m3

Volume of water = mass of water / (Sp. Gravity of water x1000)

=164.15/ (1*1000) = 0.164 m3

Volume of all in aggregates = 1 – (Volume of cement + Volume of water)

= 1 – (0.13+0.164)

= 0.72 m3

Mass of coarse aggregate = Volume of all in aggregate x 1000 x Volume of coarse

aggregate x specific gravity of coarse aggregate x 1000

= 0.72*0.484*2.672*1000

= 931.13 kgs

Mass of fine aggregate = Volume of all in aggregate x I 000 x Volume of fine

aggregate x specific gravity of fine aggregate x 1000

= 0.72*0.23*2.84*1000 = 470.304kgs

Table No.3.6: M50 Concrete Mix Design

Target Strength for Mix Proportion		
1	Maximum Water Cement Ratio (As Per IS: 456:2000) table 5	0.45
2	Adopted Water Cement Ratio	0.4
3	Target Mean Compressive Strength @ 28 days fck=fck+(1.65*S) N/mm²	58.25
4	Characteristic Strength @ 28 days N/mm²	50
5	Selection of Water Content from Table 2 (IS 1062:2009), Maximum Water Content for 20 mm aggregate	186
	Estimated water content	164.15
	Super Plasticizer Used (1.5% of cement used)	6.16
6	Calculation of Cement Content	
a	Water Cement Ratio	0.4
b	Cement Content	409.36
	Minimum Cement Content	400 kg/m³
7	Proportion of Volume of Coarse Aggregate and Fine Aggregate	
a	Volume of Coarse Aggregate as per table 3 of IS 10262:2009	69%
b	Adopt Volume of Fine Aggregate	31%
8	Mix Calculations	
a	Volume of Concrete in m³	1
b	Volume of Cement in m³	0.130
	Mass of cement/(Specific gravity of Cement*1000)	
c	Volume of water in m³	0.164
	Volume of Admixture = ((Mass of admixture)/ (Sp Gravity of admixture) *1000)	0.004

9	Volume of all in Aggregate in m³	0.72
	Vol of concrete-Vol of cement-volume of water	
10	Volume of coarse aggregate in m³	0.484
	0.71*0.69	
11	Volume of fine aggregate in m³	0.23
	0.71*0.31	
12	Mix proportions for one cum of concrete (SSD condition)	
	Mass of coarse aggregate	931.13
	Mass of fine aggregate	470.304
MIX PROPORTION		
1	Cement	1
2	Fine Aggregate	1.35
3	Coarse Aggregate	3.14

3.3.4 MIX DESIGN FOR GEOPOLYMER CONCRETE (G50)

Unit weight of concrete=2400Kg/m3

Mass of combined aggregate = 76.1% of unit weight of concrete = ((76.1/100) *2400) = 1826.4 Kg/m3

Mass of fly ash and alkaline liquid = Unit weight of concrete – Mass of combined aggregate

= 2400 – 1826.4 = 573.6 Kg/m3

Considering Alkaline liquid to fly ash = 0.4

Calculation for mass of fly ash = ((Mass of fly ash and alkaline liquid)/ (1+Alkaline liquid to Fly ash ratio))

= ((573.6/ (1+0.4)) = 409.71 Kg/m3

Calculation for Mass of Alkaline liquid = Mass of fly ash and alkaline liquid – Mass of fly ash

= 573.6 – 409.71 = 163.88 Kg/m3

Considering Na2SiO3 to NaOH ratio = 2.5

Calculation for Mass of NaOH = (Mass of alkaline liquid/ (1+ratio of Na2SiO3 to NaOH))

= (163.88 / (1+2.5)) = 46.82 Kg/m3

Calculation for Mass of NaOH for 12M (NaOH Solids) = (44.4/100) * Mass of NaOH

Where 44.4 = Number of moles for 12M

= ((44.4/100) * 46.82 = 20.79 Kg/m3

The Mass of Na2SiO3 = Mass of Alkaline liquid -Mass of NaOH

= 163.88 – 46.82 = 117.06 Kg/m3

Calculation for Mass of water = Mass of NaOH – Mass of NaOH solids for 12M

= 46.82 – 20.79 = 26.03 Kg/m3

Table No.3.7: Geopolymer Mix design (G50)

	Geopolymer Mix design (G50)	
1	Unit weight of concrete	2400 Kg/m3
2	Mass of combined aggregate 76.1% of 2400	1826.4
3	Mass of fly ash and alkaline liquid	573.6
4	Considering Alkaline liquid to fly ash as	0.4
4(a)	Mass of fly ash	409.71
4(b)	Mass of Alkaline liquid	163.88
5	Considering Na2SiO3 to NaOH ratio	2.5
5(a)	Mass of NaOH	46.82
	For 16 Molarity (NaOH solids)	20.79
5(b)	Mass of Na2SiO3	117.06
6	Mass of water	26.034
7	From Na2SiO3	163.88
	Mix proportion	
1	Fly ash	1
2	GGBS	0.17
3	Fine Aggregate	1.59
4	Coarse Aggregate	3.7

Fly Ash	Fine Aggregate	Coarse Aggregate	Water	Plasticizer	GGBS
1.74	2.77	6.47	0.82	0.03	0.30
kgs	kgs	kgs	lit	lit	kgs

4 - EXPERIMENTAL INVESTIGATIONS

4.1 GENERAL

Parameters thought-about within the course of the observation are mixture content material, alkalic substance answer, soluble glass to NaOH quantitative relation, the concentration of NaOH answer, and also the approach of natural process. the assembly of Geopolymer concrete is predicated on the standard concrete ways. Cement is certainly replaced by means that of ash magnificence f and ground coarse furnace scum to create and paperwork Geopolymer binder. Geopolymer paste is intentional by victimisation the activation of soluble glass and caustic soda via Si and Al that work uniform concrete.

Durable homes beside Acid assault resistance, sulfate attack resistance, and binary compound attack resistance square measure determined with the help of enterprise compression check on Geopolymer concrete once natural process within the kitchen appliance at sixty five˚C. The Compression strength of Geopolymer concrete before immersion in chemical compounds is decided at 3, 7, and twenty eight days. The perform strength obtained is as compared with compressive strengths earned once immersion in chemical compounds at regular intervals. A comparative look is formed at the load and compression strengths of Geopolymer concrete and standard concrete.

The Parameters are as follows:

1.Concentration of NaOH in Molar.

2. quantitative relation of metallic element to salt by mass.

3. natural process temperature

4. result of Wet-Mixing Time

5. Influence of handling time on compressive strength

6. result of super plasticiser on compressive strength

7. result of water-to-geopolymer solids quantitative relation by mass on compressive strength

5. RESULTS AND DISCUSSION

5.1 GENERAL

In this chapter, the check results square measure provided and mentioned. The check impacts cowl the effect of chemical surroundings at the compressive electricity and unit weight of low-calcium fly ash-primarily based mostly geopolymer concrete. The take look includes the resistance of Geopolymer concrete G20 G50 to a lower place Acids, Sulphates, and Chloride.

5.2 HCL ACID RESISTENCE

Table 5.1 Compressive strength of (G20&M20) MPa

Grade of concrete	Immersion period	original strength MPa	Strength of specimen when immersed in HCL solution	Compression Strength loss in percent
M20	15 days	36.2	32.5	5.9%
G20		37.1	33.31	3.8%
M20	45 days	36.2	30.56	8.2%
G20		37.1	32.89	8.1%
M20	75 days	36.2	32.1	10.3%
G20		37.1	31.5	7.9%
M20	105 days	36.2	32.66	11.2%
G20		37.1	31.0	10.5%

The M20 specimens immersed in 5% HCl solution showed maximum strength loss of 11.2% whereas G20 specimens showed strength loss of 3.8% less than normal concrete at the end of the immersion period.

Table 5.2 Weight loss of (G20&M20) Kgs

Grade of concrete	Immersion period	Initial weight Kgs	Weight of specimen when immersed in HCl solution	Weight loss in percent
M20	15 days	2.48	2.40	2.12
G20		2.33	2.07	2.03
M20	45 days	2.45	2.22	8.27
G20		2.27	2.00	8.02
M20	75 days	2.54	2.05	14.2
G20		2.34	2.03	11.1
M20	105 days	2.47	1.84	20.4
G20		2.3	1.85	18.3

The M20 specimens immersed in 5% HCl solution showed maximum weight loss of 20% whereas G20 specimens showed weight loss of 19% attaining better resistance.

Table 5.3 Compressive strength of (G50&M50) MPa

Grade of concrete	Immersion period	original strength MPa	Strength of specimen when immersed in HCl solution	Compression Strength loss in percent
M50	15 days	53	50.45	4.8
G50		56	54.37	2.8
M50	45 days	53	49.23	7.0

G50		56	53.08	4.2
M50	75 days	53	48.33	8.8
G50		56	51.9	6.3
M50	105 days	53	46.48	11.3
G50		56	50.9	8.1

The maximum strength loss of M50 in immersed in 5% HCl solution was 11.3% at the end of immersion period (105 days) whereas geopolymer concrete (G50) exhibited strength loss of
8.1%.

Table 5.4 Weight loss of (G50&M50) Kgs

Grade of concrete	Immersion period	Initial weight Kgs	Weight of specimen when immersed in HCl solution	Weight loss in percent
M50	15 days	2.48	2.42	2.01
G50		2.37	2.32	2.22
M50	45 days	2.54	2.35	7.5
G50		2.42	2.27	6.0
M50	75 days	2.60	2.28	11.3
G50		2.42	2.18	9.5
M50	105 days	2.52	2.03	18.5
G50		2.44	2.02	16.5

5.3 SULPHURIC ACID RESISTENCE

. Table 5.5 Compressive strength (M20 & G20) MPa

Grade of concrete	Immersion period	Original strength MPa	Strength of specimen when immersed in H_2SO_4 solution	Compression Strength loss in percent
M20	15 days	36.2	32.56	10.03%
G20		37.1	34.12	8.02%
M20	45 days	36.2	31.4	13.1%
G20		37.1	32.63	12.03%
M20	75 days	36.2	30.84	14.8%
G20		37.1	31.86	14.1%
M20	105 days	36.2	29.64	18.12%
G20		37.1	31.16	16.01%

The M20 specimens immersed in 5% H2SO4 showed maximum strength loss of 18.12% at the end of immersion period whereas G20 specimens showed strength loss of 16.01%

Table 5.6 Weight loss of GPC (G20&M20) Kgs

Grade of concrete	Immersion period	Initial weight Kgs	Weight of specimen when immersed in H2SO4 solution	Weight loss in percent
M20	15 days	2.463	2.42	1.50
G20		2.302	2.27	1.15
M20	45 days	2.523	2.43	3.0
G20		2.28	2.22	2.2
M20	75 days	2.486	2.27	5.0
G20		2.25	2.14	4.8
M20	105 days	2.51	2.30	8.0
G20		2.304	2.12	7.0

The maximum weight loss of M20 specimens immersed in 5% H2SO4 solution by the end of immersion period was 8.0% whereas the G20 specimens showed weight loss of 7.0%

Table 5.7 Compressive strength (M50 & G50) MPa

Grade of concrete	Immersion period	original strength MPa	Strength of specimen when immersed in H2SO4 solution	Compression Strength loss in percent
M50	15 days	53	48.70	8.1
G50		56	52.65	5.97
M50	45 days	53	46.59	12.09
G50		56	50.28	10.2
M50	75 days	53	45.47	14.2
G50		56	49.26	12.03

M50	105 days	53	44.50	16.03
G50		56	48.15	14.01

The M50 specimens immersed in 5% H2SO4 solution showed maximum strength loss of 16.03% at the end of immersion period whereas G50 specimens showed strength loss of 14.01% which is 2% less when compared with M50.

Table 5.8Weight loss of (G50&M50) Kgs

Grade of concrete	Immersion period	Initial weight Kgs	Weight of specimen when immersed in H2SO4 solution	Weight loss in percent
M50	15 days	2.57	2.53	1.33
G50		2.433	2.40	1.20
M50	45 days	2.621	2.54	2.5
G50		2.425	2.35	2.45
M50	75 days	2.55	2.43	4.4
G50		2.397	2.28	4.0
M50	105 days	2.608	2.44	5.2
G50		2.425	2.28	5.8

The maximum weight loss of M50 specimens immersed in 5% H2SO4 solution was 5.2% at the end of immersion period whereas the weight loss of G50 specimens was 5.8%

6. CONCLUSIONS

From the experimental research, the following conclusions are made:

- Geopolymer concrete may be manufactured with low calcium fly ash with specific molarities of NaOH.
- G20 and G50 grades of Geopolymer concrete are advanced that is equivalent to

M30 and M50 grade of controlled Concrete with the subsequent properties o Alkaline liquid to fly ash ratio O Sodium Silicate to Sodium Hydroxide ratio 2.Five o Sodium Oxide to Silicon Dioxide ratio 2 o Molarity of Sodium Hydroxide o Temperature 600C

- G30 and G50 grade geopolymer concrete can be made by adopting mix proportions of (1:2.21:3.Eighty five) and (1:1.59:3.7) and solving alkaline liquid to flashy ratio as zero. 4.5 and 0.4respectively.
- To increase the price of initial putting time, an most beneficial percent i.e. 15% GGBS has been replaced in fly ash.
- The clean fly ash-based geopolymer concrete is effortlessly dealt with without any signal of setting and without any degradation within the compressive energy.
- Compressive strength of geopolymer concrete increases with the boom in molarity of sodium hydroxide (NaOH) solution.
- The most compressive electricity 37.1 N/mm2 turned into observed in 12M awareness of NaOH at 28 days for oven curing (G30).
- The most compressive energy 56N/mm2 changed into discovered in 16M awareness of NaOH at 28 days for oven curing (G50).
- The most compressive energy 36.2 N/mm2 was discovered for M30-controlled Concrete and 53 N/mm2 become determined for M50-managed Concrete.
- The purpose for the improvement in compressive electricity of geopolymer concrete is the chemical reaction because of the rapid polymerization process and the growing older of the alkaline liquid.
- In oven curing the most advantageous temperature of 600C may be adopted for twenty-four hours to get higher effects.
- The compressive energy of G30 growth by using 2.Five% and G50 boom by means of 2.8% when compared with controlled Concrete of M30 and M50 respectively.
- The break-up tensile power of G30 growth by using 2.Five% and G50 boom by way of 1% whilst compared with controlled Concrete of M30 and M50 respectively.
- The flexural strength of G30 increased by means of 2.5% and G50 grew by 1% as compared with managed Concrete of M30 and M50 respectively.
- The implied rebound value of the G30 boom by using 6.66% and G50 growth through 5.55% whilst comparing with managed Concrete of M30 and M50 respectively.
- The suggested pulse velocity cost of G30 increased via 6.84% and G50 boom by way of 6.18% whilst evaluating with managed Concrete of M30 and M50 respectively.

• The early strengths are viable in oven-cured geopolymer concrete in comparison to ambient-cured and controlled concrete.

• Ambient curing is additionally applicable when early strengths are not required.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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