IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 5 Ver. III (Sep. - Oct. 2015), PP 81-88
www.iosrjournals.org

Effect of Inclusion of Glass Fibers and GGBS in Concrete Paver Blocks

B.A.V.Ram Kumar[1], J.Venkateswara Rao[2]
[1](PG student, Civil engineering department, GMRIT, INDIA)
[2](Associate Professor, Civil engineering department, GMRIT, INDIA)

Abstract : *In this experimental investigation compressive strength, flexural strength and water absorption of paver block were evaluated by replacing portion of cement with the GGBS (ground ganulated blast furnace slag). Glass fibers were also incorporated along with the GGBS to further enhance the mechanical properties. Different proportions of glass fiber starting from 0.1% to 0.4% by weight of cement in the paver block were added. The optimum fiber content from test results was found to be 0.2% by weight of cement. 10% to 40% by weight of cement was replaced with the GGBS. From the test results obtained the optimum ggbs and glass fiber content were found to be 30% and 0.2% respectively. Cost analysis of paver block was done and was compared with conventional paver block.*

Keywords: *Compressive Strength, Glass Fiber, GGBS, Flexural strength, Paver Block, and Water Absorption.*

I. Introduction

Concrete Block Pavement has been extensively used in a number of countries for quite some time as a specialized problem solving technique for providing pavement in areas where conventional types of construction are less durable due to many operational and environment constraints. The strength, durability and aesthetically pleasing surfaces have made paving blocks attractive for many commercial, municipal and industrial applications such as parking areas, pedestrian walks, traffic intersections, container yards and roads. Concrete Block Pavement (CBP) technology has been introduced in India in construction a decade ago, for specific requirements like footpaths, parking areas etc. but now being adopted extensively in different uses where the conventional construction of pavement using hot bituminous mix or cement concrete technology is not feasible or desirable.

II. Literature Review

In previous investigations researchers used fibers like nylon, polyester, polypropylene etc. for the enhancement of flexural strength and mineral admixtures for partial cement replacement like fly ash, GGBS in paver blocks for making the concrete economical. Abhinav S. Pawar, K.R. Dabhekar[1] studied the behavior of rigid pavement (concrete) when cementing waste material (GGBS) and steel fibers were added and was compared with normal concrete of M40 grade. For this study, concrete cubes and beams were produced of five partial GGBS replacement ratios (10%, 20%, 30%, 40% and 50%) with constant water-cement ratio (0.37). The cubes and beams were tested at the age of 7, 28 and 56 days. After testing it was found that at 30% GGBS replacement we can get M40 strength of concrete. Steel fibers were added in concrete by 1% of total weight of concrete with different proportions. Thus the compressive and flexural strength reached up to considerable limit. Vinayak Awasare, Prof. M. V. Nagendra [2] have done their research on strength characteristics analysis of M20 grade concrete with replacement of cement by GGBS with 20%, 30%, 40%, 50% and compared with plain cement concrete. This study extends to find best percentage of replacement by using both crush and natural sand. The maximum compressive strength was achieved at 30% of GGBS replacement in this study. S. Arivalagan [3] in his investigation has evaluated the strength and strength efficiency factors of hardened concrete, by partially replacing cement by various percentages of ground granulated blast furnace slag for M35 grade of concrete at different ages. From this study, it was concluded that, since the grain size of GGBS was less than that of ordinary Portland cement, its strength at early ages is low, but it continues to gain strength over a long period. Ghassan Jalull, Eshmaiel Ganjian, Homayoon Sadeghi-Pouya [4] in their investigation explored the use of by-product materials and waste in the production of paving blocks. The following materials were examined: ground granulated blast-furnace slag, basic oxygen slag, plasterboard gypsum and cement by-pass dust. Ternary blends were created for different mixes and tested. The tensile strength, skid/slip resistance and freeze/thaw of each paving block specimen were determined in accordance with British Standard BS EN 1338. It was found that about 30% cement replacement was achieved in comparison with current factory production in the UK without having any considerable impact on the strength and durability of the paving blocks. It was also found that a cement mix can contain ground granulated blast-furnace slag up to 55%, basic oxygen slag up to 70%, cement by-pass dust up to 10% and plasterboard gypsum up to 5% by weight. G. Navya, J. Venkateswara

Rao [5] in their experimental investigation determined the compressive strength, water absorption and flexural strength of paver blocks by adding Polyester fibers in the top 20mm thickness from 0.1-0.5%. Test results indicate that addition of polyester fiber by 0.4% paver block attains maximum compressive, flexural strengths and minimum water absorption at 7 and 28 days. G. Navya, J. Venkateswara Rao [6] in their experimental investigation determined the compressive strength, water absorption and flexural strength of paver block by adding Coconut fibers in the top 20mm thickness from 0.1-0.5%. Test results indicate that addition of coconut fiber by 0.3% in paver block attains maximum compressive strength. Thakur, Saxena and Arora T.R. [7] investigated on effect of partial replacement of cement by fly ash with using nylon fiber in concrete paver block. Initially nylon fiber was used in the range of 0.1-0.4% by weight of cement and later fly ash along with optimum nylon fiber content in the range of 10-40%.It was concluded that 20% of partial replacement of cement with fly ash and 0.3% nylon fiber improved the mechanical properties of paver block.

From previous investigations it was evident that few researchers have concentrated on combined use of fibers and pozzolonic materials in paver blocks. This experimental investigation is a continuation to study the combined effect of these materials on paver blocks. For this purpose glass fibers and GGBS were used. This study also focuses on cost reduction of paverblocks with parallel enhancement of strength properties of paver blocks.

III. Material Specification

3.1 Cement

Ordinary Portland cement (OPC) of 53 grade conforming to IS: 12269-1999 was used for casting the paver blocks. Physical properties of OPC were given in table 1.

Table 1 Physical Properties of OPC

Property	Value
Ordinary Portland Cement 53 Grade (IS 12269-1999) Specific gravity	3.14
Consistency limit	33%
Initial setting time	140 min.
Final setting time	310 min.

3.2 Coarse aggregates

Locally available crushed coarse aggregates of nominal size 10mm were used in this work. Physical properties of coarse aggregates used were given in the following table 2.

Table 2 Physical Properties of Coarse aggregates

Property	Water absorption value	Specific gravity of Aggregates	Aggregate Impact Value	Aggregate Crushing Value	Flakiness Index	Elongation Index
Value	0.45%	2.66	26%	27%	8%	9%

3.3 Fine Aggregates

The sources of fine aggregates for paving blocks are river sand or, alternatively, artificial sand by crushing rocks. Fine aggregates were used conforming to IS 383 2002.The fineness modulus and specific gravity of sand are 3.034, 2.62 respectively. Gradation details of fine aggregate were given in the table 3.

Table 3 Grading of fine aggregate

Sieve size in mm	Percent by weight of sand passing the sieve	Remarks
10	100	Conforms to Grading IS zone II, Fineness Modulus = 3.034
4.75	90.1	
2.36	76.9	
1.18	62.2	
0.6	42.2	
0.3	16.2	
0.15	6	

3.4 GGBS

GGBS was obtained by grinding the quenched blast furnace slag to fine powder.Chemical composition of GGBS used was given in the following table 4.

Table 4 Chemical composition of GGBS

Chemical	Percentage
SiO2	35.46
Al2O3	19.47
Fe2O3	0.8
MgO	8.69

CaO	33.25
Others	3.25

3.5 Glass fibers

Glass fibers were collected from Sree industrial composite products, Hyderabad. Alkali resistant E Glass fibres were used and the properties of glass fibres were shown in table 5.

Table 5 Properties of Glass fibers

Property	Diameter (μm)	Specific Gravity	Failure Strain	Elasticity (GPa)	Tensile Strength (GPa)
Value	12	2.60	3.0%	80	2.5

.

3.6 Admixture

A water reducing admixture, Sikament FF in liquid form was used in concrete. It has a relative density of 1.25 and pH range of 8-12.

IV. Mix Proportion

In this study, control mix S was designed as per IS 10262:1999 for M35 grade. Glass fibers were initially added in fractions of 0.1% to 0.4% by weight of cement. Optimum glass fiber content was obtained and then GGBS was replaced for cement in percentages of 10 to 40. The details of the mix proportions were given in the following table 6.

Table 6 Mix Proportion Details

→Materials ↓ Mix ID	**Cement (kg/m^3)**	**Fine aggregate (kg/m^3)**	**Coarse aggregate (kg/m^3)**	**Water (litres)**	**Sikament FF (kg/m3)**	**Glass Fiber (% w of cement)**	**GGBS(kg/m^3)**
S	379.8	696.3	1238.4	144.3	2.21	0	0
SGF $_{0.1}$	379.8	696.3	1238.4	144.3	2.21	0.1%	0
SGF $_{0.2}$	379.8	696.3	1238.4	144.3	2.21	0.2%	0
SGF $_{0.3}$	379.8	696.3	1238.4	144.3	2.21	0.3%	0
SGF $_{0.4}$	379.8	696.3	1238.4	144.3	2.21	0.4%	0
$SGFG_{10}$	341.82	696.3	1238.4	144.3	2.21	0.2%	37.98
$SGFG_{20}$	303.84	696.3	1238.4	144.3	2.21	0.2%	75.96
$SGFG_{30}$	265.86	696.3	1238.4	144.3	2.21	0.2%	113.94
$SGFG_{40}$	227.88	696.3	1238.4	144.3	2.21	0.2%	151.92

V. Experimental Methodology

Paver blocks were casted conforming to the mix proportions and following the recommendations laid down in IS: 15658:2006.Casting and testing process was done in two stages. In the first stage paver blocks were casted for control mix S, and mix with glass fibers SGF $_{0.1}$ SGF $_{0.2}$ SGF $_{0.3}$ SGF $_{0.4}$. The samples were cured in water for 7 and 28 days. For determining the compressive strength, samples were tested in compressive testing machine. In compressive strength test the load shall be applied without shock and increased continuously at a rate of 15 +/- 3 N/mm^2/min until no greater load can be sustained by the specimen or delamination occurs. Flexural strength test was conducted using universal testing machine. In flexural strength test load shall be applied without shock and increased continuously at a uniform rate of 6 KN/min. The compressive, flexural and water absorption tests were conducted as per IS: 15658:2006. Now from results in first stage optimum inclusion of glass fiber (%) was determined.

In the second stage cement was replaced with GGBS along with this optimum percentage of glass fibers and paver blocks were casted for $SGFG_{10,}$ $SGFG_{20,}$ $SGFG_{30,}$ $SGFG_{40}$ mix. The samples were tested at 7, 28 and 56 days. The compressive, flexural and water absorption tests were conducted as per IS: 15658:2006 and optimum glass fiber and GGBS was determined.

Figure 1 Flexural strength test

Figure 2 Paver blocks in oven

Figure 3 Compressive strength test

VI. Results & Discussion

6.1 Compressive strength

The compressive strength values of the standard concrete paver block & paver block with glass fibers were presented in figure 4.

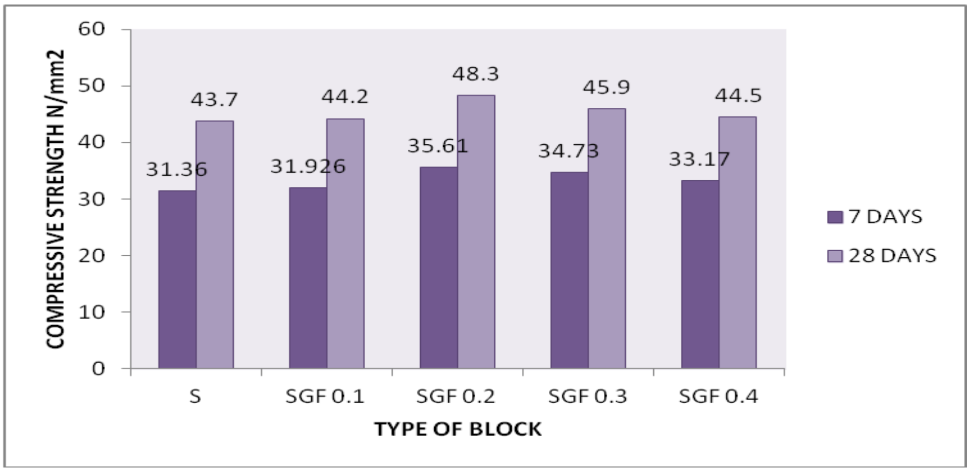

Fig. 4 Compressive strength at 7 & 28days for Paver blocks without and with fibers

From fig.4 it was observed that the compressive strength of concrete paver block was increasing with the inclusion of fibers compared to standard concrete paver block at 7 and 28 days .The graph illustrates that compressive strength at 7 and 28 days increases with the inclusion of glass fiber till 0.2% fiber inclusion and later it decreases. There was an increase of 10.52% in compressive strength at 0.2% glass fiber inclusion compared to standard paver block at 28 days.

6.2 Flexural strength

The Flexural strength values of the standard concrete paver block & paver block with glass fibers were presented in figure 5.

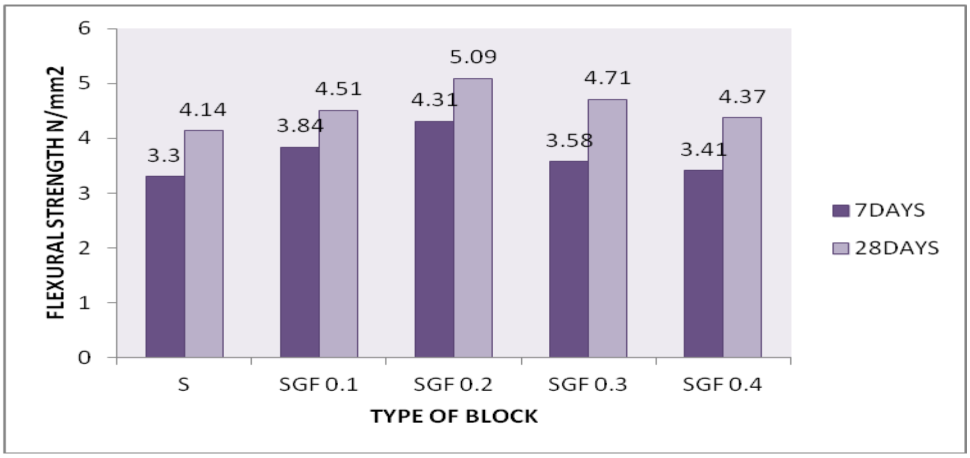

Fig. 5 Flexural strength at 7 & 28 days for Paver blocks without and with fibers

From fig.5 it was observed that the flexural strength of concrete paver block was increasing with the inclusion of fibers compared to standard concrete paver block at 7 and 28 days. The graph illustrates that flexural strength at 7 & 28 days increases with the inclusion of fiber till 0.2% glass fiber inclusion and later it decreases. There was an increase of 22.94% in flexural strength at 0.2% glass fiber inclusion compared to standard paver block at 28 days.

6.3 Water absorption

The Water absorption values of the standard concrete paver block & paver block with glass fibers were presented in figure 6.

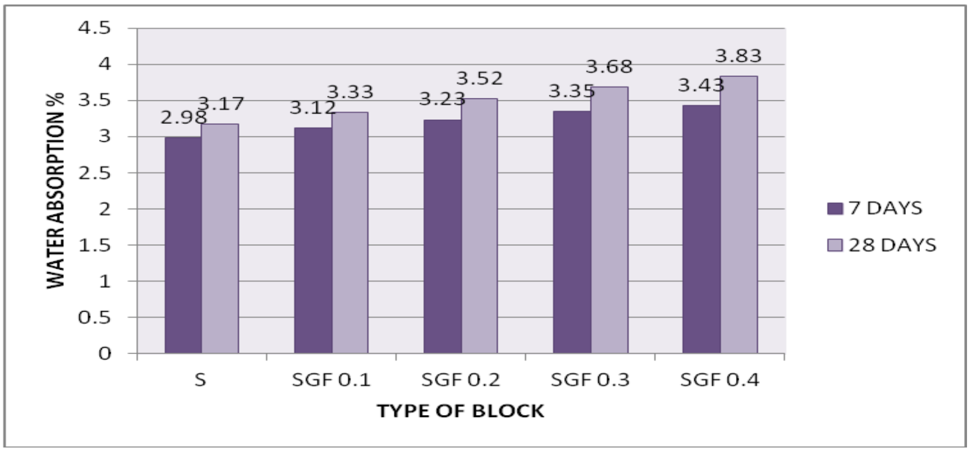

Fig. 6 Water absorption at 7 & 28 days for Paver blocks without and with fibers

Fig.6 illustrates that water absorption at 7 & 28 days increases with the increase in glass fiber content. The increase in water absorption was due to the hydrophilic nature of the glass fibers. However the maximum water absorption at 0.4% fiber inclusion obtained was 3.83% which is within the limit of 6% stipulated by code IS 15658:2006.

6.4 Compressive strength

The compressive strength values of the standard concrete paver block, paver block with glass fibers and GGBS were presented in figure 7.

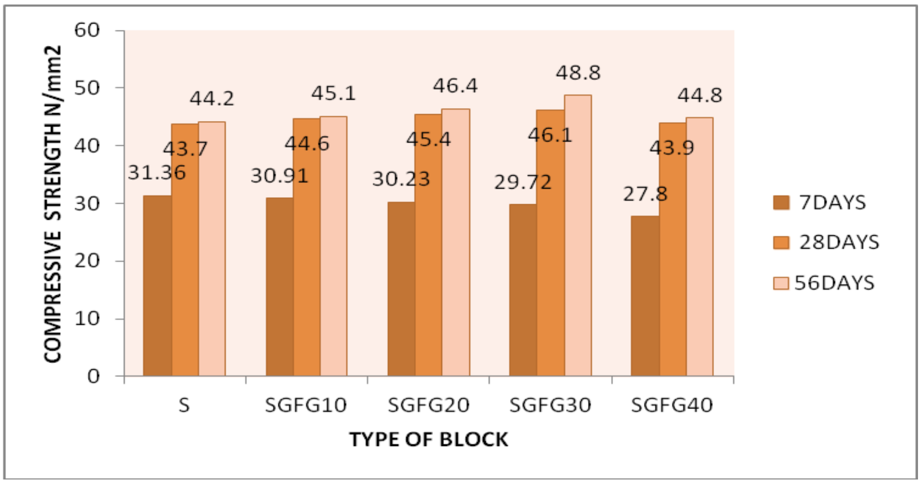

Fig. 7 Compressive strength at 7, 28 & 56 days for Paver blocks without and with GGBS

Fig.7 shows the variation of compressive strength at the age of 7, 28&56 days for standard, 10%, 20%, 30%, 40% GGBS replacement with cement along with optimum fiber inclusion i.e 0.2%.. The graph illustrates that compressive strength at 7 days decreases with the increase in percentage of GGBS replacement due to low reactivity of GGBS at early stages. At 28 days compressive strength slightly increases at 30% GGBS replacement by 5.49% compared to standard paver block. At 56 days 10.4% increase in compressive strength can be observed at 30% GGBS replacement compared to standard paver block.

6.5 Flexural strength

The Flexural strength values of the standard concrete paver block, paver block with glass fibers and GGBS were presented in figure 8.

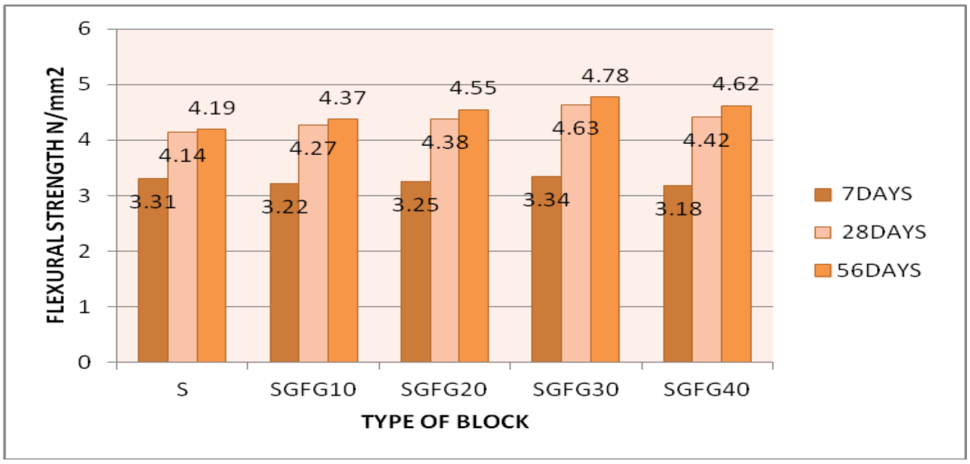

Fig. 8 Flexural strength at 7, 28 & 56 days for Paver blocks without and with GGBS

Fig.8 shows the variation of flexural strength at the age of 7, 28&56 days for standard, 10%, 20%, 30%, 40% GGBS replacement with cement along with optimum fiber inclusion i.e. 0.2%. At 7 days Flexural strength slightly increases at 30% GGBS replacement. At 28 days flexural strength was maximum at 30% GGBS replacement .There was an increase of 11.83% in flexural strength at 30% GGBS replacement compared to standard paver block at 28 days. At 56 days 14.08% increase in flexural strength can be observed at 30% GGBS replacement compared to standard paver block.

6.6 Water absorption

The Water absorption values of the standard concrete paver block, paver block with glass fibers and GGBS were presented in figure 9.

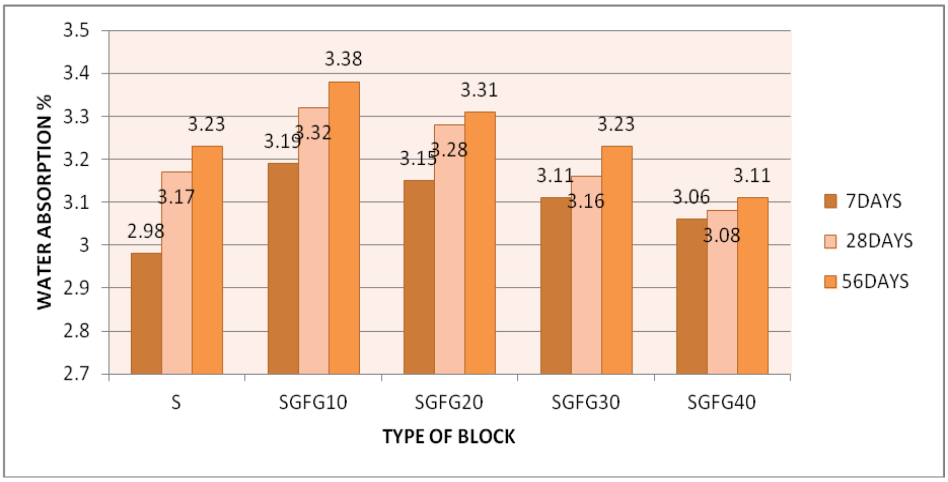

Fig.9 Water absorption at 7, 28 & 56 days for Paver blocks without and with GGBS

Fig.9 shows the variation of Water absorption at the age of 7, 28&56days for normal, 10%, 20%, 30%, 40% GGBS replacement with cement along with optimum fiber inclusion i.e. 0.2%. The graph illustrates that water absorption at 7, 28&56 days decreases with the increase in GGBS content.

VII. Cost Evaluation

Table 7 Cost details of materials used

S.No	Materials	Cost (Rs/kg)
1	Cement	7.60
2	Sand	0.80
3	Quarry Dust	0.40
4	Coarse aggregate	1.20
5	Dolomite Powder	1.40
6	Sikament FF	82
7	Glass Fiber	150
8	GGBS	1.50

Table 8 Cost details of Paver blocks

S.No	Type of paver block	Cost per unit (Rs)	Cost per cubic meter (Rs)
1	S	9.54	4971
2	$SGF_{0.1}$	9.65	5028
3	$SGF_{0.2}$	9.76	5085
4	$SGF_{0.3}$	9.87	5142
5	$SGF_{0.4}$	9.98	5199
6	$SGFG_{10}$	9.31	4853
7	$SGFG_{20}$	8.87	4621
8	$SGFG_{30}$	8.42	4390
9	$SGFG_{40}$	7.98	4158

Table 8 indicates that the cost of paver block increases with increase in glass fiber content. On replacement of cement with GGBS the decrease in cost can be observed. On replacement of cement with 30% GGBS along with inclusion of 0.2% fiber it was observed that there was decrease in cost by 11.74% compared to standard paver block.

VIII. Conclusions

1. Compressive strength and flexural strength of paver blocks increases by addition of glass fiber and optimum content of fiber inclusion was 0.2% by weight of cement.
2. On addition of 0.2% glass fibers there was 10.52% increase e in compressive strength and 22.94% increase in flexural strength compared to standard paver block
3. Test results at 56 days curing period with optimum GGBS and glass fiber indicates an increase of 10.4% in compressive strength and 14.08% in Flexural strength.
4. There was 3.71% decrease in Water absorption at 40% replacement of cement with GGBS at 56 days.
5. At optimum inclusion of GGBS and glass fiber there was decrease in cost by 11.74% compared to standard paver block.

6. The increase in cost which occurs due to inclusion of glass fibers was compensated by partial replacement of cement with GGBS, therefore making the paver block economical with parallel enhancement of properties.

References

[1]. Abhinav S. Pawar, K.R. Dabhekar (2014) "Feasibility study of concrete based pavement by using fibers & cementing waste materials"IJRET: Volume: 03 Issue: 05.

[2]. Vinayak Awasare, Prof. M. V. Nagendra (2014) "Analysis of strength characteristics of GGBS concrete"IJAET: Volume:07.

[3]. S. Arivalagan (2014) "Sustainable Studies on Concrete with GGBS as a Replacement Material in Cement" Jordan Journal of Civil Engineering, Volume 8, No. 3

[4]. Ghassan Jalull, Eshmaiel Ganjian, Homayoon Sadeghi-Pouya (2014) "Using ground granulated blast furnace slag and mineral wastes to reduce cement in paving block" ICE: Volume 167 Issue CM2.

[5]. G. Navya, J. Venkateswara Rao. (2014) "Experimental Investigation on Properties Concrete Paver Block with the Inclusion of Natural Fibers" ISSN: 2248-9622, Vol. 4, Issue 8(Version 6), pp.34-38.

[6]. G. Navya, J. Venkateswara Rao. (2014) "Influences of polyester fiber on concrete paver blocks" ISSN: 2278-1684 Volume 11, Issue 4 Ver. VII.

[7]. Bhavin K.Kashiyani, Prof. Jayeshkumar pitroda, Dr. Bhavnaben k.Shah. (2013) "Effect of Polypropylene Fibers on Abrasion Resistance and Flexural Strength for Interlocking Paver Block" Volume4 Issue5.

[8]. Thakur, Saxena and Arora T.R., (2014) "Effect of Partial Replacement of Cement by Fly Ash with Using Nylon Fiber in Concrete Paver Block" (IJERT) Vol. 3 Issue 1.

[9]. Bhavin K. Kashiyani, Jayeshkumar pitroda & Bhavnaben K. shah(2013) "Innovative addition of polypropylene fiber in interlocking paver block" IJCSEIERD Vol. 3, Issue 2.

[10]. K. Vamshi Krishna and J. Venkateswara Rao (2014) "Effect of Glass Fibers In Rigid Pavement" International Journal Of Scientific Research And Education, Volume2, Issue9Pages1797-1804.

[11]. Vishal panchal , Lakshya Gupta, Chetan Deshmukh(2015) "Comparative Study Of Interlock Paver Block" IJSART , volume 1 Issue 6.

[12]. IS 10262: 2009, Concrete Mix Proportioning – Guidelines.

[13]. IS 15658:2006, Precast Concrete Blocks for Paving — Specification.

[14]. IS 383:1997, Specification For Coarse And Fine Aggregates From Natural Sources For Concrete.