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Effect of Inclusion of Glass Fibers and Fly ash in Concrete Paver Blocks

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Abstract— In this experimental investigation compressive strength, flexural strength and water absorption of paver block were evaluated by replacing portion of cement with the flyash in M35 grade concrete. Glass fibers were also incorporated along with the fly ash 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 fly ash. From the test results obtained the optimum fly ash and glass fiber content were found to be 20% and 0.2% respectively. Cost analysis of paver block was done and was compared with conventional paver block.
Keywords— Compressive Strength, Glass Fibre, Fly ash, Flexural strength, Paver Block and Water Absorption.

I. INTRODUCTION

Over the past two decades, paving composed of segmental blocks has become a feature of our towns and cities. Now-a-days concrete paver blocks are used in various applications like street road, small and medium market roads, low volume roads , footpaths, parking areas etc. The use of fly ash in concrete paver blocks is aimed at reducing cement content and heat of hydration leading to better economy and durability. It will also help in safeguarding the environment from ill effects of CO2 emissions from cement industry and contribute towards the solution for safe disposal of fly ash produced by thermal power plants.

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. Ritesh Mall, Sharda Shrama and R.D.Patel [1] investigated the Properties of Paver Block using Fly Ash as partial replacement of Cement in the range of 5-30% and was concluded that the Compressive Strength and Flexural Strength increase with the increase in Fly Ash content up to 25% replacement and there is 10-20% reduction in cost with the addition of 25% fly ash in concrete. Som Nath Sachdeva, Vanita Aggarwal, S. M. Gupta [2] studied the effect of varying proportions of fly ash in the range of 20% to 40%, on compressive strength and flexural strength of concrete. The mix designs studied are M-30, M-35, M-40 and M-50. It was observed that all the fly ash based mixes are able to achieve the required compressive and flexural strengths and a little more at 90 days. RamaMohanRao. P, Sudarsana Rao.H and Sekar.S.K [3] in their experimental investigation used glass fibers in different volume fractions with 25% and 40% replacement of cement by fly ash to study the effect on compressive strength, split tensile strength, flexural strength of concrete. V. M. Sounthararajan and A. Sivakumar [4] investigated the reinforcing efficiency of glass fiber addition in the low volume fly ash concrete. Glass fibers are proved to improve the matrix densification, refinement of microstructure, reduction of voids, minimize cracking due to stresses, and enhance durability to reinforcement corrosion, sulphate attack, and alkali-silica expansion. 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

Volume 3 Issue IX, September 2015
ISSN: 2321-9653

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 fly ash were used. This study also focuses on cost reduction of paver blocks with parallel enhancement of strength properties of paver blocks.

II. MATERIAL SPECIFICATION

A. 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.

B. 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%

C. 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.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	

D. Fly ash

Class F Fly ash was collected from National Thermal Power Corporation (NTPC), Visakhapatnam, Andhra Pradesh was used. Specific gravity of fly ash used was 2.50.Chemical composition of fly ash used was given in the following table 4.

Volume 3 Issue IX, September 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Table 4 Chemical composition of fly ash

Chemical	SiO2	Al2O3	Fe2O3	Na2O	MgO	CaO	SO3
Percentage	61.24	25.00	8.71	0.09	0.09	4.42	0.49

E. 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

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

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F. Admixture

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

III. MIX PROPORTION

In this study, control mix S was designed as per IS 10262:1982 for M35 grade. Glass fibers are initially added in fractions of 0.1% to 0.4% by weight of cement. Optimum glass fiber content was obtained and then fly ash was replaced for cement in percentages of 10 to 40. The details of the mix proportions are given in the following table.

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)	Fly ash(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
SGFF$_{10}$	341.82	696.3	1238.4	144.3	2.21	0.2%	37.98
SGFF$_{20}$	303.84	696.3	1238.4	144.3	2.21	0.2%	75.96
SGFF$_{30}$	265.86	696.3	1238.4	144.3	2.21	0.2%	113.94
SGFF$_{40}$	227.88	696.3	1238.4	144.3	2.21	0.2%	151.92

IV. EXPERIMENTAL METHODOLOGY

Paver blocks are casted conforming to the mix proportions and following the recommendations laid down in IS: 15658:2006.Casting and testing process is 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

Volume 3 Issue IX, September 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

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 fly ash was added along with this optimum percentage of glass fibers and paver blocks are casted SGFG10, SGFG20, SGFG30, SGFG40 mix. The samples were tested at 7, 28 and 90 days. The compressive, flexural and water absorption tests were conducted as per IS: 15658:2006 and optimum glass fiber and fly ash was determined.

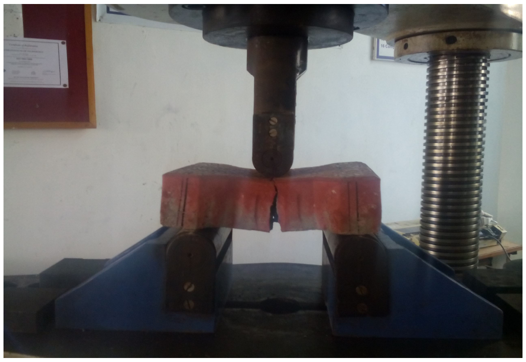

Fig. 1 Flexural strength test

Fig. 2 Paver blocks in oven

Fig. 3 Compressive strength test

V. RESULTS & DISCUSSION

A. Compressive strength

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

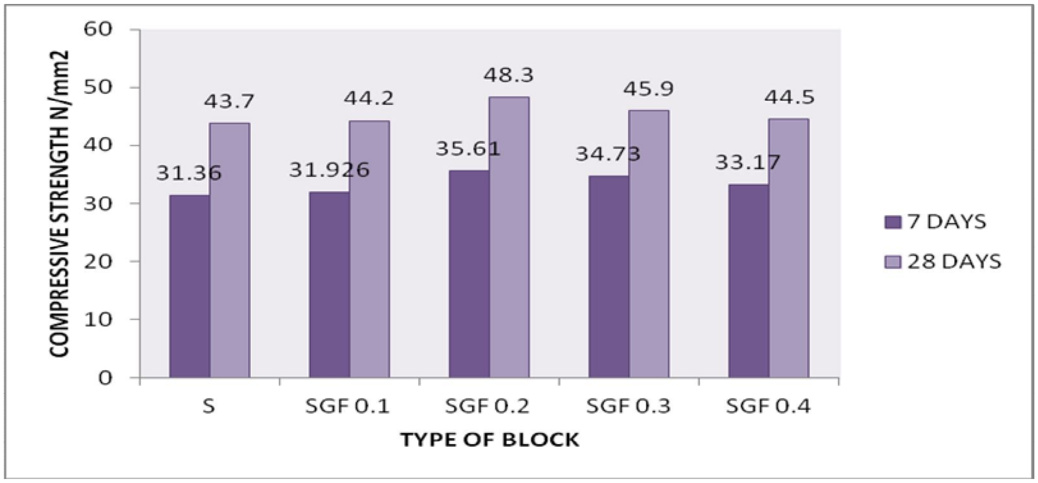

Fig. 4 Compressive strength at 7 & 28days without and with fibers for Paver blocks

From fig.4 it was observed that the compressive strength of concrete paver block was increasing with the inclusion of glass 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 normal paver block at 28 days.

B. Flexural strength

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

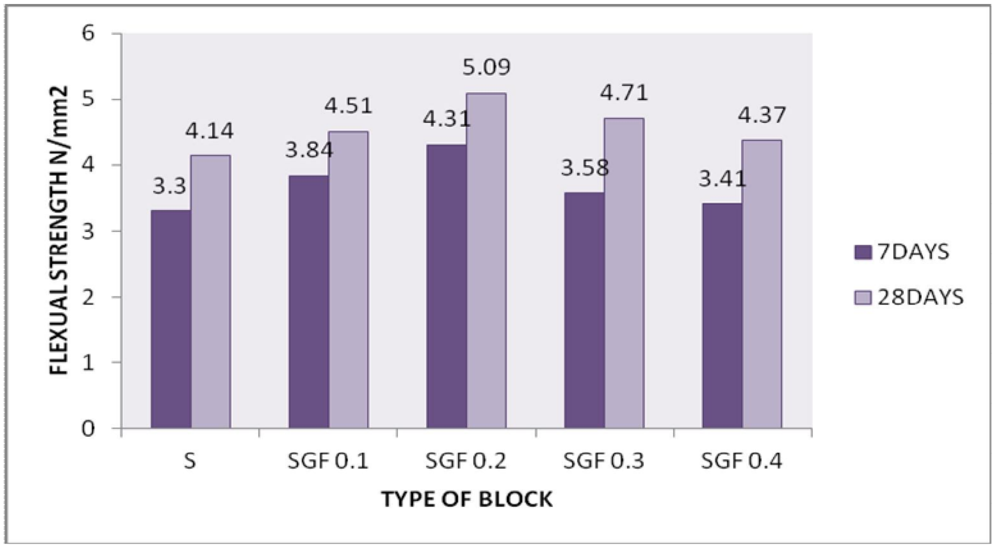

Fig. 5 Flexural strength at 7 & 28 days for Paver blocks without and with fibers

From fig.5 it was observed that the flexural strength of concrete paver block was increasing with the inclusion of glass 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 normal paver block at 28 days.

C. Water absorption

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

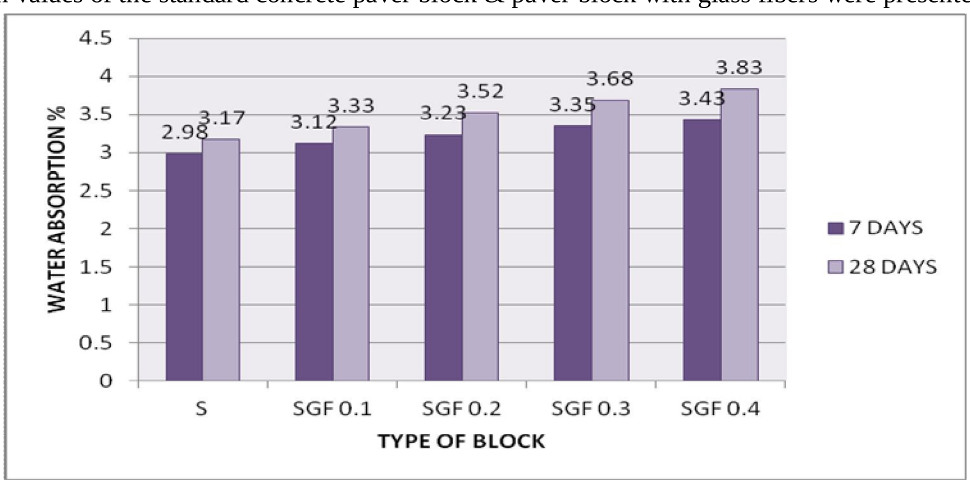

Fig.6 Water absorption at 7 & 28 days for Paver blocks without and with fibers

The graph illustrates that water absorption at 7 & 28 days increases with the increase in glass fiber content. The increase in water absorption is 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 15658:2006.

Volume 3 Issue IX, September 2015
ISSN: 2321-9653

D. Compressive strength

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

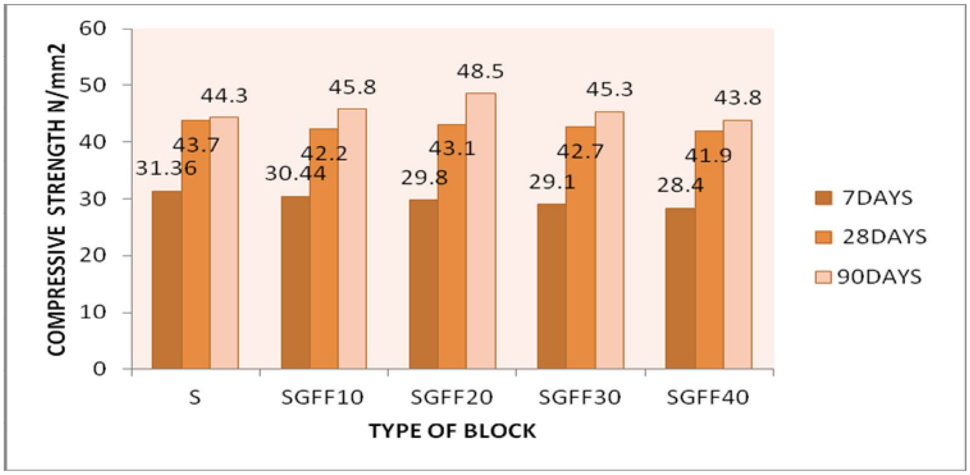

Fig. 7 Compressive strength at 7, 28 & 90 days without and with fly ash for Paver blocks

Fig. 7 shows the variation of compressive strength at the age of 7, 28 & 90 days for normal, 10%, 20%, 30%, 40% fly ash 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 Fly ash replacement. At 28 days, compressive strength slightly increases at 20% fly ash replacement but the value was less than the compressive strength of normal paver block at 28 days. Test results at 90 days curing period indicates an increase of 9.48% in compressive strength at 20% Fly ash replacement compared to conventional paver block.

E. Flexural strength

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

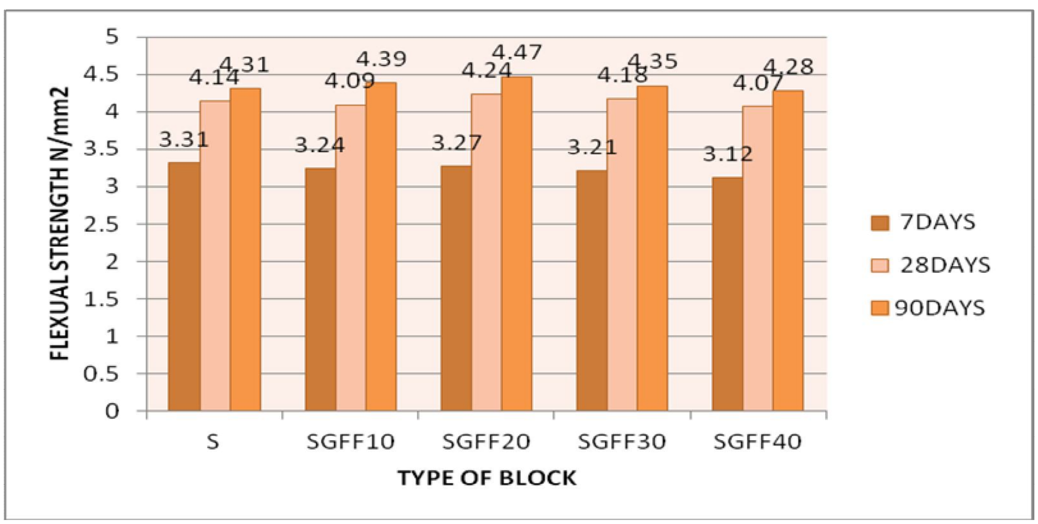

Fig.8 Flexural strength at 7, 28 & 90 days without and with fly ash for Paver blocks

Fig. 8 shows the variation of Flexural strength at the age of 7, 28 & 90 days for normal, 10%, 20%, 30%, 40% Fly ash replacement with cement along with optimum fiber inclusion i.e. 0.2%. At 7 days Flexural strength slightly increases at 20% fly ash replacement but the value was less than the flexural strength of normal paver block at 7 days. At 28 days flexural strength was maximum at 20% fly ash replacement .There was an increase of 2.41% in flexural strength at 20% fly ash replacement compared to conventional paver block at 28 days. Test results at 90 days curing period indicates an increase of 3.71% in Flexural strength at 20% Fly ash replacement compared to conventional paver block.

Volume 3 Issue IX, September 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

F. Water absorption

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

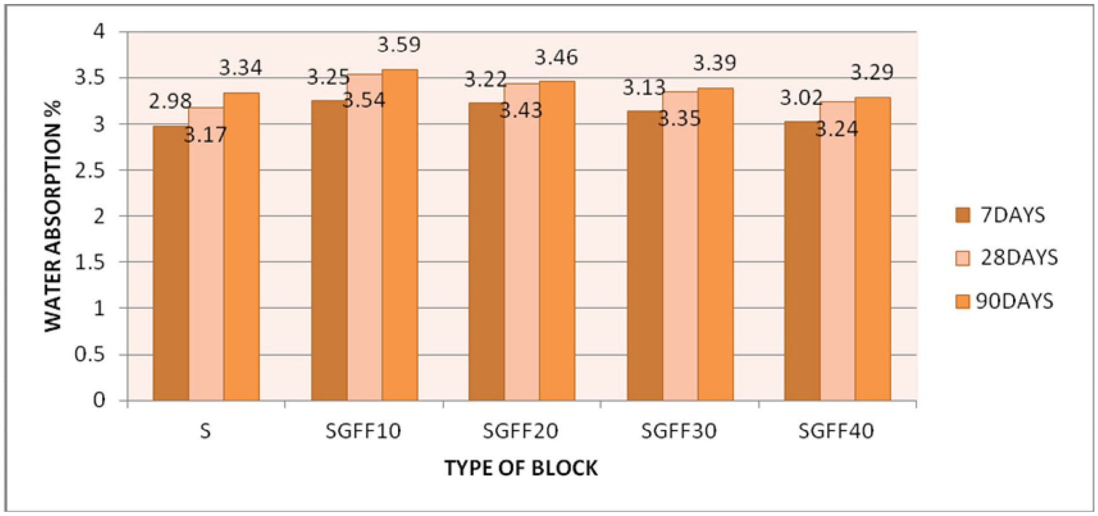

Fig. 9 Water absorption at 7, 28 & 90 days without and with fly ash for Paver blocks

Fig.9 illustrates that water absorption of paver block decrease with increase in replacement of cement with fly ash percentage. This is due to conversion of porous and undesirable product calcium hydroxide into cementitious material by puzzolonic reactivity of fly ash which makes the concrete denser.

VI. 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

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	$SGFF_{10}$	9.21	4797
7	$SGFF_{20}$	8.65	4508
8	$SGFF_{30}$	8.10	4220
9	$SGFF_{40}$	7.54	3931

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Table 8 indicates that the cost of paver block increases with increase in glass fiber content. On replacement of cement with fly ash the decrease in cost can be observed. There was an increase of 7.69% in cost at 0.2% inclusion of fibers. On replacement of cement with 20% fly ash along with inclusion of 0.2% fiber it is observed that there is decrease in cost by 9.31% compared to conventional paver block.

VII. CONCLUSIONS

A. Compressive strength and flexural strength of paver blocks increases by addition of glass fiber and optimum content of fiber inclusion is 0.2% by weight of cement.
B. On addition of 0.2% glass fibers there was 10.52% increase in compressive strength and 22.94% increase in flexural strength compared to conventional paver block at 28 days.
C. Test results at 90 days on replacement of cement with fly ash indicates an increase of 9.48% in compressive strength and 3.71% in Flexural strength at 20% Fly ash replacement compared to conventional paver block.

D. Water absorption percentage is found to decrease with replacement of cement with fly ash and the decrease was 1.5% compared to conventional paver block at 90 days .

E. On replacement of cement with 20% fly ash along with inclusion of 0.2% fiber it was observed that there was decrease in cost by 9.31% for each unit compared to conventional paver block.
F. Combined effect of fly ash and glass fibers resulted in enhancement of strength properties with simultaneous decrease in cost, making the paver block economical.

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