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Study on the Light Weight Geopolymer Concrete Made of Recycled Aggregates from Lightweight Blocks

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***Abstract:** This study studied the properties of lightweight geopolymer concrete that contained recycled lightweight block aggregate. The recovered blocks are classified as coarse aggregates after being crushed.To reduce greenhouse gas emissions, geopolymers have the potential to be used to create new, environmentally beneficial materials. A new class of building materials called geopolymer concrete (GPC) has a replacement for regular Portland cement concrete (OPCC) and are capable of revolution in the construction sector. The impact of On the strength characteristics, alkaline activators have been investigated. Used fly ash was obtained for this study from a nearby thermal power plant. Samples were produced from low-calcium fly ash through activation with a combination of sodium silicate solution and sodium hydroxide. Fly ash was added to the concrete with a ratio of 0.5. Using a mix proportion and 5,10,15 Molar of sodium hydroxide solution, geopolymer specimens were cast. The samples underwent compression testing. test with ambient temperatures for curing. From the analysis ofLiterature suggests that the combination of the aforementioned ingredients is healing. FromAccording to a review of the literature, the amalgamation of the aforementioned elementshas a favorable effect on the strength properties of geopolymer concrete. Since fly ash is viewed as a waste product, geopolymer concrete made from low-calcium fly ash costs less than Portland cement concrete as a result. Low-calcium fly ash-based geopolymer concrete has good compressive strength, very little drying shrinkage and minimum creep, great resistance to sulphate attack, and superior acid resistance.*
***Keywords:** Geopolymer concrete, Sodium hydroxide flakes, Sodium silicate ,Recycled lightweight blocks, Low calcium flyash.*

I. INTRODUCTION

In order to create binders, Davidovits suggested using an alkaline liquid to react with the silicon (Si) and aluminium (Al) in a source material having a geological origin or in by-product materials like fly ash and rice-husk ash. Geopolymer are a part of the inorganic polymer group. The geopolymer material's chemical make-up is comparable to naturally occurring zeolitic minerals, however it has an amorphous microstructure. The Under alkaline conditions, the polymerization process requires a very rapid chemical reaction. Circumstances that result in a three-dimensional polymeric state in silicon-aluminum minerals Si-O-Al-O bonds form a chain and ring structure. There has been a rise in the production of lightweight aggregate concrete, which now includes all types of no-fines concrete with low densities of 300–1200 kg/m3 for block manufacturing and medium densities of 1000–2000 kg/m3. Structures made of concrete need m3.

All types of concrete are produced using lightweight aggregate, and because it is more affordable, lightweight aggregate concrete is used instead of regular concrete. Alkaline liquids and silicon- and aluminum-rich source materials, including fly ash, rice husk, silica fume, and GGBS, are the two basic components of geopolymer.The strength of GPC is influenced by temperature and curing time. GPC can be made using the same sand and coarse aggregate that are used to manufacture traditional concrete.The use of recycled aggregates in geopolymer concrete has not received much attention, according to a thorough examination of the literature. The goal of this study is to evaluate the strength of fly ash-based geopolymer concrete made with recycled aggregates and to compare it to conventional concrete.

II. REVIEW OF LITREATURE

The strength parameters of geopolymer concrete using recycled aggregates were investigated by Anuar K.A et al. in 2011. The strength of geopolymer concrete, which is at day 7, is increasing.Geopolymer concrete's strength increased by over 90% after 28 days. using theexperimentation outcomes

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It has been demonstrated that employing a higher concentration of sodium hydroxidebecause of the larger concentration of, offers the concrete a higher compressive strength.NaOH will create a strong connection between the concrete paste and aggregate.Shinde, B. P., B. S. A. Suryawanshi, and D. A. Chougule. 2016 were investigated Within 24 hours, the lightweight Geopolymer concrete gains strength without using water to cure it. As the molarity of the lightweight geopolymer concrete decreased, its strength arose .a solution of alkaline. With a 1M solution, the sample was found to give a good compressive strength and a density that can be achieved to make it lightweight. It is discovered that 1.64 to 2 Mpa of compressive strength is provided by 1M solution.densities ranging from 0.750 kg/m3 to 0.850 kg/m.Błaszczyński, Tomasz Z., and Maciej R. Król. 2017This study demonstrates how the most alkaline activators affect the fundamental factors affecting the durability of geopolymer binders. Water glasses, wastegranules, and very alkaline hydroxides were employed in this investigation. Materials in numerous procedures occurring in chemical plants. As theFly ash made of coal was employed as the substrate for the geopolymer bindersand significant levels of calcareous ash from lignite burning. The power comes from Materials that have been hardened demonstrate that fly ash is more reactive than calcium.They provide greater estimates of the fly ash geopolymer's compressive strength.MERMERDAŞ, Kasım, et al 2020this study revealed a strong exponential association with an R-squared value of 0.937 between the compressive strength and dry density of geopolymer mortar mixture.The geopolymer mortars' ultrasonic pulse velocity ranges from 1479 to 2596.depending on the variable A-LWA content, m s-1. The highest and lowestValues of the ultrasonic pulse velocity were found with 0% and 100% replacement.A-LWA level, accordingly. Results of ultrasonic pulse velocity indicated thatResults of producing geopolymer mortar with more than 20% fine A-LWAin the substandard pore structure. There was also a significant exponentiallink between the geopolymer's UPV and compressive strengthmixtures with an R-squared coefficient of determination of 0.985.

III. MATERIALS USED AND THIER PROPERTIES

A. Fly Ash

Fly ash is the term used to describe the finely divided byproduct of burning ground or powdered coal that is transported by flue gases from the combustion zone to the particle treatment system. From the Tuticorin power plant, fly ash with a low calcium level (class F) was removed. Under most circumstances, calcium hydroxide reacts with low calcium fly ash Class-F, which is mostly pozzolanic and contains less than 10% calcium oxide, to produce cementitious compounds. Low calcium flyash has fewer thermal cracks and is more workable and resistant to chemicals.

Figure-1: Fly Ash (Class F)

Table1.PropertiesofLow calcium fly ash class F

Chemical compositions	%
SiO2	46.34
Al2O3	21.03
Fe2O3	13.27
CaO&MgO	15.36 &2.09
K2O	3.15
Na2O	0.47
Loss of ignition	0.78

B. Alkaline Activator Solution

The alkaline liquid can be a mixture of sodium silicate solution and sodium hydroxide (NaOH) solution. It is advised to prepare the alkaline liquid by combining the two solutions at least 24 hours before use. Different grades of sodium silicate solution are offered commercially. It is advised to use sodium silicate solution A53, which has a SiO2-to-Na2O mass ratio of about 2, or 29.4% SiO2, 14.7% Na2O, and 55.9% water. Commercially accessible sodium hydroxide in flake or pellet form has a purity of 97-98%. In order to create a solution with the necessary concentration, the solids must be dissolved in water.

Figure-2: Sodium Hydroxide Flakes

Figure-3: Sodium Silicate solution

C. Fine Aggregate

M-Sand is used in concrete as fine aggregate. It can be found at the local quarry in Madurai. Sand's specific gravity is discovered to be 2.62. According to IS specifications, Zone II was the grading zone for fine aggregate. The particle size of manufactured sand is smaller than 4.75mm.

Figure-4: M-Sand

D. Coarse Aggregate

Coarse aggregates from recycled light weight blocks of nominal size 20mm are chosen. Particle size range from 4.75 mm and Specific gravity 1.54.

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Figure-5:Recycled Aggregate From Lightweight Blocks

E. Superplasticizer

Sikacim Pink acts as a superplasticizer in this experiment. It is getting easier to work with without adding extra water. Sikacim pink is a polycarboxylate ether-based super plasticizer.

IV. MIX DESIGN

Performance requirements form the basis of the mixture design process. Aggregates do the same purpose and have the same effects as Portland cement concrete. Between 75% and 80% of the mass of the geopolymer concrete may be assumed to be the bulk of mixed aggregates. The application determines the performance standards for a geopolymer concrete mixture. For ease of use, the performance criteria are chosen to be the compressive strength of hardened concrete and the workability of fresh concrete. The alkaline liquid-to-fly ash ratio by mass, the water-to-geopolymer solids ratio by mass, the wet-mixing time, the heat-curing temperature, and the heat-curing duration are chosen as parameters in order to achieve these performance objectives.With regard to 16 alkaline liquid-to-fly ash ratio by mass, values in the range of 0.30 and 0.5 are recommended.

A. Geopolymer Concrete Mixdesign

Masso f Combined aggregate: 80%of mass of geopoly merconcrete: 0.8*2400=1920kg/m
Massofcoarse aggregate: 0.7*19=1344kg/m^3
Massofcoarse aggregate: 0.3*19=576kg/m^3
AlkalineliquidtoFlyashratio: 0.5
Mass of flyash: 480/(1+0.5)=320kg/m^3
Mass of Alkaline Liquid: 480-32 = 160kg/m^3
Ratio of Na2sio3solution to: 2.5
NaOHsolutionbymass
MassofNaOH: 160/(1+2.5)=45.714kg/m^3
Mass of Na_2SiO_3: 160- 45.714=114.286kg/m^3
In NaOH solids (31.4%): 45.714*0.314= 14.354 kg/m^3
In NaOH water: 45.714-14.354= 31.359 kg/m^3
In Na_2SiO_3water (55.9%):114.286 *55.9%= 63.89 kg/m^3
InNa_2SiO_3solids: 114.286-63.89=50.4kg/m^3
Totalmassofwater: 95.25 kg/m^3
Totalmassofwater::384.754kg/m^3

Table2.Mix Design

Materials	Proportion
Fly ash	1
NaOH solution	0.09
Na2SiO3solution	0.25
Fine aggregate	1.21
Coarse aggregate	2.83
Superplasticizer (1.2%)	0.012

B. Preparation Of Alkaline Liquid

The sodium hydroxide (NaOH) solids were dissolved in water to make the solution. The mass of NaOH solids in a solution varied depending on the concentration of 10M consisted of 10x40 = 400 grams of NaOH solids (in flake or pellet form) per liter of the solution, where 40 is the molecular weight of NaOH. The sodium silicate solution and the sodium hydroxide solution were mixed together at least one day prior to use to prepare the alkaline liquid. On the day of casting of the specimens, the alkaline liquid was mixed together with the super plasticizer and the extra water (if any) to prepare the liquid component of the mixture.

V. PREPARATION OF SPECIMEN

A. Cube Specimens

After the mixing is finished, the samples are made by properly compacting three layers into which the cubes were perfectly cast and crushed. All of the cubes were correctly cured in the lab's ambient curing system at ages of 7 days and 28 days after being demolded after 24 hours. The cubes were cast using standard cube moulds (l50 mm X 150 mm X 150 mm). Concrete cubes' compressive strength was evaluated.

Figure-6:Cube Specimen

B. Cylinder Specimens

Cylinder Specimen moulds are having Diameter of 150 mm, length of 300 mm.The liquid component of the mixture was added to the dry materials and the mixing continued for further about 4 minutes to manufacture the fresh concrete. The fresh concrete was cast into the moulds immediately after mixing, in three layers for cylinder specimens For compaction of the specimens each layer was given 60-80 manual stokes using iron rod. Then the concrete was cast into the moulds and was kept for drying at laboratory temperature.

Figure-7: Cylinder Specimen

C. Beam Specimens

Reinforcement Details Beams reinforced with two numbers of 8mm diameter rods for longitudinal reinforcement and two numbers of 6mm diameter hanger rods with 6mm diameter two legged stirrups at 100mm centre were fabricated and placed inside steel moulds. The longitudinal section andcross sectional details of specimen are shown in Figure-8

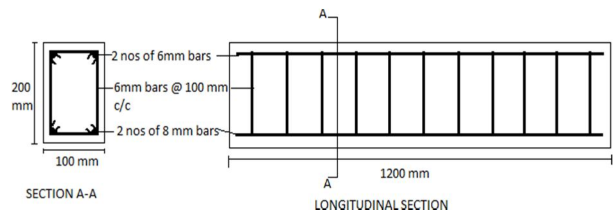

Figure-8: Reinforcement Details

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Figure-9: Beam Specimen

VI. TEST RESULTS AND DISCUSSIONS

A. *Compressive Strength Test Of Cube Specimen*

Figure-10:Compressive strength test

Table 3.Liquid alkaline/ash ratio

Liquid alkaline/ash ratio	Compressive strength Mpa	Density kg/m3
2.0	8.78	1078
2.4	14.53	1226
2.8	6.82	1357

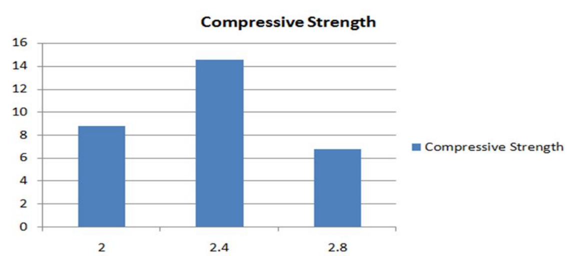


Table 4.Sodium silicate/NaOH ratio

Sodium silicate/NaOH ratio	Compressive strength Mpa
1.00	11.76
1.50	13.9
3.00	15.63

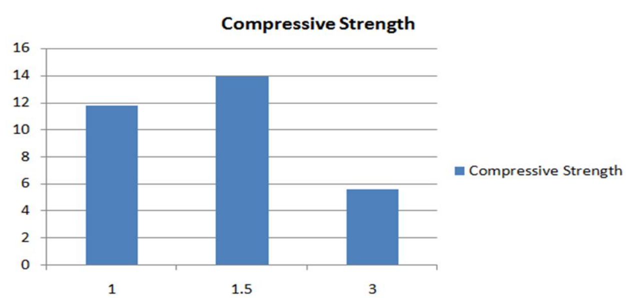


Table5.Concentration of NaOH solution

ConcentrationofNaOH solution	Compressive strength Mpa
5M	10.2
10M	14.5
15M	7.6

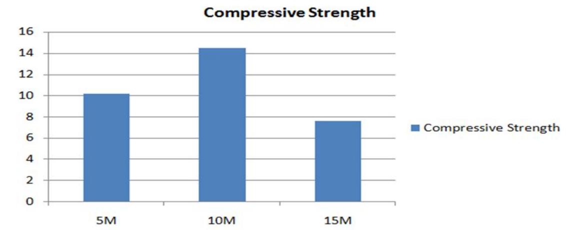
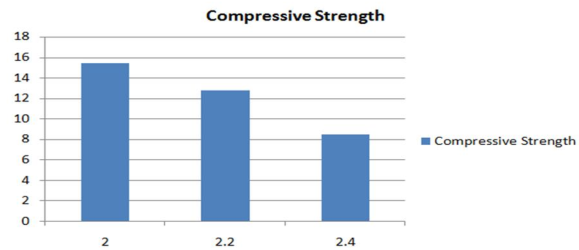


Table 6.Aggregate/ashratio

Aggregate/ashratio	Compressive strength Mpa
2.0	15.4
2.2	12.8
2.4	8.47

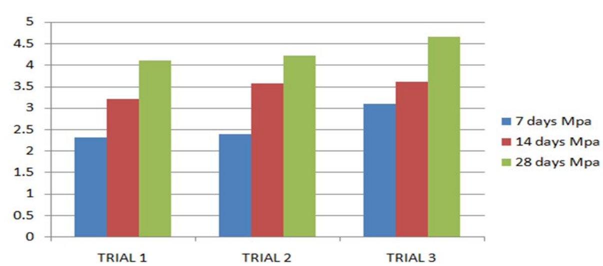


B. *Split Tensile Strength Of Concrete*

Figure-11:Testing of cylinder

Table 7.Split tensile strength of cylinder

sample	7days Mpa	14 days Mpa	28 daysMpa
Trail 1	2.32	3.21	4.10
Trail 2	2.39	3.57	4.23
Trail 3	3.1	3.62	4.65



C. *Flexible Action Of Beams*

The beams are simply supported over a 1200mm span and are loaded in two places at that time. The loads are separated by 1000 mm. Two places, each 500 mm from the beam's centre and pointing in the direction of the support, are where the load is applied. For measuring the deflections under the load points and at mid-span, dial gauges with a 0.01 mm least count are utilised. At various loads, the dial gauge values are recorded. The load is applied at 0.1 kN intervals. Visual inspection is used to determine the initial crack loads.

Table 7. Flexural strength of 10M LWGPC

Specimen	Compressive strength N/mm2	Ultimate moment KNm	Midspan deflection mm
Sample1	19.67	13.9	0.492
Sample2	21.11	14.37	0.568
Sample 3	21.94	15.3	0.531

Table 8. Flexural strength of 15M LWGPC

Specimen	Compressive strength N/mm2	Ultimate moment KNm	Mid span deflection mm
Sample1	24.56	23.33	0.781
Sample2	24.56	22.27	0.743
Sample 3	25.00	23.86	0.796

VII. CONCLUSION

Due to ash's low density, the use of a greater proportion of flyash produced geopolymer concrete that had a higher density. Compressive strength decreased at increasing concentrations of NaoH with an increase in concentration 18–20M. At very early stages, too many hydroxide ions led to the creation of aluminium silicate gel. Nonetheless, density is unaffected. Due to increased geopolymerization and moisture loss from the prepared sample, the density of light weight concrete does, however, decrease with increasing curing temperature, making ambient temperature itself more suited for geopolymer concrete. With more flyash present, water absorption reduced. Because the flyash contains voids, it also reduces porosity. With an increase in the aggregate/ash ratio, water absorption increased. The 28 days results of Lightweight Geopolymer Concrete, Compressive strength are1.00-16.00 Mpa Density of LWGPCare840-1400Kg/m3.As molarity of sodium hydroxide in geopolymer concrete increases the strength of geopolymer concrete also increases.The flexural strength of geopolymer concrete with Recycled aggregates is lesser than the geopolymer concrete with Normal aggregates.

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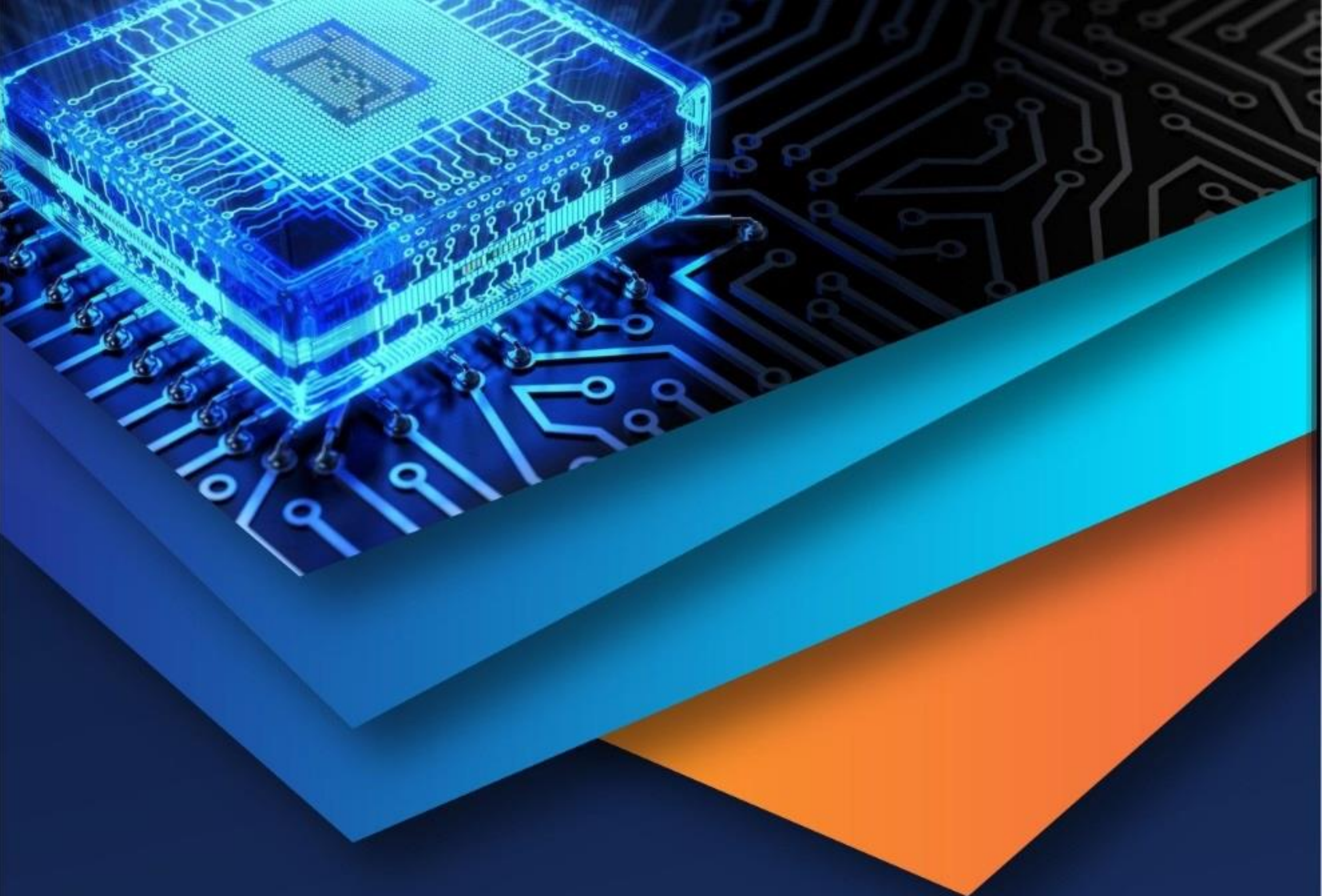

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