



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 5, May 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Fiber Reinforced Pervious Geopolymer Concrete Paver Blocks

Pramod B V¹, Leshan Kumar², Mohammed Adnan³, Mohammed Arfath Khan⁴, Rohan Mahadevappa Mopagar⁵

¹Department of Civil Engineering, Dayananda College of Engineering, Bengaluru, India

²⁻⁵Student, Department of Civil Engineering, Dayananda College of Engineering, Bengaluru, India

ABSTRACT: Most of the countries are in search of various techniques to lessen greenhouse gas emissions since Global warming and climate changes are progressively essential problems. Cement production results up to 1T of CO₂ per each ton of cement, paralleling to approximately 3% of total global greenhouse emissions. Hence an alternate to ordinary concrete called Geopolymer Concrete is used in this research purpose which contains 0% of Portland cement. More advantages in rapid strength gain, these paver blocks are eliminating the water curing, it provides good mechanical strength and durability properties and these are eco-friendly and sustainable. In this paper, geopolymer concrete made up of 45% Fly ash and 45% Ground Granulated Blast Furnace Slag (GGBS) is used as cementitious material. Sodium hydroxide (NaOH) of 8M and sodium silicate (Na₂SiO₃) are used in this study for the Geopolymerization. To increase the mechanical strength of the block Fibers are added as per ratio of 0.15% of total weight of material used. The alkaline liquids help the cementitious particle and aggregates to bind and produce the concrete. Also to achieve permeability to the paver blocks to drain of maximum water through its voids. To study the porosity, permeability, acid resistance of geopolymer concrete paver blocks.

KEYWORDS: Global Warming, GGBS, Fly Ash, Eco-Friendly, Sodium Hydroxide, Sodium Silicate, Porosity, Permeability, Acid Resistance, Geopolymer Materials.

I.INTRODUCTION

General: Introduce the concept of pervious concrete and its role in mitigating runoff, setting the stage for the integration with geopolymer technology. Pervious concrete is a porous form of concrete designed to allow water to pass through its structure easily. This permeability facilitates water drainage, reduces surface runoff, and promotes groundwater recharge. Pervious concrete is particularly valuable in managing stormwater in urban and suburban areas. Geopolymer concrete is an environmentally friendly alternative to traditional Portland cement-based concrete. It is created by combining industrial by-products, such as fly ash or slag, with an alkaline activator solution. Geopolymer concrete offers lower carbon emissions and a reduced environmental impact compared to conventional concrete. Paver blocks are precast concrete units or bricks used for creating durable and flexible paved surfaces. These interlocking blocks are commonly employed in outdoor applications like walkways, driveways, and landscaping and parking's and gardens etc.

Geopolymer concrete: Geopolymer concrete, made from alkaline solutions and aluminosilicate materials like fly ash, offers sustainable, durable paver blocks. It reduces carbon emissions and waste while providing high compressive strength, low shrinkage, and resistance to weather and chemicals. With versatile design options, including colours and textures, geopolymer paver blocks mimic natural stone or brick. They cure faster than traditional concrete, enabling quicker installation and reduced construction time. Geopolymer paver blocks are an environmentally friendly, aesthetically pleasing choice for outdoor paving projects. In 1978, geopolymer matrix was introduced by Davidovits and proposed that it can replace cement in concrete. Geopolymerization is an innovative technology that can transform several Aluminosilicate materials into useful products called geopolymers or inorganic polymers. Geopolymerization involves a heterogeneous chemical reaction between solid Aluminosilicate oxides and alkali metal silicate solutions at highly alkaline conditions and mild temperatures yielding amorphous to semi-crystalline polymeric structures, which consist of Si-O-Al and Si-O-Si bonds.

II. EXPERIMENTAL INVESTIGATIONS

Materials used:

Coarse aggregate (6mm and 12mm)

Coarse aggregate, an essential component in construction, refers to a material widely utilized in concrete production. It typically comprises gravel, crushed stone, and sometimes recycled concrete. Coarse aggregate comes in various sizes, generally ranging from 3/8 inch to 1.5 inches in diameter. It serves to enhance the structural integrity and durability of concrete formulations.



Fig 1 Aggregates

Sodium Hydroxide Solution

Solid sodium hydroxide, usually in the form of pellets or flakes, is widely used in industrial settings. Its price is determined by its level of purity, with a recommended purity range of 94% to 96%. To create a sodium hydroxide solution, pellets are dissolved in water to reach the desired molar concentration. The concentration of the solution varies based on its molarity, affecting the mass of NaOH solids present. In the context of this investigation, an 8M molar concentration is utilized.



Fig 2 sodium hydroxide

Sodium Silicate Solution

Sodium silicate, with a Na₂O to SiO₂ ratio of 2.0, serves as a bonding agent in geopolymer concrete, sourced from detergent and textile firms. The solution is characterized by a density of 52Be and contains Na₂O and SiO₂ concentrations of 13.50% and 31.50%, respectively. The Na₂O to SiO₂ ratio stands at around 1:2.30, while the overall solid content constitutes 47%.

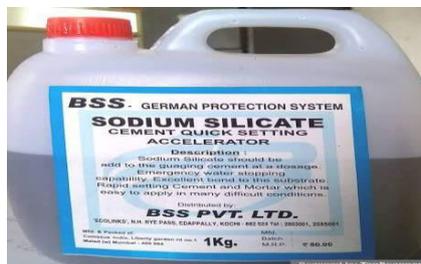


Fig 3 sodium silicate

Fly ash (IS 3812-2003)

The most extensively used source material for geopolymer concrete is Fly ash due to its ease of availability and appropriate composition. Fly ash is a spin off product of the coal industry. It is a fine material produced from burning of coal and collected from the combustion system. The main composition of fly ash is Silica dioxide (SiO₂), Ferric oxide (Fe₂O₃), Aluminium oxide (Al₂O₃), Calcium oxide (CaO). The specific gravity of fly ash is found to be 2.3.



Fig 4 flyash

Ground Granulated Blast Furnace Slag (GGBS) (IS 12089:1987)

Ground granulated blast furnace slag (GGBS) is a byproduct originating from the iron industry. During iron production, a mixture of iron ore, coke, and limestone is heated in a furnace, resulting in molten iron and a floating slag layer at temperatures around 1500oC to 1600oC. The molten slag typically contains 30-40% silicon dioxide (SiO₂) and approximately 40% calcium oxide (CaO), like ordinary Portland cement (OPC) in chemical composition. Once the molten iron is removed, the remaining slag, rich in siliceous and aluminous residues, is rapidly cooled by water quenching. GGBS is produced by quenching the molten iron slag with water, forming a glassy granular substance. This granulated slag is then dried and finely ground into a powder, resulting in ground granulated blast furnace slag. GGBS exhibits a specific gravity of 2.7.



Fig 5 GGBS

MIX DESIGN FOR GEOPOLYMER CONCRETE

Table 1 Mix variations for 1m³

Mix Ratio (%)	M1	M2	M3
Sodium Hydroxide	44.11	44.11	44.11
Sodium Silicate	109.72	109.72	109.72
12mm	1018.09	1018.09	1018.09
6mm	678.73	678.73	678.73
Fly Ash	180.99	135.74	135.79
GGBS	45.24	90.49	90.49
Fiber	-	-	0.15%

Table 2 Mix Ratios

Mix Ratio (%)	1	2	3
Fly ash	80%	60%	40%
GGBS	20%	40%	60%

Preparation of sample: preparation of geopolymer concrete is similar that of cement concrete. Two types of coarse aggregates that is nominal aggregates of 12mm and 6mm with GGBS and fly ash were mixed in dry state. Then prepared mix solution of sodium hydroxide and sodium silicate was added along with extra water based on water to geopolymer binder ratio and mixed thoroughly for 3 to 4 minutes to give homogeneous mix. And using machine mixer the materials should be mixed and caste it for about 8 moulds of paver size of 200mm length and 160mm wide, after 24 hrs the specimen should be removed from moulds and keep it for curing for about 7, 14, 28 days respectively. Various mix design should be adopted as per table 1.



Fig 6 Mixing process

Fibers: Fibers are commonly added to concrete to enhance its mechanical properties and durability. These Fibers, typically made from materials like synthetic polymers, steel, glass, or natural Fibers like sisal or hemp, are dispersed throughout the concrete matrix to provide reinforcement.

1. **Mechanical Reinforcement:** Fibers act as internal reinforcements, improving the tensile strength, flexural strength, and toughness of concrete. They help control cracking caused by plastic shrinkage, thermal stresses, or dynamic loading.
2. **Types of Fibers:** Fibers used in concrete can vary in composition and properties. Synthetic polymer Fibers, such as polypropylene or polyethylene, offer excellent crack control and impact resistance
3. **Dosage and Dispersion:** The effectiveness of Fibers in concrete depends on factors like Fiber type, length, aspect ratio, and dosage. Proper dispersion of Fibers throughout the concrete mix is essential to ensure uniform reinforcement and achieve the desired performance.
4. **Applications:** Fiber-reinforced concrete finds applications in various construction projects, including pavements, industrial floors, shotcrete for tunnel linings, precast elements, and overlays. The choice of Fiber type and dosage depends on the specific requirements of each application, considering factors such as anticipated loads, exposure conditions, and desired durability.



Fig 7 Fibers

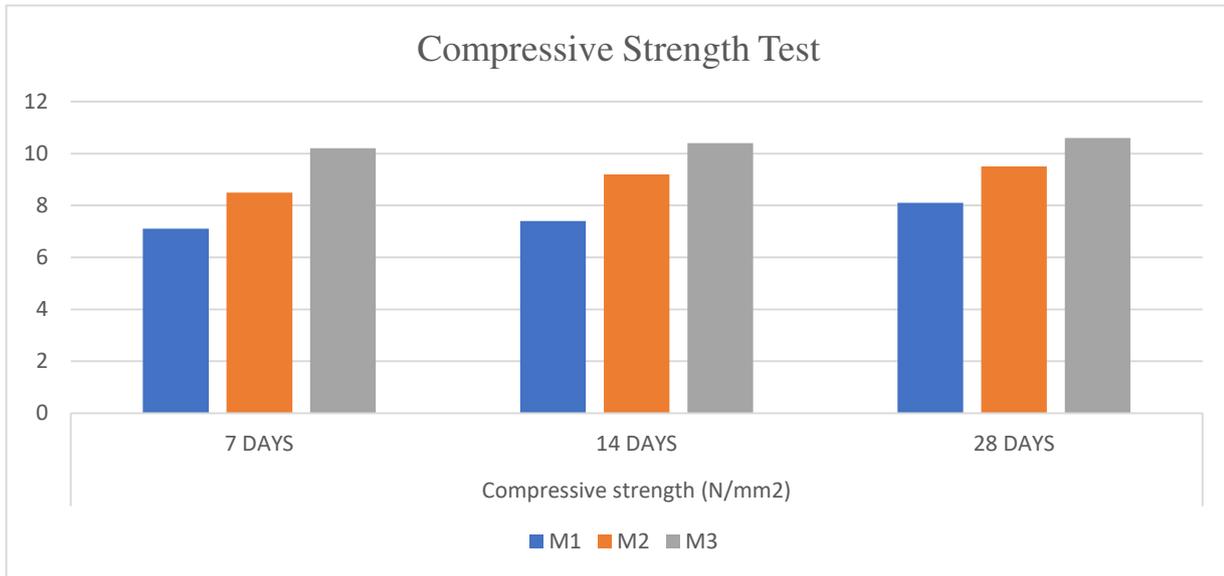
III. TESTS RESULTS AND DISCUSSIONS

1. Compressive Strength Test (IS:516-1959)

The compressive strength of concrete is crucial as it directly influences essential properties such as elastic modulus and tensile strength. Additionally, it plays a pivotal role in structural design, as the load-bearing capacity of structures is closely tied to concrete's compressive strength. Understanding and optimizing this property is vital for ensuring the structural integrity and stability of concrete structures, given below table 2

Table 3 compressive strength

Mix	Compressive strength (N/m ²)		
	7 DAYS	14 DAYS	28 DAYS
M1	7.1	7.4	8.1
M2	8.5	9.2	9.5
M3	10.2	10.4	10.6

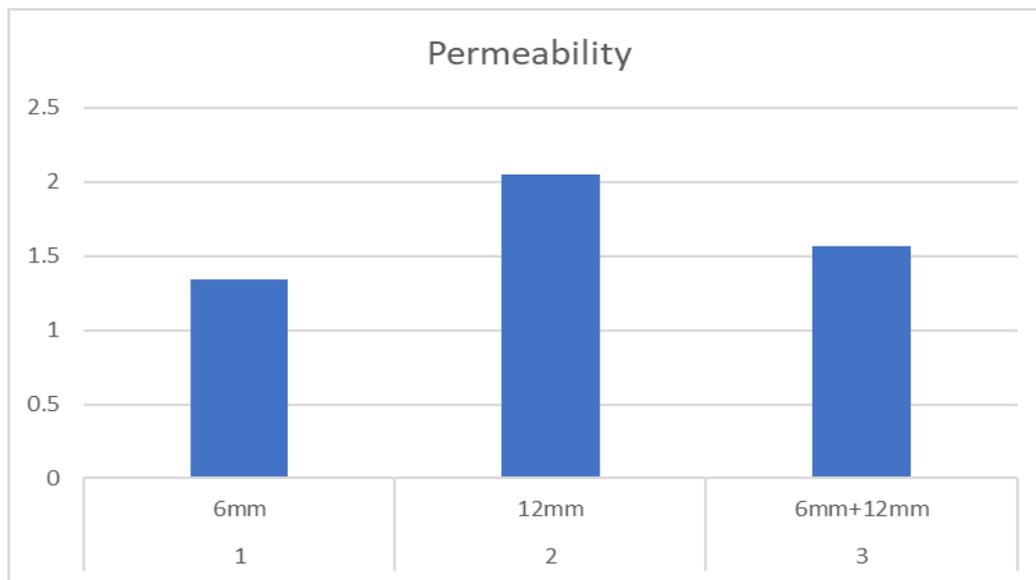


Permeability and porosity

Porosity and permeability are crucial factors to consider when evaluating geopolymer concrete paver blocks. Porosity refers to the amount of void space within the concrete, which can impact its durability and resistance to environmental factors. Permeability, on the other hand, relates to the ability of water or other substances to pass through the concrete. Understanding and controlling porosity and permeability in geopolymer concrete paver blocks are essential for enhancing their performance and longevity in various applications, including paving and landscaping.

Table 3 permeability values

Sl No	Size of Aggregates	Volume of Water	Thickness	Cross Sectional Area	Head	Permeability	Specific Permeability	Time
1	6mm	8200	8400	8	24	1.34	0.16	5sec
2	12mm	12600	12800	8	24	2.05	0.26	5sec
3	6mm+12mm	10270	10000	8	25	1.57	0.19	5sec



IV.CONCLUSION

- Sustainable Construction: Pervious Geopolymer Concrete Paver Blocks offer a tangible contribution to sustainable construction by reducing reliance on traditional cement, thereby lowering carbon emissions and environmental impact.
- Stormwater Management: The permeable design of these blocks plays a crucial role in effective stormwater management, mitigating surface runoff and contributing to groundwater recharge in urban and suburban environments.
- Durability and Versatility: Combining the durability of paver blocks with the environmentally conscious attributes of geopolymer concrete, this innovative material provides a robust and versatile solution for a variety of outdoor applications.
- Environmental Responsibility: In an era where environmental responsibility is paramount, the adoption of Pervious Geopolymer Concrete Paver Blocks aligns with the global movement towards sustainable infrastructure

REFERENCES

- 1) Smith, J. A., Brown, M. R., & Johnson, L. P. (2018). "Geopolymer Advances in Concrete Technology."
- 2) Garcia, R., Patel, S., & Wang, Q. (2019). "Urban Stormwater Management with Pervious Geopolymer Pavers."
- 3) Rodriguez, A., Hernandez, B., & Smith, T. (2017). "Geopolymer Concrete Pavers: Properties and Impact."
- 4) Li, J., Yang, K., & Wang, X. (2016). "Water Permeability in Geopolymer Pavement."
- 5) M.K Thangamanibindhu, Dr. D.S. Ramachandra Murthy " An Experimental Investigation on the Mechanical Properties of Geopolymer Concrete Partially Replaced with Recycled Coarse Aggregates" International Journal of Scientific & Engineering Research, (311 - 323), Volume 6, No.8,2015.
- 6) N B Azmil, F S Khalid, J M Irwan, N Anting and P N Mazenan"A study on the performance of concrete containing recycled aggregates and ceramic as materials replacement" IOP Conf. Series: Materials Science and Engineering 271 (2017) 012081 DOI:10.1088/1757- 899X/271/1/012081.
- 7) T.V. Srinivas Murthy, Dr Ajeet Kumar Rai, "Geopolymer Concrete, An Earth Friendly Concrete, International Journal of Civil Engineering and Technology



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details