EXPERIMENTAL STUDY OF HYBRID PAVER BLOCKS ENGULFED WITH BINARY BLENDS

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Abstract*-Concrete is the efficacious used building material in construction engineering industry because of its excessive structural strength and stability. Ditching the trash stuff deep through the surroundings accidently guides ecosystem crisis along with health problems. This study analysis shares with Cement likely to be partially reserved by fly ash of 20%, 25%, 30% and fine aggregate reserved by glass powder of 10%, 15%, 20% by weight were investigated for the prime time. The strong assemblage jacked with Pulverised stone of sole size 12.5 mm. By casting trihex paver block of novel size 260×150×60 mm with hybrid grade of amalgamed concrete mix were used. Diverse testings were included for the durability and strength aspects. It was found that the conversion of 30% fly ash and 20% glass powder accorded with inert durability besides performance satisfactory with strong effect on mechanical features such as compression and flexure are observed.*

Key words: Fly ash, Glass powder, Paver block, Strength, Durability

1. INTRODUCTION

Innovation is gigantic investment in construction by virtue of its enlarging supremacy. The paver blocks outreached to different types of shapes and sizes to bear traffic loads .The acceptance of blocks entrenched by outstanding exigency and well efficiency. These amalgamed blocks are versatile because of its great resilience, its strength in accommodate heavy traffic density, edged lateral bond formation, premolded expansion joint filler.

The surge in demand for paving blocks as a construction material has provoked the increased cement requirements for the mass production of paving blocks. Turning down the utilization of cement within the manufacture of cement rooted matters like mortar, concrete and paving block can seriously bring down CO_2 emissions from cement production, nearly 0.9ton of CO_2 for entire 1.0 ton of cement [1]. Roughly 8% of total global CO_2 emissions are produced from cement production. The emitted blight of disastrous fumes are greatly soaring.

To control this problem, plenty of efforts has been made to take advantage of waste materials and by-products like fly ash, silica fume, GGBS, ceramic waste powder, rice husk ash, vegetable oil fuel ash, bamboo bagasse cinders, and incinerator bottom cinders as an proxies to partially substitution of cement within the cement-rooted materials [4],[5],[6], [7],[8],[9].

The bulk of previous studies have enthusiastic about integrating waste materials for the substitute of aggregate in paving block production like reprocessed dismantled aggregates, cinderblock aggregate , latex waste , reprocessed cathode ray tube funnel glass , and squiggled terracotta . Wide exploratory studies points on integrating mineral waste materials as a cement substitute in concrete paving block production by Ganjian etal [2].

The satisfactory choice is proportional to scrutinizing previous studies, which often used as additives and replacement material in paver blocks. The main incentive is to test the behaviour of hybrid blocks and to yield realistic outcome from hybrid material. The proper proportioning by unifying both blends while production solves the contamination crisis from poor handling plus controls cement within the paving block production. Circumscripting the approaching mess emerging from climate crisis. Therefore, waste material fills the void by novel cement replacement and good amalgamatory mixing can produce environmentally friendly paving blocks.

2. EXPERIMENTAL INVESTIGATIONS

2.1 Materials

Ordinary Portland cement (OPC) grade 53 that conformed to IS 12269 with a specific gravity of 3.07 was employed on this. Manufactured sand with a 2.77 fineness module and a specific gravity of 2.58, respectively were used as a good measure. Coarse aggregates complied with the necessities of IS 383 was used. The maximum amount as possible crushed/semi crushed aggregates were used. Crushed stone with specific gravity and maximum size aggregate of 2.83 and 12.5 mm, respectively was used as coarse aggregate. The grading curves of fine aggregates and coarse aggregate are shown in Fig. 1. Fly ash affiliated to Grade 1 of IS3812 (Part 1).Fly ash used in this experimental work was obtained from National Thermal Power Corporation (NTPC), ENNORE.

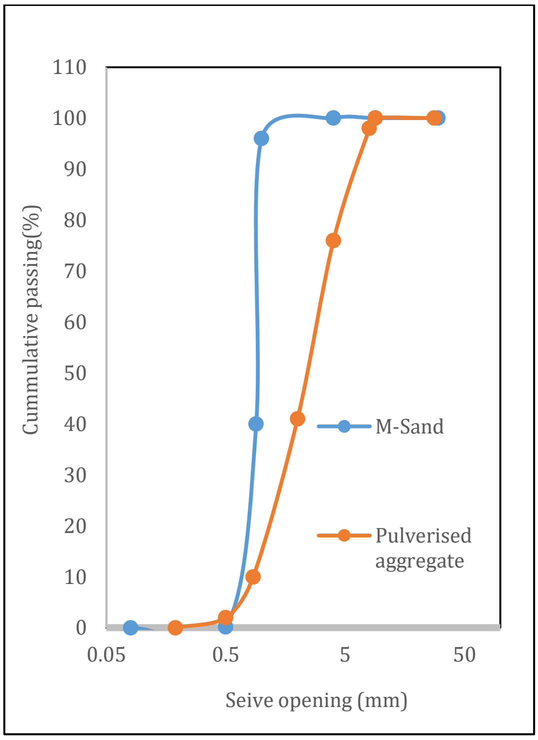

Fig-1: Sieve aggregate analysis

Fig-2: Fly ash and glass powder after being sieved to 300 μm and 90 μm

Material	**Glass powder**	**Fly ash**
Physical properties		
Specific gravity	3.08	2.05
Max. sizes particles	90µm	300 µm
Chemical compound (%)		
SiO_2	62.5	43.74
Al_2O_3	0.9	20.42
Fe_2O_3	0.6	4.15
CaO	14.5	20.47
SO_3	0.4	0.32
MgO	0.99	0.11
K_2O	–	4.04
P_2O_5	–	0.92
LOI	4.61	_

Table-1: Chemical properties of Fly ash and glass powder

1.2 Specimen preparation

The hybrid paving block was based on proper mix proportioning in accordance with manufacturer's recommendation. The ratio of the component of the hybrid paver block was 1: 1.49: 2.68 as cement, fine aggregate, and coarse aggregate, respectively. This research article deals with Cement is to be partially replaced by fly ash of 20% 25%, 30% and fine aggregate with replacement percentages of glass powder 10%, 15%, 20% by weight. Table 2 shows the mixed component of the paving blocks.

The mixing procedure was as follows: first, the cement, fly ash, glass powder, fine and coarse aggregates were dry mixed manually .Then, water was added to the mixture and mixing was continued until homogeneous. Finally, the fresh mix was placed into steel melds of 260 mm × 150 mm × 60 mm and compacted employing a handy press. Afterward, the blocks were taken out from the molds and left within the exterior for 24 h before they were cured until the testing age. Then they further undergone for testing to seek out the assorted mechanical and durability results to propose the acceptable conclusions from the experimental results using graph and charts.

Required Quantities	
Cement	428 kg/m^3
Water	253 kg/m^3
w/cement ratio	0.4
Water reducer	8.67 kg/m^3
Coarse aggregate	1153 kg/m^3
Fine aggregate	641 kg/m^3

Table- 2 : Mix proportion of the paving blocks

S.No	C.A (%)	F.A (%)	G (%)	F (%)	Cement (%)
CC	100	100	0	0	100
FG1	100	85	15	20	80
FG2	100	80	20	25	75
FG3	100	75	25	30	70

Table -3: Mix designation of samples

The compressive strength corresponds to traffic is mentioned below:

S.No	Compressive strength (N/ mm^2)	Grade	Traffic category
1.	30	M-30	Non-traffic
2.	35	M-35	Light - traffic
3.	40	M-40	Medium-traffic

4.	50	M-50	Heavy - traffic
5.	55	M-55	Very heavy-traffic

Table -4: Shows grades of paver blocks

Fig -3: Procedure for making the paving block (a) mixing; (b)molding; (c) demolding ; (d) curing method.

2.3 TESTING METHODS

2.3.1 Density

The density of the concrete blocks make up by sampling during a dry oven at 105 ° C for twenty-four hours then cooled to 25 ± 2 ° C for five hours. Afterward, the samples were weighed. Density depicts the degree of compactness of fabric material.

2.3.2 Compressive strength

The compressive strength of the blocks was tested at 7, 14 and 28 days supported the methodology described in IS 516:1959 'Method of test for strength of concrete' employing a universal testing machine.

The samples CC0, CC1 ,CC2 ,CC3 ,FG10 ,FG11 ,FG12 ,FG13 ,FG20 ,FG21 ,FG22, FG23, FG30, FG31,FG32,FG33,respectively are tested for 7,14,28 days. The load was applied to the surface of the block until the failure of the sample, as shown Compressive strength was calculated as (Eq. 1).

$\sigma_C = P/A$.........(1)

where σ_C be the compressive strength (N/mm^2)

P be the failure load of the specimen (N)

A be the surface area of the applied load (mm^2)

Fig- 4: Paver block under compression

2.3.3 Flexural strength

The flexural strength test was performed at 7, 14 and 28 days in as shown in Fig. 7. The samples CC0, CC1,CC2,CC3,FG10,FG11 ,FG12, FG13, FG20, FG21, FG22, FG23, FG30, FG31, FG32, FG33, respectively are tested for 7,14,28 days. The sample was placed within the flexural beam apparatus and subjected to a 2-point loading with a clear span of 170 mm. The load is applied to the sample of the paved block with a metal rod until the sample failure. The resistance to fracture of every sample resolve using Eq. 2.

$\sigma_F = 1.5 PL/ (b^2d)$............ (2)

where, σ_F is the flexural strength (N/mm^2)

P be the failure load of the sample (N)

L be the span length (mm)

b be the width of the sample (mm)

d be the depth of the sample (mm)

Fig-5: Paver block under flexural loading

2.3.4 Water absorption

The water absorption of the samples made up in accordance of 28 days curing period. First, block samples tend to soaked in H_2O for twenty-four hours. After being taken out from the water, the surplus water cutting off from the block sample, and conjointly the load was measured (W1).Then, the samples were oven dried at 105 °C unless a sustained weight (W2) was reached. The water absorption was calculated as (Eq. 3).

(WA = (W1-W2)/W2 × 100 %..............(3)

where WA be the water absorption (%),

W1 be the wet weight of the paving block (kg)

W2 be the dry weight of the paving block (kg).

2.3.5 Acid resistance test

The acid resistance of paving blocks was allotted at twenty-eight days by immersed in a 3 % of H_2SO_4 solution for 56 days as per codal provisions. After 56 days, the paving blocks were taken out and washed with water and in the out of door condition unless reaching a stable weight. Then, the compressive strength of paving blocks was calculated by using a universal testing machine.

Fig-6: Paver block under acid test

3. RESULTS AND DISCUSSION

3.1 Density

The average densities of the paving blocks at every replacement levels of cement and M-sand with fly ash and glass powder are given in Fig. The density values falloff with increasing fly ash content.

The density of the paving blocks decreased by2.29% ,3.5% ,5.7%, 7.79%, 8.4%, 12.2%, 14.9%,16.6%,18.2%,20.79%,22.9%,25%,25.3%,33.33% for CC1 ,CC2 ,CC3 ,FG10 ,FG11 ,FG12 ,FG13,FG20 ,FG21 ,FG22, FG23, FG30, FG31, FG32, FG33, respectively toward CC0. This could be of the lower density of fly ash that decreases the density of paving blocks, in addition to the high content of glass powder with in the paving blocks. This may generate higher porousness content leafed from water bubble as compared to the paving blocks with no replacement.

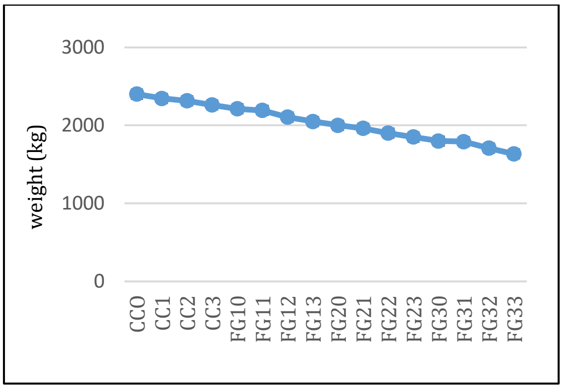

Fig-4: Density of paver blocks

3.2 Compressive strength

The compressive strength is an important parameter that affects the sturdiness of concrete. Fig.5. shows the results of 7, 14 and 28 days compressive strength values of the paving blocks. The compressive strength of the paving blocks CC0, CC1 ,CC2 ,CC3 ,FG10 ,FG11 ,FG12 ,FG13 ,FG20 ,FG21, FG22 ,FG23 ,FG30 , FG31 ,FG32,FG33 are in MPa are 56.2 ,56.6 ,56.8, 57.2, 57.8, 58.2,58.4 ,58.6 ,58.8, 59, 59.25, 59.4, 59.6,59.8,60.2,58.2, subsequently at 28 days . The compressive strength of paving blocks enhanced with proper time and decrease by increasing the proportion of glass powder behind the optimum as a partial replacement of M-Sand. This means that the super-plasticizing result on glass powder is lower compared to the Portland cement as cement starts diluting and reacting as before long as water is worth added to the combo. However, glass needs longer period to begin pozzolanic reaction. Decreasing the particle sizes will improve the fineness of pozzolanic materials that contributed to the strength development by acting as a micro-filler and enhancing the pore structure of the cement matrix.

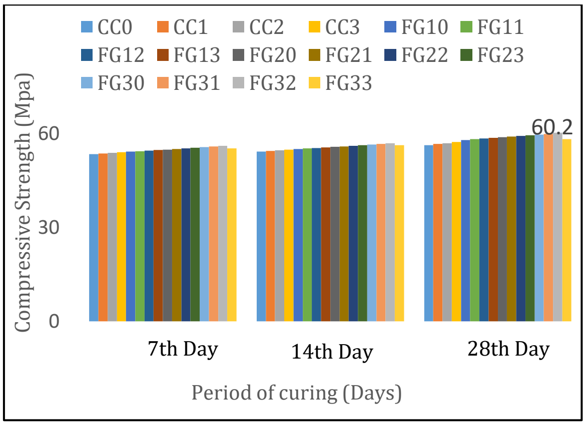

Fig-5: Compressive strength of paver block

Target compressive strength of 60.2 MPa in 28 days was achieved for all samples up to 0–20% glass addition while that for 25% addition was slightly lower. The paving blocks ready up to 30% fly ash and 20% glass powder met the necessities for heavy traffic loads.

3.3 Flexural strength

The flexural strength of the paving blocks at 7,14and 28 days is presented in Fig. 6. An analogous trend obtained within the compressive strength as that for the flexural strength values of the paving blocks. The flexural strength of paving blocks CC0, CC1 ,CC2 ,CC3 ,FG10 ,FG11 ,FG12 ,FG13 ,FG20 ,FG21, FG22 ,FG23 ,FG30 , FG31 ,FG32,FG33 in MPa are 4.41 ,4.42 ,4.44,4.48,4.52, 4.56 ,4.58, 4.60, 4.62, 4.66, 4.68,4.70,4.74,4.82, 4.74, subsequently at 28 days. There is an incentive increase in the flexural strength by addition of Fly Ash & Glass powder after 28 days of curing followed by strength decrease with increment of Fly Ash & Glass powder. The flexural strength contracted by 9% at first, then increase to 29% additional belittled to 23%.The maximum flexural strength of block is 4.82 Mpa.

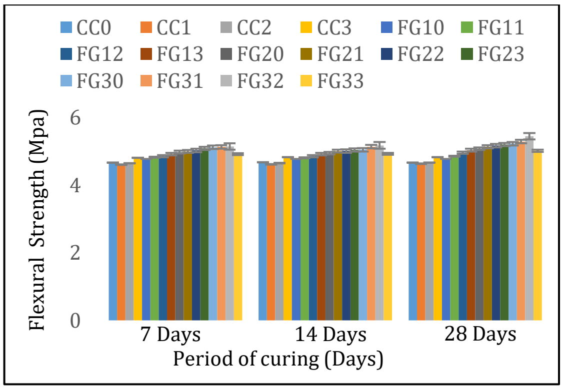

Fig-6: Flexural strength of paver blocks

3.4 Water absorption

Water absorption of hardened concrete is said to be the behaviour of the pore system inside the hardened concrete. Though aggregate also contains pore, it is typically discontinuous. Aggregate particles are encircled by a cement molecule that is steady state in concrete which makes aggregate highly impervious to water particle to enter inside .The activity of aggregate in water absorption is hardly impossible. The water absorption of paving blocks is given in Fig. 13.

This may be attributed to the porous nature of the paving blocks compared to the prime sample CC0. Water absorption was found to be 0.64%, 0.82%,0.4%,1.12%,1.21%,1.21%,1.32%, 1.39%,1.41%,1.43%,1.46%,1.48%,1.51%,2.03%,2.12%, 2.24%,and 2.3% for paving blocks CC0, CC1 ,CC2 ,CC3 ,FG10 ,FG11 FG12 ,FG13 ,FG20 ,FG21, FG22 ,FG23 ,FG30 , FG31 ,FG32,FG33, subsequently, than that of CC0.

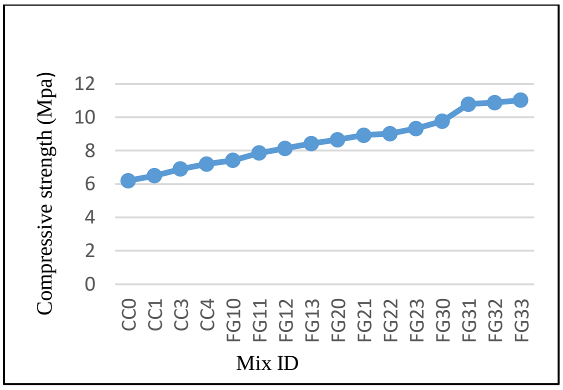

Fig-7: Water absorption of paving blocks at 28 days

3.5 Acid resistance test

Fig. 8 shows the compressive strength of the paving block after kept in a dehumidifier condition followed by 3 % H_2SO_4 solution for 56 days. Specimens stored in an AC laboratory.

It was ascertained that the compressive strength of paving blocks CC1 ,CC2 ,CC3 ,FG10 ,FG11 ,FG12 ,FG13 ,FG20 ,FG21, FG22 ,FG23 ,FG30 , FG31 ,FG32,FG33 increased by 0.64%, 0.82%, 0.4%,1.12%,1.21%,1.21%,1.32%,1.39%,1.41%,1.43%,1. 46%,1.48%,1.51%,2.03%,2.12%, 2.24%, and 2.3% ,subsequently was differentiated with the compressive strength of CCO at 28 days.

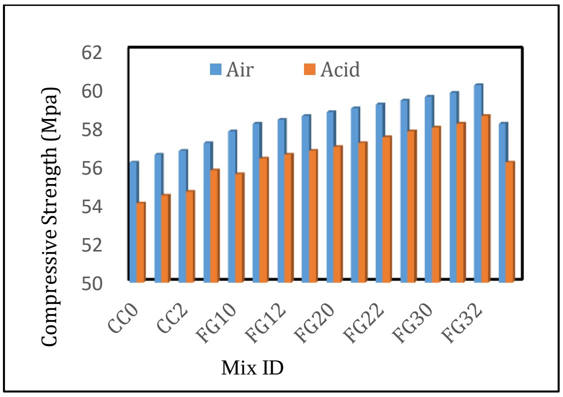

Fig-8: Compressive strength of the paving block kept in laboratory air condition and immersed in a 3 % H_2SO_4 solution for 56 days.

4. CONCLUSIONS

The present study utilized Fly Ash and glass powder as a replacement for cement and fine aggregate respectively to produce paving blocks. The results showed that the porous surfaces of fly ash increased the water to binder ratio of paving block with increasing the fly ash content as a cement replacement. The density of the hybrid paving blocks decreased as the percentage of cement replacement increased because the glass powder had a lower density than that of the cement. The maximum compressive strength and flexural strength was found to be 60.2Mpa and 4.82 Mpa.The percentage of water absorption is 10.2%.The loss of strength in acid resistant test is less than 10%. The increased glass powder content decreased the paving block quality in terms of compressive strength, flexural strength, water absorption, and acid resistance beyond the optimum due to the increase of voids within paving blocks. The increase of fly ash and glass powder content simultaneously produces larger voids, which significantly affected the quality of the paving block.

The results of compressive strength, flexural strength and water absorption showed that the replacement of cement with up to 30 % fly ash and 20% glass powder satisfied the requirement of paving block specified by IS.

The incorporation of fly ash and glass powder as a replacement in paving blocks could help decrease CO_2 fumes from cement production and allow the production of a more sustainable and low-cost paving block.

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