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STUDY AND ANALYSIS OF DURABILITYFOR CEMENT CONCRETE PAVEMENT AND FLEXIBLE PAVEMENT IN EXPANSION SOIL REGION

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Abstract: The construction industry currently makes heavy use of concrete, which is among the most used building materials. When making concrete, Portland cement is the main ingredient. A vital component that does not produce greenhouse gases and does not depend on Portland cement is geopolymer. Davidovits created geopolymer technology in 1978, and it shows great promise as a Portland cement alternative in the concrete industry. He proposed a polymeric reaction as a means of producing binders from silicon and aluminium contained in several geological source materials or by-products, including Fly Ash, Slag, and Rice-Husk Ash. The reaction would use alkaline liquids. Geopolymers were the name he gave to these binder types. Of all the waste products and byproducts, the two most potential sources of geopolymers are slag and fly ash. This study employs fly ash and ground granulated blast-furnace slag to investigate the mechanical, durability, and micro-structural properties of geopolymer concrete. At different levels of substitution (FA0-GGBS100, FA25-GGBS75, FA50-GGBS50, FA75-GGBS25,FA100-GGBS0), this research will examine the effects of class F Fly Ash (FA) and Ground Granulated Blast Furnace Slag (GGBS) on the mechanical and durability properties of geopolymer concrete (GPC). Solutions of sodium hydroxide (NaOH) and sodium silicate (Na2SiO3) have been used as alkaline activators. Compressive, split tensile, bond, and flexural strengths are the mechanical parameters that are being examined inthis study. Water absorption, Rapid Chloride Permeability, and Sulphur attack tests were among the durability features investigated in the study of geopolymer concrete produced from ground granulated blast furnace slag and low-calcium Fly Ash. Under standard room temperature circumstances, the properties of these materials have been evaluated at7,28,56, and 90 day curing intervals. When it comes to micro-level investigations, you can rely on XRD,SEM, EDS, FTIR, TGA, and DTA methods. A28-day curing period at room temperature was followed by the examination of these micro-level properties. The results of a 2005 study on GPC by Hardjito and Rangan were used to establish the GPC mix proportions used in this inquiry. The mechanical, microstructural, and durability characteristics of geopolymer concrete (GPC) mixes derived from fly ash (FA) and ground granulated blast furnace slag (GGBS) are investigated in this work over a short period of time. In addition, the study compared GPC to ordinary concrete of the M45 grade in terms of its short- term mechanical, durability, and micro-level properties. Geopolymer concrete with fibre reinforcement has been the subject of research. The mechanical and durability properties of various geopolymer concrete mixes have been studied. Various percentages of fibers— 0.25%,0.5%,0.75%, and 1.0% by volume—were added to the concrete mixture. Compressive strength, split tensile strength, and flexural strength were some of the mechanical properties that were evaluated at 28 days for various fibre mixtures. Rapid chloride penetration test (RCPT), water absorption, and acid assault are some of the durability characteristics that have been investigated for the same mixes.

I.Introduction

Davidovits (1978) proposed geopolymer technology as a viable substitute for Portland cement as a binder in the concrete industry. This technology has the ability to cut carbon dioxide emissions by around 80%, mainly from the cement and aggregate industries. In this process, two types of source materials—Fly Ash (FA) and Ground Granulated Blast Furnace Slag (GGBS)—containing silicon (Si) and aluminium (Al) undergo geopolymerization in a very alkaline solution. A binding substance is formed as a result of this process. One innovative material that canstand on its own, geopolymer concrete, does away with the need for traditional cement. Pollution of the environment is the most pressing problem facing the world today.Carbon dioxide (CO2) is released into the atmosphere during the cement manufacturing process. The production of cement results in two separate sources of carbon dioxide (CO2) emissions. Combustion of fossil fuels to power the rotating kiln is the principal contributor to carbon dioxide emissions during cement manufacturing. Limestone, which is chemically transformed into lime in the cement kiln, is another major source. Research on reducing cement industry emissions of greenhouse gases was carried out by Hendricks et al. (2004). Carbon dioxide (CO2) emissions from the cement industry around the world have been recorded by Ernest Overall and Lynn Price et al. (2002). Emissions of CO2 by India were approximately

2,069,738 metric tonnes in 2010. Cement is made in India using a variety of raw resources, including clay, limestone, and other minerals. Deterioration of the environment is another consequence of extracting these essential minerals. It takes 1.6 metric tonnes of raw materials to make 1 metric tonne of cement. Although people utilise limestone at a dizzying rate, its creation is a glacial process.The cement industry is known for its high energy usage. The manufacturing of Portland cement, with its 4 gigajoules per tonne, is the third most energy- intensive process after that of steel and aluminium. After the thermal power plants and iron and steel industries, Figure 1.1 shows the flow diagram for the Portland cement and geopolymer concrete business. Keep in mind that the cement industry in India is the country's third-biggest coal consumer. Thus, thermal power plants generate a lot of fly ash (FA), which causes a slew of problems when it comes time to dispose of it. India currently produces 130 million tonnes of FA per year, with projections to reach 175 million tonnes by 2012. FA has been successfully used as a mineral admixture in Portland pozzolano mixed cement for nearly 60 years. Its use in cement concrete is very successful because it helps control environmental pollution and offers technical advantages. However, despite these efforts, the overall utilisationof FA remains around 50%. In this work, we substitute Portland cement with a geopolymer derived from low-calcium fly ash for the binder in concrete. Fly ash-based geopolymer paste binds unreacted components, including fine aggregate sand, coarse aggregates, and other materials, to produce geopolymer concrete. It is not necessary to utilise admixtures for this binding process to take place. The production of geopolymer concrete follows the same steps as that of regular concrete. Aggregates constitute about 75–80% of the overall mass in geopolymer concrete, which is comparable to OPC concrete. The low-calcium (ASTM Class F) fly ash reacts chemically with an alkaline liquid that contains sodium hydroxide and sodium silicate to release silicon and aluminium. The aggregate and any unreacted material are bound together by the geopolymer paste that is formed during this reaction. The byproduct of the blast furnace process for manufacturing iron is known as ground granulated blast furnace slag (GGBS). GGBS is a non- metallic material with a grainy, smooth texture. Among its many base components, calcium silicate and aluminate make up the bulk of it. With respect to particle size, GGBS is almost indistinguishable from cement. Concrete's workability, density, durability, and resistance to alkali-silica reaction are all enhanced by GGBS, a cheap filler that is often added with Portland cement. Geopolymer concrete and geopolymer concrete reinforced with steel fibres using fly ash and GGBS are the subjects of this project's strength and durability studies. Geopolymer blends with fly ash and GGBS as the main binder are the subject of this thesis.

II.THESIS OBJECTIVE

This study focuses on analysing and experimenting with the ingredients used in GPC (General Purpose Concrete) to understand their features and how they affect the mix design and workability of the concrete.Implementation of Ground Granulated Blast Furnace Slag (GGBS) and other cementitious materials in a 10:1 molarity ratio in Geopolymer Concrete(GPC).Investigation of the mechanical and durability characteristics of GPC.Investigation of the microstructural characteristics of GPC.Investigation of the analytical methodology for assessing the mechanical properties of GPC.

CHAPTER-3 MATERIALS AND METHODS

3.1 INTRODUCTION

A number of cementitious elements are absent from the concrete that makes up the GPC. In most cases, the cement in Ordinary Portland Concrete is hydrated in order to increase its strength. Because the cementitious materials used in GPC are inert to water, hydration does not occur in this process. Cementitious ingredients, which are high in silica and alumina, go through a polymerization chemical reaction to get the strength needed in concrete. In order to create two- or three-dimensional polymeric chains, monomer molecules undergo a chemical reaction known as polymerization. The process of GPC polymerization is aided by the presence of alkalinesolutions. Cementitious materials and alkaline liquids (catalysts) are the primary components of GPC. Both naturallyoccurring substances (such as Kaolinite or clay) and industrial wastes (such as GGBS, FA, or SF) can serve as source materials. The GPC can be performed with either a sodium- or potassium-based alkaline solutions. They can also exhibit characteristics of both kinds. The physical and chemical properties of the materials utilised in this experiment are discussed in chapter 3. In addition, the mix design for the M45 grade geopolymer concrete used to prepare the specimens is laid out in a straightforward and understandable manner. A number of cementitious elements are absent from the concrete that makes up the GPC. In most cases, the cement in Ordinary Portland Concrete is hydrated in order to increase its strength. Because the cementitious materials used in GPC are inert to water, hydration does not occur in this process. Cementitious materials, which are high in silica and alumina, go through a chemical process known as polymerization to achieve the strength needed in concrete. Polymerization is defined as the formation of two- or three-dimensional polymeric chains by means of reactions between monomer molecules.

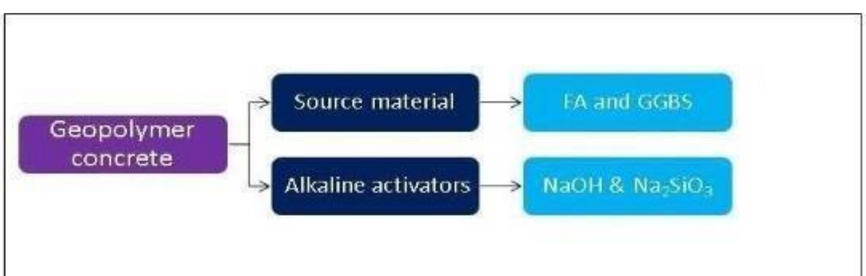


Figure 3.1 Typical constituents of a GPC

3.2 Materials The current research utilised Class F fly ash and GGBS as the source ingredients for the geopolymer concrete. However, there are many more options. Aggregates made up around 75% to 80% of the overall mass of the concrete, just as they did with OPC. The parts that go into making GPC are broken down in the sections that follow. This section presents the physical and chemical qualities of the materials that make up the product. • Soot from combustion engines • Granulated blast furnace ash Aggregate, both fine and coarse 5. Liquids with an alkaline pH 6. Regular Portland cement (53 grade) Experiment performed on fly ash (3.3) Fly ash specific gravity is tested in this way. The specific gravity of fly ash was found to be GGBS, or ground granulated blast furnace slag, was the subject of the test. The specific gravity of GGBS is tested in the following way: The specific gravity of GGBS was determined to be Evaluations carried out on crushed rock As for fine aggregate, we put it through these tests: (i) Two variables: specific gravity and water absorption. Molus for finess Here is the outcome: - The specific gravity of stone is 2.62. Adsorption of water by fine aggregate= 1% The modulus of fine aggregate finesse is 2.47. 3.6 Coarse aggregate testing 3.5.1 Coarse aggregate with a 10mm and 20mm particle size is subjected to the following tests: (i) Variable specific gravity Iii) Absorption of water Gradient of fineness.The steps for creatinggeopolymer concrete using low calcium fly ash and ground glass beads (GGBS) are laid forth in this chapter. The procedure for creating the test specimens, including the ingredients, quantities, and curing time, is detailed first. The test processes follow this. Standard procedures for making and testing concrete with Ordinary Portland Cement (OPC) were adhered to to the best of our ability. The concrete building business intended to benefit from the advertising of this "new" substance, which is why this move was taken. The development process was made easier by using the compressive strength as the standard. This is typical, as compressive strength is fundamental to concrete building construction (Neville, 2000). Ch 4 provides the specifics of the experiments that were conducted.

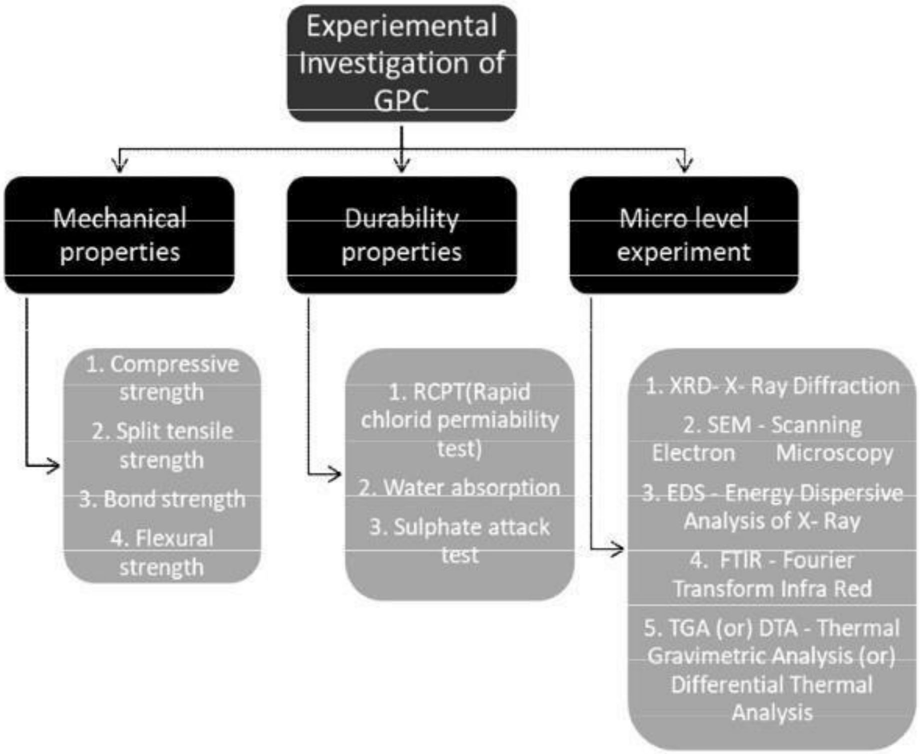


Fig 4.1 Experimental Investigations of GPC

Figure 4.2 Concrete cubes with reinforcement

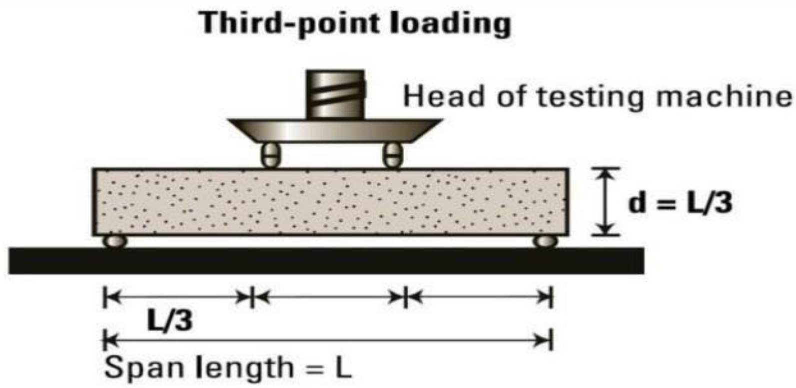


Fig 4.3 Flexural Strength Test Arrangement

The Flexural Strength or modulus of rupture (f_b) is given by

$f_b = pl/bd^2$ (when **a** > 20.0cm for 15.0cm specimen or > 13.0cm for 10cm specimen)

or

$f_b = 3pa/bd^2$ (when **a** < 20.0cm but > 17.0 for 15.0cm specimen or < 13.3 cm but > 11.0cm for 10.0cm specimen.)

Where,

a = the distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen

b = width of specimen (cm)

d = failure point depth (cm)

l = supported length (cm)

Fig 4.4 Flexural Strength Test

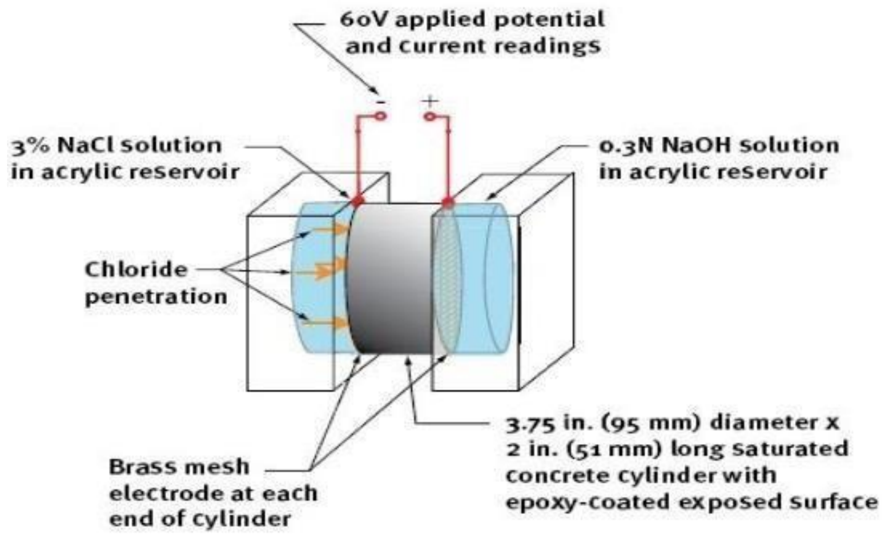


Fig. 4.5. Rapid chloride permeability Test procedure

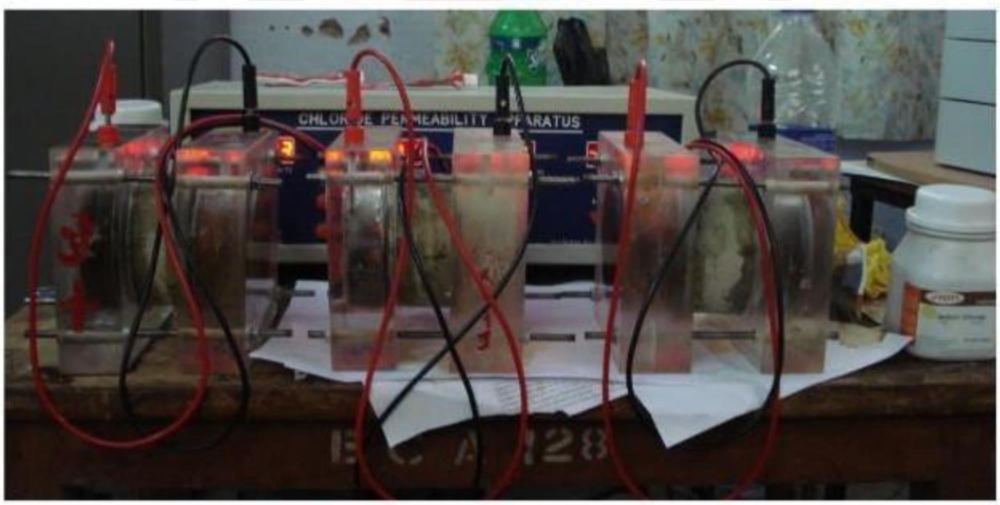


Fig. 4.6. Rapid chloride permeability test setup

From the current values, the chloride permeability is calculated in terms of coulombs at the end of 6 hours by using the formula.

$$Q = 900\ (I_0 + 2\ I_{30} + 2\ I_{60} + 2\ I_{90} + \ldots\ldots\ldots\ldots + 2\ I_{300} + 2\ I_{330} + 2\ I_{360})$$

The relationship between chloride penetrating rate and the charge passed by coulombs is given in below Table 4.1.

Table 4.1 Chloride penetrability characteristics as per ASTM C1202

Charge Passed (Coulomb)	Chloride Penetrability
> 4000	High
2000 to 4000	Moderate
1000 to 2000	Low
100 to 1000	Very Low
<100	Negligible

sample should be usually in a powder form, consisting of fine grains of crystalline material to be studied.

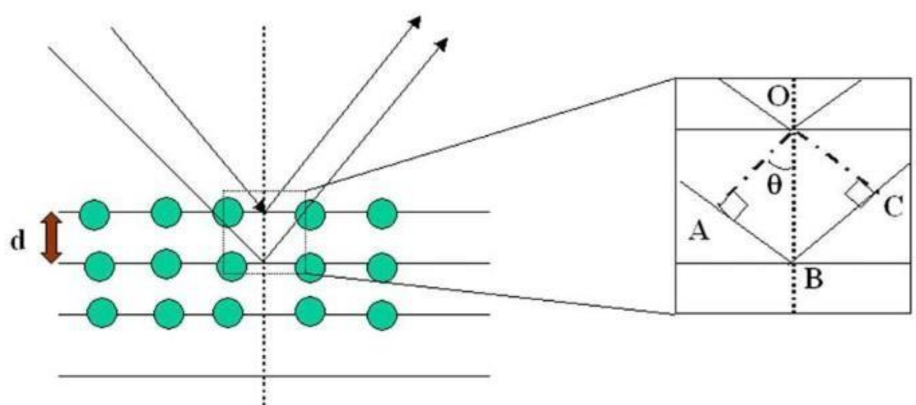


Figure 4.7 X Ray Diffraction

Path difference= AB+BC, AB=BC=d cos (90-θ) = d sin θ

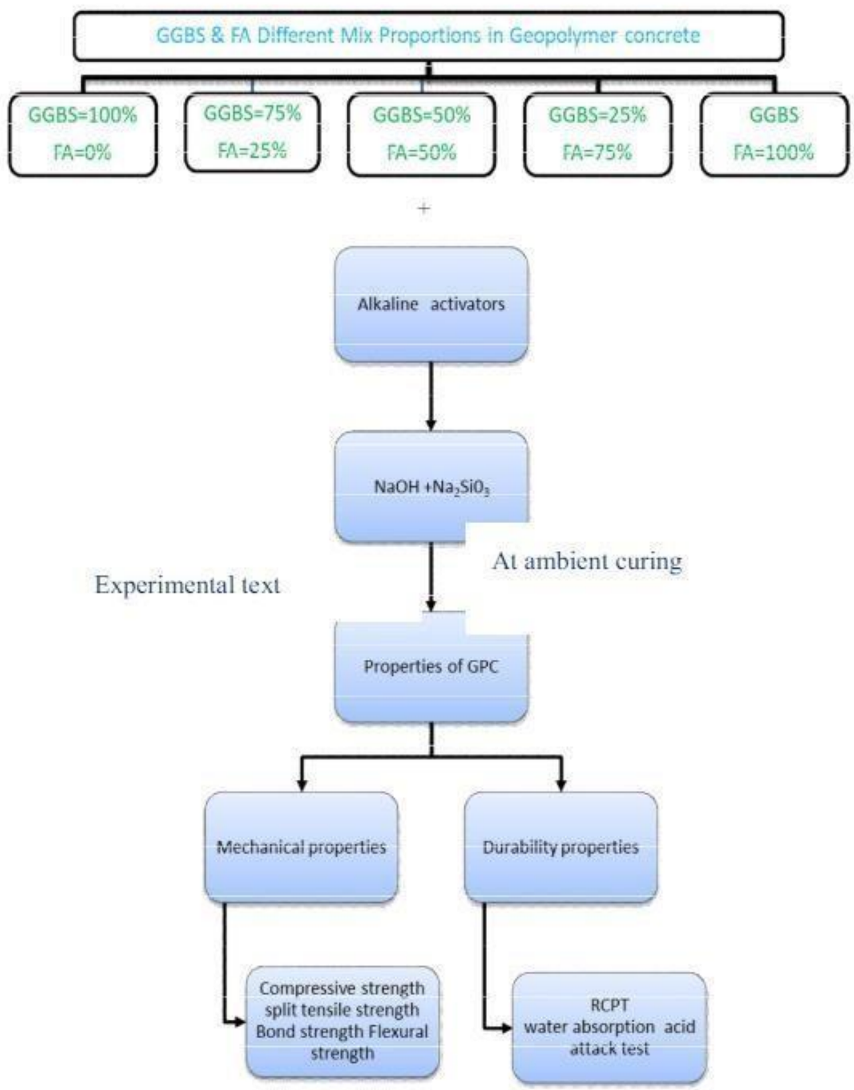
Hence AB+BC=2d sin θ= n λ

Derivation of Bragg's Law using the reflection geometry and applying trigonometry. The lower beam must travel the extra distance (AB + BC) to continue traveling parallel and adjacent to the top beam.

Results And Discussion On Mechanical, Durability

The steps for creating geopolymer concrete using low calcium fly ash and ground glass beads (GGBS) are laid forth in this chapter. The procedure for creating the test specimens, including the ingredients, quantities, and curing time, is detailed first. The test processes follow this. Standard procedures for making and testing concrete with Ordinary Portland Cement (OPC) were adhered to to the best of our ability. The concrete building business intended to benefit from the advertising of this "new" substance, which is why this move was taken. The development process was made easier by using the compressive strength as the standard. This is typical, as compressive strength is fundamental to concrete building construction (Neville, 2000). Results from the tests show how FA and GGBS affected the mechanical qualities (such as bond strength, compressive strength, and split tensile strength) and durability properties (such as water absorption and rapid chloride permeability) of GPC when cured at room temperature. The GPC mixtures' compressive strengths were evaluated at7,28,56, and 90 days after curing. After 28, 56, and 90 days of curing, the durability characteristics values of the GPC mixtures were measured. Comparing these mechanical and durability qualities over the short term to those of conventional concrete (CC) grade M45 was the next step.

Flow chart of different proportion in strength and durability properties of Geopolymer concrete: -



Chapter 5 presents the findings and discusses the mechanical and durability aspects. Multiple visual representations, including tables, bar charts, and graphs, showcase the findings of this inquiry regarding bond strength, split tensile strength, and compressive strength. Both tabular and bar chart formats are used to display the findings of the water absorption and fast chloride permeability tests. At each stage of the experiment, the results are interpreted to make analysis easier. This understanding of the findings is predicated on the nature of the results and the existing body of research. Results are valuable because they are significant in relation to the criteria set out by the applicable prior mix design. 5.2 Discussion and results regarding compressive strength Table 5.1 displays the compressive strength of various CC (M45) and GPC mix formulations at various curing durations. The mixesinclude FA100-GGBS0, FA25- GGBS75, FA50-GGBS50, FA75-GGBS25, and FA0-GGBS100.

Table 5.1 Compressive strength of CC and GPC

Mechanical property	Age	Mix type					
		M45	FA0-GGBS100	FA25-GGBS75	FA50-GGBS50	FA75-GGBS25	FA100-GGBS0
Compressive strength pc (MPA)	7	26.12	54.29	51.11	35.30	13.30	10.51
	28	51.39	60.23	58.12	46.32	15.55	12.11
	56	54.23	63.11	59.02	48.33	28.22	18.68
	90	56.34	65.23	62.32	51.78	33.02	22.03

After seven days of curing, the compressive strength of regular concrete is 26.12 MPa. After 7 days of curing, the compressive strength values of geopolymer concrete with mix proportions FA: GGBS:0:100, FA: GGBS:25:75, and FA: GGBS:50:50 are greater than those of conventional concrete. In contrast, with mix proportions FA: GGBS:75:25 and FA: GGBS:100:0, the compressive strength values of geopolymer concrete are lower than those ofconventional concrete.

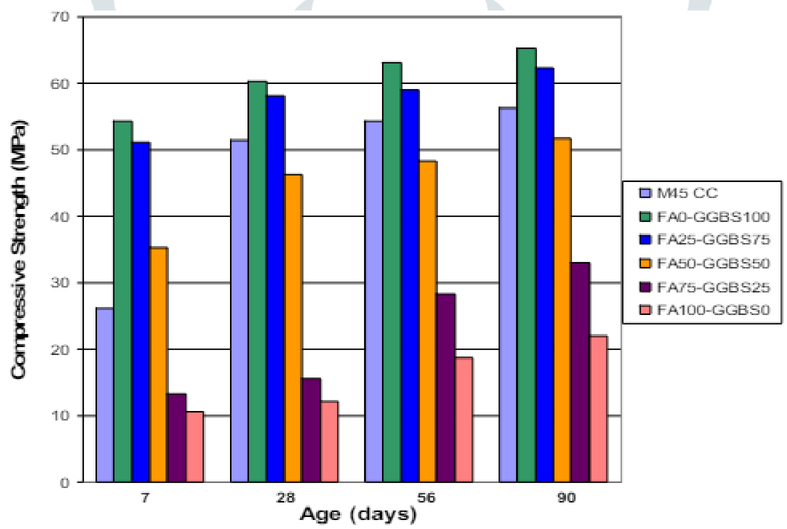


Fig. 5.1 Compressive strength versus Age

Figure 5.1 is a bar diagram showing the fluctuation of the compressive strength of geopolymer concrete for varied curing periods and FA:GGBS mix fractions. At all curing times, the bar diagram clearly indicates that the compressive strength value of geopolymer concrete combined with 100% GGBS is larger than that of traditional concrete (M45 grade). At all curing periods, the compressive strength values of geopolymer concrete blended with 100% FA are lower than those of ordinary concrete (M45 grade), and they remain at a minimum.

5.4 Discussion and findings about binding strength As indicated in Table 5.3, the specimens for all the mixtures were subjected to a bond strength test after 7, 14, and 28 days of curing. In the middle of the cube, the specimens were laid out horizontally on top of the 1 metre TMT bar. All ages and mixes had their specimens cast and tested.

Table 5.3 Bond strength of CC and GPC

Mechanical property	Age	Mix type					
		M_{45}	FA0-GGBS100	FA25-GGBS75	FA50-GGBS50	FA75-GGBS25	FA100-GGBS0
Bond Strength MPa	7	8.95	12.48	10.77	10.43	9.21	4.47
	14	10.99	13.85	12.59	11.15	8.88	6.39
	28	14.37	16.78	15.22	13.33	10.9	8.23

SUMMARY AND CONCLUSION

Quantity calculation of M45 grade of CC						
Dry co-efficient of concrete : 1.52 (a)						
Material	**Weight (Kg/m^3)** (b)	**Specific gravity** (c)	**Volume (m^3)** (d)=(b)/(c)	**Volume Proportions** (e)=(d)/(f)	**Quantity per cubic meter of concrete (m^3)** (h)=(e)*(a)/(g)	**Remarks**
Cement	533	3.06	174.18 (f)	1.00	0.33	Let 1 cement bag of 50 kg =0.0347 m^3 volume
Sand	625	2.62	238.55	1.37	0.45	
CA 20	606.4	2.58	235.04	1.35	0.44	
CA 10	404.3	2.65	156.71	0.90	0.30	
Total volume of proportions				4.62 (g)	Total: 1.52	

Results from the study of GPC mixes based on FA and GGBS are reviewed in this chapter. This study's GPC mixture proportions were refined using data from a prior GPC investigation (Hardjito and Rangan, 2005). This research looked at the mechanical and durability characteristics of GPC mixes based on FA and GGBS in the short term. Additionally, the study contrasted the mechanical and durability qualities of GPC and M45 grade CC over the short period. In today's building business, concrete is a material that is utilised extensively. The primary ingredient in concrete is Portland cement. One important component that doesn't use Portland cement or produce greenhouse emissions is geopolymer.

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