



# STUDY ON GEOPOLYMER CONCRETE USED FOR PAVING BLOCKS

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**Abstract** — Paver block is used in various applications like in street road and other construction places. Portland cement generates large amounts of carbon dioxide ( $CO_2$ ) which is responsible for global warming hence it is a greenhouse gas. And the concrete paver block production consume large amount of water and space for curing purpose. The other great problem today is disposal of solid waste from Coal fired thermal power plants generate fly ash and pond ash. This project combined sustainability, curing free with waste management leading to a wonderful product called geo-polymer concrete pavers. This paper represents the results of the geopolymer concrete paver block with the mix of M40 grade Test results indicate that low calcium fly ash based geopolymer concrete pavers has excellent compressive strength within short period (3 days) without water curing & suitable for practical applications

**Keywords**—Geopolymer , Fly ash, Sodium Hydroxide, Sodium Silicate, Compressive strength, Flexural strength, Abrasion resistance

## I. INTRODUCTION

Inter locking Pavers are the modern day solution for low cost outdoor application. Paver block is used in various applications like in street road and other construction places. Paver block is solid unreinforced pre-cast cement concrete paving units used in the surface course of pavement. They are high strength concrete precast elements in various shapes, sizes and colours to suit the imagination of landscape architects & nature's essence. By improving its abrasion resistance and flexural strength it can be used in heavy traffic area and give surface resistance for higher life. Green paver blocks is an eco-friendly method of making concrete paver block using geo-polymer concrete, ie, geopolymer concrete production technology can also applicable in pavers production. Therefore, they do not easily crack, low cost, cement free, curing free pavers can be produced. Polypropylene fiber is used in the construction industry as a secondary reinforcement which arrests cracks, increases resistance to impact/abrasion and greatly improves quality of construction. So fly ash based GPC pavers are good alternative to ordinary paver blocks. This paper study on the use of fly ash based geo-polymer concrete in precast concrete paver blocks and compares the performance with the commercial available OPC paver blocks of the same mix proportions. The mix design with target strength of 40 MPa was developed to create paver blocks suitable for medium traffic.

## II. EXPERIMENTAL PROGRAMME

### A. MATERIALS USED

The materials used in the preparation of rubberized and steel fibre reinforced rubberized concrete mixes are:

- 1) *Fly ash: Conforming to Grade 1 of IS3812 (Part 1) conforming to the requirements specified in IS 456 may be used as replacement of Ordinary Portland cement was used in this study.*
- 2) *Fine Aggregate: Manufacturer's sand has been used for the present investigation. It conforms to Zone II with a specific gravity 2.62.*
- 3) *Coarse Aggregates: Crushed stone from granite was used as course aggregate. Material passing 10mm sieve and retained on 4.75mm were used. They were free from deleterious matter confirming to IS 383-1970. The specific gravity of aggregate is 2.67.*
- 4) *Water : Potable clean drinking water available in the water supply system conforming to the requirements of water for concreting and curing as per IS:456-2009 was used.*
- 5) *Sodium Hydroxide: Commercially available sodium hydroxide flakes with a purity of 98% were used*
- 6) *Super plasticizer: Commercially available sodium silicate solution supplied to the industries was used.*

**B. MIX PROPORTIONS**

Based on base proportion of OPC mix as show in table 1, the geopolymer mix of fly ash, fine aggregate and course aggregate was taken. Ratio of alkaline liquid to fly ash was taken as 0.35. Ratio of sodium silicate to sodium hydroxide was taken as 2.5. The concentration of sodium hydroxide was 10M. For good casting slump values need to be between 0 to 10cm or 100mm.

**TABLE 1: MIX PROPORTION**

Sl.No	Specimen	Cement (kg/m <sup>3</sup> )	Fly ash (kg/m <sup>3</sup> )	FA(kg/m <sup>3</sup> )	CA (kg/m <sup>3</sup> )	Water (kg/m <sup>3</sup> )	Na <sub>2</sub> SiO <sub>3</sub> Solution (kg/m <sup>3</sup> )	NaOH Solution (kg/m <sup>3</sup> )
1	OPC	530	-	636	1060	185.5	-	-
2	GPC	-	530	636	1060	-	132.5	53
3	GPC1	-	530	636	1060	-	132.5	53
4	GPC2	-	530	636	1060	-	132.5	53
5	GPC3	-	530	636	1060	-	132.5	53
6	GPC4	-	530	636	1060	-	132.5	53
7	GPC5	-	530	636	1060	-	132.5	53

**C. TESTING PROGRAM**

In this experimental study, following properties of concrete were tested as per relevant standards.

- 1) *Fresh properties: As per IS 15658:2006 , concrete paving blocks should be a stiff mix with zero slump*
- 2) *Compressive Strength Test: Compressive strength of paver blocks were determined at 1 day, 3 days, 7 days, and 28 days in accordance to IS 15658:2006.*
- 3) *Flexural Strength Test: Flexural strength is express in term of flexural stress or in form of breaking load. IS 15658:2006.*
- 4) *Abrasion Resistance Test: Abrasion test for paving was done in accordance to IS 15658:2006 .The abrasion resistance of paver block at 28 days*
- 5) *Water absorption Test: As per IS 15658:2006 , 24 hour water absorption*
- 6) *Dencity Test: The key for strong paver blocks is the density*



*Fig. 1 Compressive Strength Test*

**III. RESULTS AND DISCUSSIONS**

**A. SLUMP**

As per IS 15658:2006 concrete paving blocks should be a stiff mix with zero slump. However for practical applications concrete with slump between 10 to 50 mm is required. Increasing the concentration of NaOH solution reduces the slump.

**TABLE 2: FRESH PROPERTIES OF CONCRETE**

MIX DESIGNATION	SLUMP ( MM )
OPC	80
GPC	70
GPC1	68
GPC2	65
GPC3	63
GPC4	61
GPC5	60

Recommended value of slump for concrete to be vibrated is 10-25 mm. Hence all the mix satisfies the slump requirements.

**B. COMPRESSIVE STRENGTH TEST**

Compressive strength of paver blocks were determined at 1 day, 3 days, 7 days, and 28 days in accordance to IS 15658:2006 are as shown in table 6.2 and the compressive strength versus age as shown in fig.2. The compressive strength is measured using paver blocks specimens selected as per the IS 15658 - 2006 on compression testing machine. The size of the paver specimens used was 125mm x 125mm x 80mm. 9paver specimens were casted for each concrete mix proportions. The compressive strength of three paver specimen was measured and an average was taken after 3, 7 and 28 days

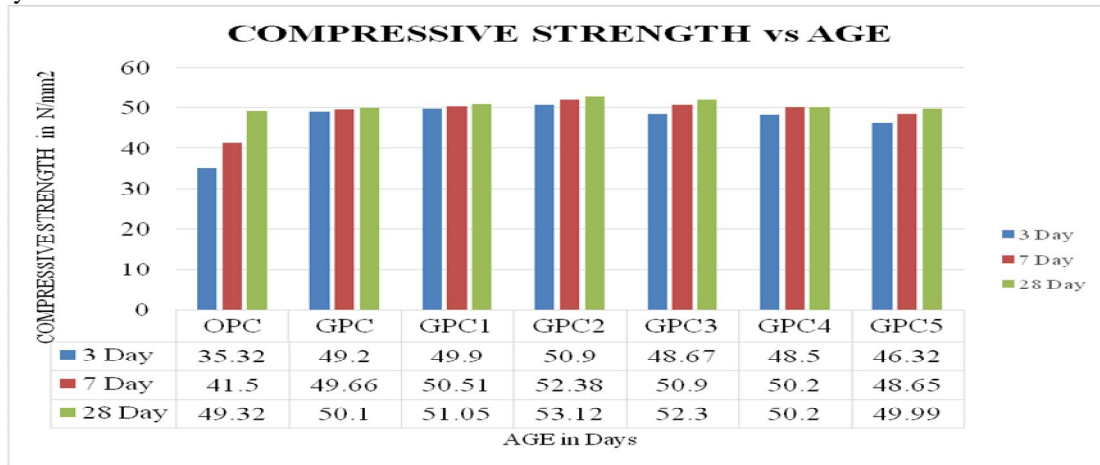


Fig. 2 Comparison of 28th day compressive strength

**D. ABRASION RESISTANCE TEST**

GPC paver blocks were found to have superior abrasion resistance than OPC pavers. As per IS 15658:2006, Annex E – abrasion value should be less than 2 mm for 80 mm block and 3 mm for 60 mm blocks. OPC paver blocks have lower abrasion resistance than specified by the standards. The abrasion resistance of paver block at 28 days is higher in GPC than OPC. In abrasion resistance is also increased up to adding 0.2% by weight of polypropylene fibre in paver block shown in fig.3

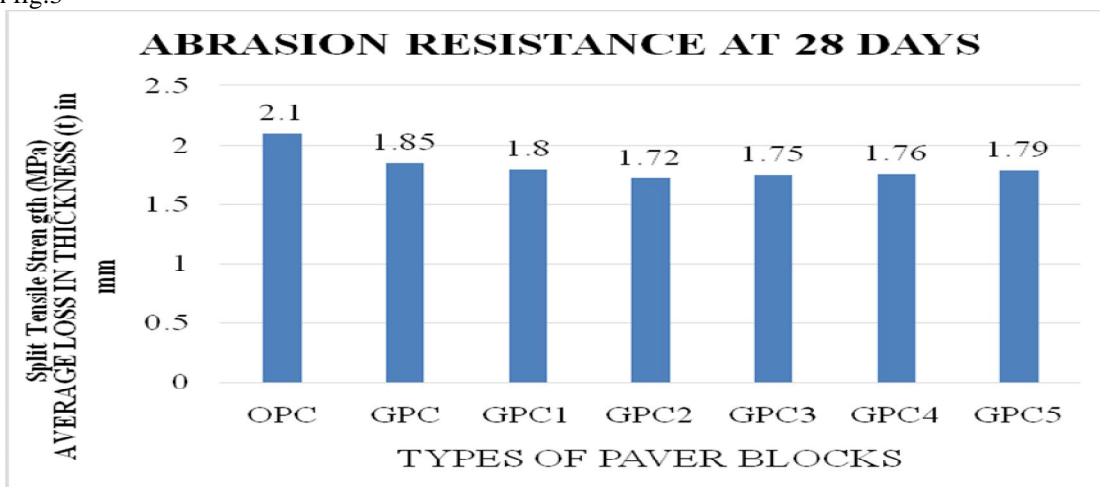


Fig. 3 Abrasion Resistance

**E. FLEXURAL STRENGTH TEST**

GPC was found to have better flexural strength compared to OPC. All blocks satisfied the specification for heavy traffic paving. Flexural strength of GPC is increased very highly with increasing PPF ranges from 0% to 0.4% compared to flexural strength of the standard paver block. Maximum results obtain in a sample of GPC4 i.e. PPF has added 0.4% by weight.

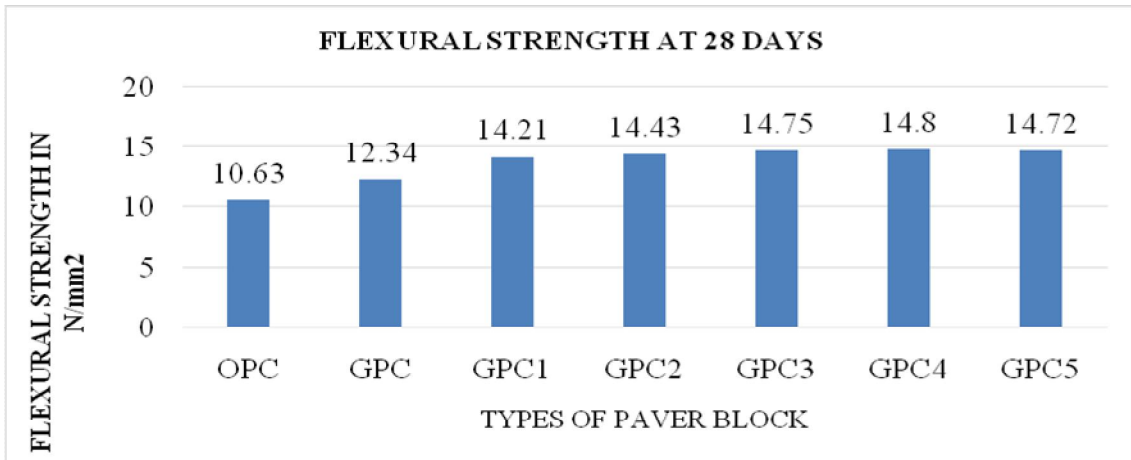


Fig. 4 Comparison of Flexural Strength

**F. WATER ABSORPTION TEST**

As per IS 15658:2006, 24 hour water absorption should be less than 7% for individual blocks. GPC paver blocks had very less water absorption. All blocks met the specifications. Water absorption of GPC is decreased with increasing PPF ranges from 0% to 0.2% compared to flexural strength of the standard paver block.

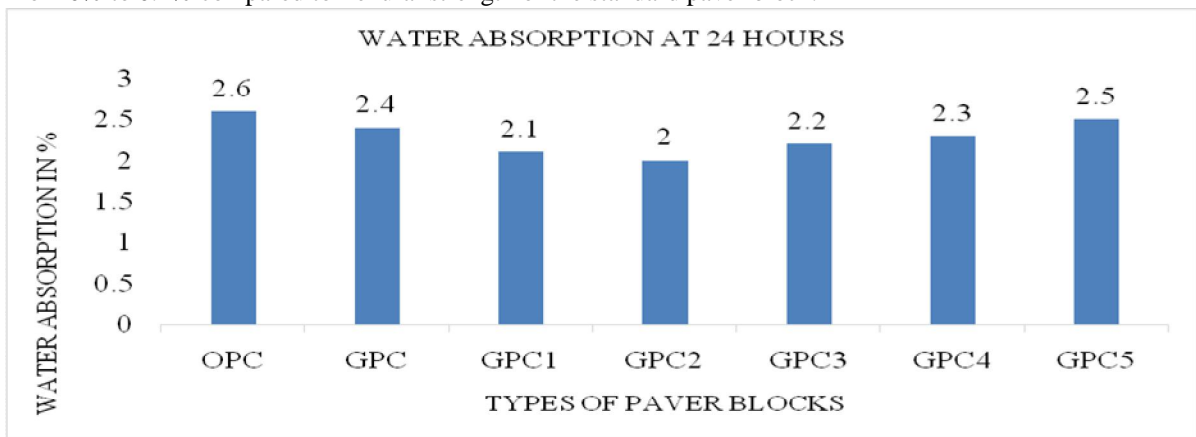


Fig. 5 Water Absorption

**G. DENSITY TEST**

The key for strong paver blocks is the density; high dense paver blocks can resist abrasion better and have better resistance to freezing and thawing. GPC paver blocks were found to have higher density than OPC paver blocks. Increase of PPF increased the density of paver block slightly.

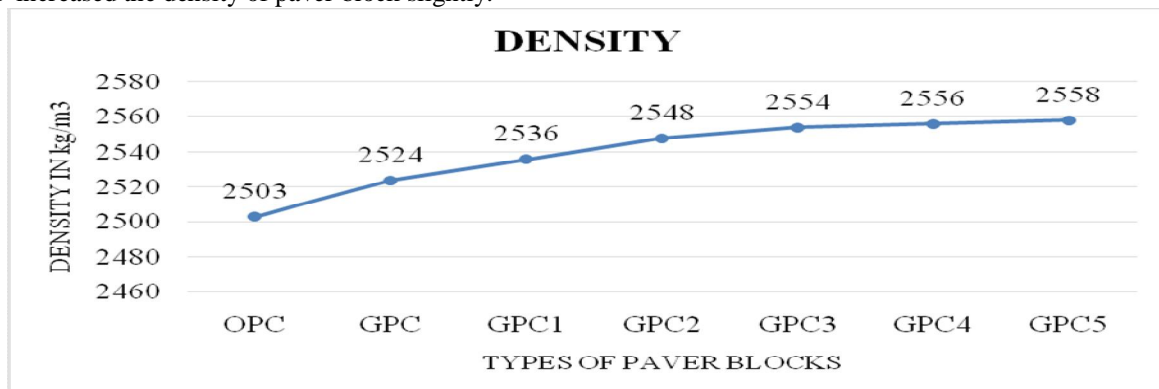


Fig. 6 Density

#### IV. CONCLUSIONS

From this study the following conclusion can be drawn:

- 1) Geopolymer concrete is an excellent alternative to Portland cement concrete. Based on this experimental study conducted geopolymer concrete can be effectively used for manufacture of precast concrete paver blocks.
- 2) Low calcium fly ash based Geopolymer concrete pavers has excellent compressive strength within short period (3 days) & suitable for practical applications. And no need of water curing for GPC, this can save lot of curing time and space at manufacturing units.
- 3) The GPC paver block attained higher strength at 7<sup>th</sup> day than the OPC pavers at 28 days. The variation of GPC paver block at 7<sup>th</sup> day strength to 28 day strength is very small. So it can be concluded that the GPC paver attain early strength than OPC pavers.
- 4) GPC paver blocks have superior resistance to chemical attack making them suitable for aggressive soils.
- 5) Compressive strength, Abrasive resistance & other most of them properties of polypropylene fiber reinforced geopolymer concrete at 28 days increases with respect to increase in percentage volume fraction of polypropylene up to 0.2% by weight.
- 6) Flexural strength is increased very highly compared to flexural strength of the standard paver block. Maximum results obtain in a sample of GPC4 i.e. PPF has added 0.4% by weight.

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