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Experimental Study on Strength Properties of Precast Concrete Paver Blocks Using Fly Ash, Crumb Rubber and Waste Plastic

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Abstract - The paver blocks are manufactured from zero slump plain concrete is a small aspect used for out of doorways functions and flexible avenue surfaces. Depending upon the web site traveler depth these are fabricated with a quantity of thicknesses, dimensions and shapes to meet with the requirement of a range of applications. In the current discover out about M30 grade paver blocks with thickness 60mm with replacement of OPC with 30% fly ash, 10% sand thru rubber crumb and waste plastic has been introduced @ 0.0% to 0.5% with increment of 0.1% by using weight of cement have been manufactured to get admission to the suitability for Indian avenue surfaces for particular applications. The blocks have been examined at the age 7 and 28 days for electrical energy and sturdiness criteria. For energy residences compressive electricity and flexural electrical energy take appear at had been conducted, every being fundamental for functions for avenue surfacing. The cease end result of compressive electrical energy and flexural power suggests that it is manageable to use OPC with 30% fly ash, 10% sand by means of rubber crumb, added and addition of 0.3% WPF in manufacturing of paver blocks. Paver blocks have attained intention compressive electricity and flexural power at 28 days in all the grades. The present day locate out about is crucial for paver block producers as it meets the dreams such as mix design, electrical energy and sturdiness requirements for Indian roads associated with utilization of waste fabric fly ash. Also, analyze about will help the usa financial device for 20% diploma in future, alongside with sustainability of virgin materials.

Key Word- Paver block, waste plastic, Fly ash, water absorption, Compressive Strength, Flexural Strength

1. INTRODUCTION

Precast cement concrete paver blocks are solid, unreinforced products made out of cement concrete of low water-cement ratio. These are made in varied dimensions with different grades of concrete to fulfil the need of diversified traffic environmental conditions. The paver blocks are manufactured from concrete composite comprising of cement, water, aggregates and super plasticizer, which are available locally everywhere in country. Pavers blocks are pre-fabricated in the factory using press/vibrating table system before their actual use. These are used in surface layer of pavements, urban and semi urban roads, village roads, streets, foot paths, gardens, passengers waiting sheds, petrol pumps bus stops, platforms, industry, etc. Precast paver blocks are ideal materials for pavements and footpaths along roadside where a lot of face lift is being given owing to easy laying, better look, easy to repair and ready to move after laying. Paver blocks are economical as they do not break and these have 100% salvage value in case of replacement. The term precast means that the blocks are manufactured and hardened before laying and are brought to job site. The paver blocks are manufactured in such a fashion that these interlock with each other during laying to maintain structural strength.

Pavements surface using blocks are made by using individual interlocking paver blocks by installing one to another. These are laid on prepared sub grade with sand bed below bounded by edge restraints from both sides. The blocks are laid in proper bond with joints in between to have structural stability. These joints are filled with sand of suitable grading. The interlocking mechanism of concrete block pavement provides sufficient area for load spreading. Concrete block pavements have certain advantages over asphalt and concrete pavements. The general advantages are maintenance, operational, structural, aesthetics and economical. A well-constructed interlocking pavement provides better performance. The use of fly ash in concrete paver blocks as part replacement of Portland cement is with the objective to reduce cement particulate content and hence heat of hydration which results in economy and durability enhancement. It will also help in energy saving in cement production. It is a good option for safe disposal of fly ash which is a waste from electric power generation plants. The advancement in industrialization worldwide, the production of electricity has increased manifold which has resulted into availability of large amount of fly ash at thermal power plants whose safe disposal is a burden. The utilization of fly ash in manufacturing of paver blocks will provide relief for safe and economic disposal of fly ash.

Cement concrete is strong under compressive loads at the same time it is inherently poor under tensile stresses. It is of brittle nature so it is not advisable to make paver blocks from concrete of such nature. The material for paver blocks has to be ductile. Thus to make concrete ductile, polypropylene fibres are added in small proportions during manufacturing of paver blocks to encounter the impact and flexural stresses which are inevitable on road surface during running of traffic. The micro crack formation in concrete at early stage due to plastic shrinkage may also be addressed with the addition of waste plastic.

2. OBJECTIVES

1. To prepare design mix for zero slump concrete composite for manufacture of paver block M30 grade designation of thickness 60 mm by replacing OPC with 30% fly ash, 10% sand by rubber crumb and waste plastic has been added @0.1%, 0.2%, 0.3%, 0.4% and 0.5% in each grade.
2. To test the strength properties of hardened paver blocks for various design mixes i.e. compressive strength and flexural strength at 07 and 28 days of age.
3. To establish optimum dosage of WPF addition in manufacturing of paver blocks with OPC with 30% fly ash, 10% sand by rubber crumb.
4. To study cost effectiveness of paver block with optimum dosage of waste plastic.

3. LITERATURE REVIEW

Chamundeswari et al. (2012) carried out study on concrete replacing OPC by C class fly ash @ 50%, 55% and 60% and adding PPF @ 0.9% in all the mixes of M35 grade and found that better compressive strength was obtained at 50% level of replacement. Gummadi et al. (2012) evaluated flexural strength of fly ash polypropylene composite by varying concentration of fly ash @ 0%, 10%, 15%, 20% and 25% by weight and reported that strength of the composite increases up to 10% level for smaller size particles of 53-75µm. Kashiyani et al. (2013) studied the water absorption of interlocking concrete paver blocks by adding polypropylene fiber@ 0.1%, 0.2%, 0.3%, 0.4% and 0.5% and found that water absorption reduces up to 0.4%. and studied the strength of interlocking concrete paver blocks by adding polypropylene fiber in the ratio of 0.1%, 0.2%, 0.3%, 0.4% and 0.5% by weight and found 0.4% PPF addition for maximum flexural strength. Naraganti et al. (2017) evaluated flexural strength of M30 grade concrete adding sisal and PP fiber @ 0.5%, 1.0%, 1.25% and 1.50% by volume of concrete of 12 mm length. The strength increases with age in both the cases and the maximum flexural strength was obtained at 1.50% in both cases separately. Satyavendra et al. (2021) Enormous utilization of fly debris in paver squares will assist the country with making affordable paver hinders and will address difficulties related with ecological issues and removal of waste In the current concentrate on M35 level paver blocks with thickness 80mm with substitution of OPC by 20% fly debris and expansion of fiber @ 0.0% to 0.4% with addition of 0.1.2% by weight of concrete have been made to get to the reasonableness for Indian street surfaces for various applications. The squares have been tried at the age 28 days for strength and toughness models. For strength properties compressive strength. The aftereffect of compressive strength and flexural strength demonstrates that it is doable to utilize OPC supplanted by 20% fly debris and expansion of 0.24% PP in assembling of paver blocks. Paver blocks have achieved target compressive strength and flexural strength at 28 days in every one of the grades.

4. Materials Used

a) Ordinary Portland cement (OPC)

Cement is a finely ground material which possess adhesive and cohesive properties. It is obtained by burning a mixture of argillaceous and calcareous materials at high temperature of about 145ºC as per Neville et.al. The Portland cement has mainly three grades, namely OPC33 grade, OPC43 grade and OPC53grade. The classification of cement is attained on the basis of the strength of cement at 28 days as per Aggarwal ei.al. Cement acts as a binder in production of paver block. In this research, 43 grade OPC procured from local market of Patna conforming to IS: 8112 has been used. The results obtained for the physical properties are given in Table1.

Table 1: Physical properties of OPC 43 grade

Properties	Result s
Bulk density (loose) kg/m^3	1440
Specific gravity	2.63
Water absorption (%)	0.48
Impact value (%)	14
Abrasion value (%)	19
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b) Coarse Aggregates (CA)

Physical property	Observed results
Normal consistency (%)	30
Initial setting time (minute)	94
Final setting time (minute)	245
Fineness (using 90 µm IS sieve) (%)	6
Soundness (mm)	2.0
Specific gravity	3.15
Compressive strength (N/mm^2) 03 days 07 days 28 days	25 35.5 44.5

The aggregates most of which are retained on4.75 mm IS sieve are known as coarse aggregates. These can be crushed or uncrushed gravel. In the present research stone cursed aggregates has been used of maximum nominal size 10 mm procured from local market, Bhopal, M.P. The coarse aggregates tested according to IS: 2386. Test results of sieve analysis and physical properties of coarse aggregates

Table 2: Physical properties of coarse aggregates

c) Fine Aggregate (FA)

Natural river sand or Artificial sand (stone crushed sand) with fraction passing 4.75 mm IS sieve are called fine aggregates. The river sand procured from son river, Satna (M.P.) conforming to IS: 383 has been used for the present research. The sand has been tested as per IS: 2386. The test results of the sieve analysis and physical properties observed of fine aggregates.

Table 3: Physical properties of fine aggregates

Properties	Observe d values
Bulk density (loose) kg/m^3	1567
Specific gravity	2.57
Water absorption (%)	0.60

Fly ash is used in various sectors. One such sector is concrete manufacture. The fly ash concrete results in poor early strength and long term good strength. It has low heat of hydration. It fills the voids of concrete resulting in more durable concrete products and thus increases the life of product. In the present study, the fly ash has been procured fromVijay tiles, Govinpura, Bhopal, M.P

Table 4: Physical properties of fly ash

Sr. No.	Property	Observed value
01.	Specific gravity	2.08
02.	Class	F-type

d) Chemical Admixture (Super Plasticizer)

Paving blocks are manufactured from semi-dry concrete which have poor flow under vibration. Use of chemical admixture improves workability as per Concrete Institute. Midrand. BASF Master Glenium SKY 8233 super-plasticizer based on Polycarboxylic Ether (PCE) chemical admixture has been used for manufacture of cement concrete interlocking paver blocks. It complies with IS: 9103 BASF Master Glenium SKY 8233 procured from local market Govindpura J.K Road, Bhopal

e) Water

Potable tap water was used for casting and curing of paver blocks. The water confirms to the requirements of IS: 456.

f) Waste Plastic

A plastic bag, poly bag, or pouch is a type of container made of thin, flexible, plastic film, nonwoven fabric, or plastic textile. Plastic bags are used for containing and transporting goods such as foods, produce, powders, ice, magazines, chemicals, and waste. It is a common form of packaging. Open bags with carrying handles are used in large numbers. Stores often provide them as a convenience to shoppers.

g) Crumb rubber

Crumb rubber is the name given to any material derived by reducing scrap tires or other rubber into uniform granules with the inherent reinforcing materials such as steel and fiber removed along with any other type of inert contaminants such as dust, glass, or rock. This is the physical compositions of the crumb rubber has been procured From Mandideep Bhopal, M.P

Figure 1: Waste Plastic

Table 5: Mix design of M30 grade concrete with fly ash, rubber crumb and varying % of waste plastic

Mix ID	Cementitious material		Water	Fine aggregate	rubber crumb	Coarse aggregate	SP	WPF
	Cement	fly ash						
	kg/m^3							
M30F30C10P0.0%	269	116	152	857.7	95.3	879	2.08	0
M30F30C10P0.1%	269	116	152	857.7	95.3	879	2.08	0.385
M30F30C10P0.2%	269	116	152	857.7	95.3	879	2.08	0.770
M30F30C10P0.3%	269	116	152	857.7	95.3	879	2.08	1.155
M30F30C10P0.4%	269	116	152	857.7	95.3	879	2.08	1.540
M30F30C10P0.5%	269	116	152	857.7	95.3	879	2.08	1.925

5. Compressive Strength Test

The paver block specimens 4 in number shall be selected randomly and physically checked for observation of dimensions, aspect ratio and plan area before testing as per code. The compressive testing machine of capacity 200 tons used for test. The specimen shall be capped with 4mm thick plywood sheets of size larger than the specimen and placed between the bearing plates of the CTM and tightened by hand. The load shall be applied without any jerk and increase continuously @15±3 N/mm^2 per minute until the specimen fails. The failure load is recorded in N. The apparent compressive strength of the paver block is calculated by using formula, compressive strength = failure load/ plan area in N/mm^2, for the individual specimen.

Figure 2: Compressive strength test setup

6. Flexural Strength Test

The paver blocks manufactured will be used for road surfacing. The flexural property of the paver block is very important to be observed when used on roads where traffic is running. The test specimen shall be checked for length, width, thickness and aspect ratio. The apparatus used for the test shall be same as per IS: 15658 and IS: 516. The supporting rollers of the machine should have diameter in the range of 25mm to 40mm. The distance from centre to centre of rollers shall be adjusted to fix the specimen -50mm. Four paver block randomly selected for the test and kept with capping material as per IS: 15658. The load shall be applied without any shock and increased continually @ 6kN/minute and shall be increased until failure of the specimen.

Figure 3: Flexural strength test setup

7. RESULTS

a) Compressive Strength

Corrected Compressive Strength of 60 mm Thick Paver Blocks with OPC Replaced by 30% Fly Ash, 10% sand by rubber crumb and varying proportions of WPF for M30 grade of paver blocks

The corrected compressive strength results of 60 mm thick paver blocks with OPC replaced by 30% FA and10% sand by rubber crumb addition of 0.0% to 0.5% PPF at different ages are tabulated in Table 7. The paver blocks have been named according to their grade designation, FA replacement proportion and PPF addition. The variation of corrected compressive strength with age for M30 grade of paver blocks has been shown graphically.

Table 6: Corrected Compressive Strength of 60 mm Thick Paver Blocks OPC with 30% fly ash, 10% sand by rubber crumb and varying %age of WPF for M30 grade of paver blocks

Grade	WCR	SP	WPF	Thick	Corrected compressive strength (N/mm^2)	
					07 Days	28 Days
M30F30C10P0.0%	0.43	2.08	0.000	60	23.63	35.80
M30F30C10P0.1%	0.43	2.08	0.385	60	23.80	37.50
M30F30C10P0.2%	0.43	2.08	0.770	60	24.96	38.40
M30F30C10P0.3%	0.43	2.08	1.155	60	25.53	39.10
M30F30C10P0.4%	0.43	2.08	1.540	60	24.83	38.80
M30F30C10P0.5%	0.43	2.08	1.925	60	24.60	38.40

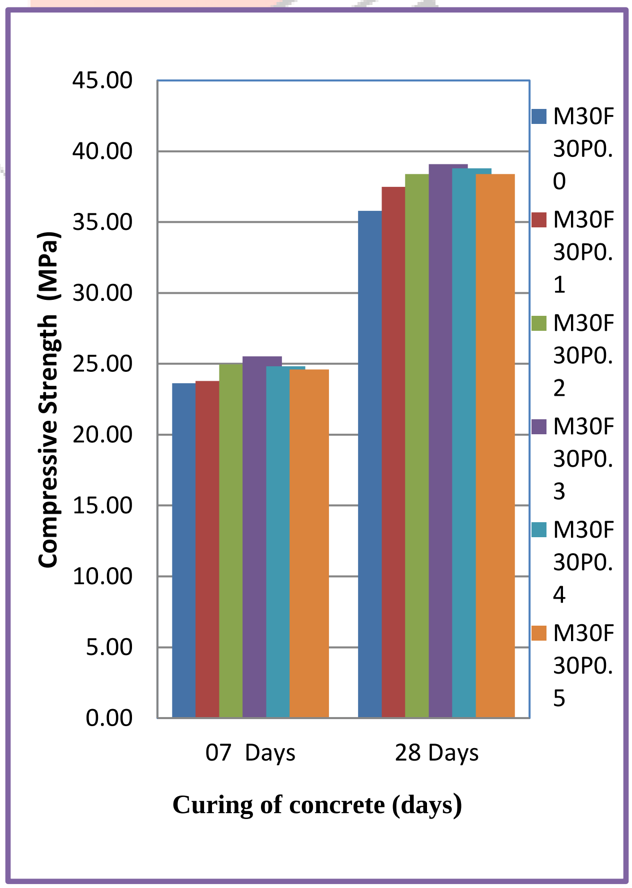

Figure 4: Variation of corrected compressive strength with age for M30 grades with varying proportions WPF for 60mm thick paver block

B) Flexural Strength

Flexural strength of M30 grade paver blocks of 60 mm thickness with replacement of OPC by 30% fly ash, 10% sand by rubber crumb and addition of WPF @ 0.0% to 0.5% for 7 and 28 days was observed and tabulated in Table 9, shown graphically in Figure 7. The paver blocks have been named as per their proportions in the mixes.

Table 7 Flexural Strength of 60 mm Thick Paver Blocks with OPC Replaced by 30% Fly Ash, 10% sand by rubber crumb and varying %age of WPF for M30 grade of paver blocks

Grade	WCR	SP	PPF	Thick	Flexural strength (N/mm^2)	
					07 Days	28 Days
M30F30C 10P0.0%	0.43	2.08	0.000	60	3.65	4.56
M30F30C 10P0.1%	0.43	2.08	0.385	60	3.80	4.76
M30F30C 10P0.2%	0.43	2.08	0.770	60	3.97	5.30
M30F30C 10P0.3%	0.43	2.08	1.155	60	4.24	5.94
M30F30C 10P0.4%	0.43	2.08	1.540	60	4.28	5.72
M30F30C 10P0.5%	0.43	2.08	1.925	60	4.08	5.48

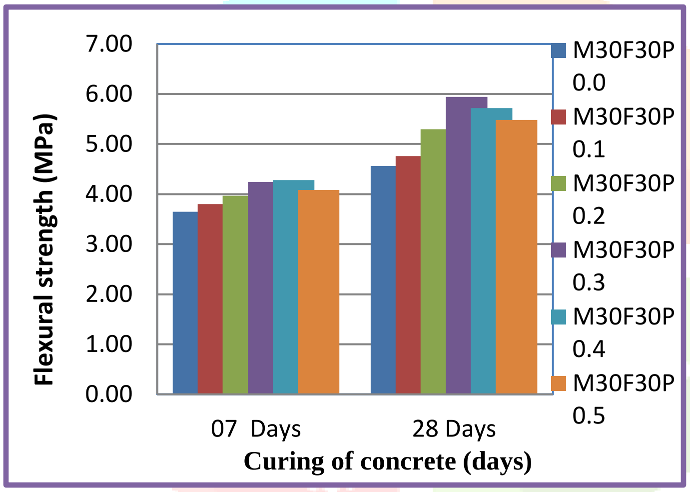

Figure 5: Variation of Flexural Strength with age for M30 grades with varying proportions WPF for 60mm thick paver block

8. Cost Effectiveness

The cost of manufacture of paver block with optimum addition of 0.3% WPF and 30% replacing OPC by fly ash, 10% sand by rubber crumb has been calculated in Table 11.

Table 8: Cost Effectiveness

Paver blocks with 100 % OPC	with OPC, fly ash, rubber crumb PF composite
Manufacture of 100 pieces of paver blocks by using cement 50 kg (1 bag). Cost of 50 kg (1 bag) of OPC = Rs 320/-	Manufacture of 100 pieces of paver blocks by using (cement 35 kg + 15 kg fly ash + 5kg rubber crumb + 0.125 kg WPF). Cost of 35 kg cement @ 300/50 kg = Rs 210/- Cost of fly ash (waste material) = Rs 0/- Cost of rubber crumb (waste material) = 10 Cost of WPF 0.125 kg = Rs 30/- Total cost = Rs 250/-
	Saving in cost = 320-250 = Rs 70/-
	Percentage saving = $(\frac{70}{320}) \times 100 = 21\%$

*Rest of the other materials and labor cost will remain constant in both the cases

Since, India is a large country with large number of rural/urban road network and other application areas where paver block can be consumed in large quantity. Manufacture of paver blocks by using waste material will help the nation by consuming waste materials, having zero production value, saving large amount of CO_2 emission and at the same time maintaining economy.From the above discussion, it can be concluded that for the sustainable world, it is necessary to conserve the raw materials by using waste materials in manufacturing of paver blocks which will help the nation economy environment friendly construction and is beneficial for paver block manufacturers.

9. CONCLUSIONS

1. Corrected compressive strength for reference mixes increases with age in M30 grade in 60 mm thick paver blocks. At 28 days of curing the strength has increased slightly from target strength.
2. Maximum gain in strength for all the grades at 28 days was observed with 0.3% PPF addition which may be taken as optimum dose.
3. All the mixes with addition of WPF in varying proportions in all the grades at 28 days have attained the target strength.
4. Effect of fly ash on hardened paver blocks tends to decrease the strength and with addition of WPF strength marginally increased.
5. Flexural strength for the reference mixes increases with age in M30 grade in 60 mm thick paver blocks. At 28 days reference mix attained target strength.
6. Maximum gain in flexural strength for all the grades at 28 days was observed with 0.3% WPF addition which may be taken as optimum dose.
7. Cost of paver blocks will increase in small amount due to addition of WPF.
8. Fly ash and rubber crumb is a waste materials to be used for manufacture of paver blocks of different grades and thicknesses the resulting product will be economical, energy saving and eco- friendly.
9. OPC replaced by fly ash and sand by rubber crumb will earn more economy resulting into overall reduction in cost by 21% at optimum level of 0.3% WPF in all the grades and thicknesses.

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