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Strength Analysis of Paver Block Using Fly Ash

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Abstract- The solid and hollow paver blocks made from precast cement concrete are thought to be a flexible, beautiful, functional, and cost-effective alternative to conventional road construction methods. Paver blocks are useful in a wide range of traffic situations, from light to heavy. Paver blocks are superior to traditional avenue methods in that they need little or no maintenance. When they're made with care and placed out properly. There are two areas of concern: failure due to surface wear and a wide range of mechanical strength between these blocks. Paving blocks are a common technique for constructing pathways that are ideal for uses such as driveways, walks, patios, public utility areas, garages, and so on. According to IS 15658: 2006, paver blocks may be used in Low Volume Traffic Roads if they are cast with M 35 concrete and are 60 mm thick. In this test, concrete paver blocks with a thickness of 60 mm and a M 35 concrete grade are cast. Fly ash, a waste product of the stone industry that is formed as a byproduct during the device for reducing and crushing stones, will be used as the first-combine in this initiative. With the help of a method, a fine combination will be replaced. Look at how compressive energy and flexural power are done on paver blocks using fly ash (which is held on a 4.75 mm IS sieve) up to a 100 percent at a 10% c programmed language period. The stable's functionality is also examined.

Keywords- concrete, compressive strength, M 35 Grade, Paver block, Fly ash, workability.

I. INTRODUCTION

Because of its many benefits, concrete block pavement is now commonly employed. It takes on a rectangular shape in line with the shape of bricks, and there are currently many other shapes of paving blocks. Because of the production and the proper mixing procedure, these blocks are a form of concrete with high quality and endurance.

Concrete pavement blocks are also intriguing and adaptable due to their high durability, strength in accommodating traffic flow, interesting aesthetics, and function, cost effectiveness, and lack of maintenance if installed correctly from the start. Paver block pavement is made up of individual solid blocks that are meticulously aligned to make a pavement surface. A typical paver block pavement is laid on top of a thin sand layer that serves as a sub foundation. PAVER BLOCK PAVEMENT comes in many different forms and designs. Between the blocks, there are shared zones.

Concrete block pavers are very adaptable, making them perfect for high-traffic pedestrian and automotive areas. The concrete paver blocks are available in paving thicknesses ranging from 60mm, which is ideal for light automobile and pedestrian traffic, to 80mm, which can sustain traffic from overburdening trucks in applications like as ports, air terminals, cargo yards, and other businesses. These spaces are filled with sand that has been graded appropriately. Edge constraints keep the blocks away from the facets.

The material used for paving blocks has seen significant changes, with many paving blocks being added or replaced with recycled or waste materials to prevent environmental pollution while also improving strength and mechanical characteristics. Many researchers, according to the literature review, employ waste materials as aggregate and cement replacements to make paving blocks. Plastic, fly ash, bottom ash, tin, limestone dust, tiles, rubber, coconut fibre, glass, and other materials are employed, and

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these resources are either inexpensive or free. However, there are various flaws in conventional paving blocks that necessitated a high cost of production. Furthermore, paving slabs manufactured from gravel in large numbers are heavy. As a result, the goal of this research was to see whether waste materials like tin and plastic, as well as quarry dust, might be used as additions or replacement components in paving blocks.

It is also designed to safeguard the environment from the build-up of waste products that might harm the ecology and environment, particularly for animals and people. The study's goal is to make paving blocks out of tin, plastic, and quarry dust, as well as to determine the most cost-effective paving block price. This research also aims to produce lighter paving stones and demonstrate their durability via compression testing. [2].

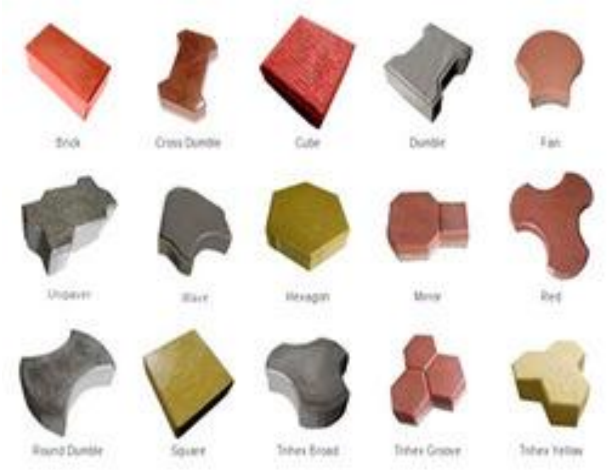

Fig 1. Different types of paver blocks.

II. MATERIALS AND METHODS

The paver brick used in this research is made for experimental purposes. For the experimental task, a 60 mm thick M-35 grade Paver block is stable. This chapter covers the fundamental tests performed on the materials used for casting paver block samples, as well as a short discussion of the material mixing and curing procedures employed. The numerous tests performed on the material are mentioned at the end.

1. Dimension of the paver blocks:
Firstly, for production of paver blocks dimension is decided, which is consistent with producer is given under:

- Shape: I section
- Length: 230 mm
- Width: a hundred and sixty mm
- Thickness = 60 mm
- Aspect ratio (L/T) = 200/80 = 2.5 <4.0, as in step with IS 15658: 2006

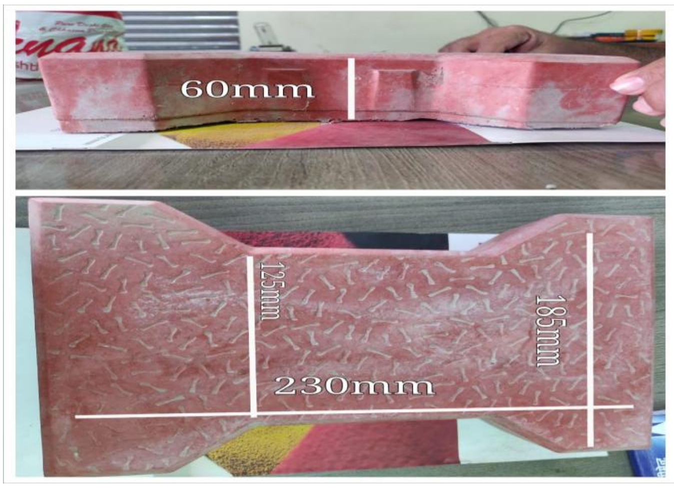

Fig 2. Dimension of Paver Blocks (All Dimensions are in mm).

Area shall be calculated by as per IS 15658: 2006 their method and regard are given under.

1.1 Plan Area (A_{sp}) (Method 1): Count to the nearest 0.01N the weight of the test specimen as it is suspended on a metal wire and submerged in water (Wa). Draining them on a 10mm coarser wire mesh for a minute can remove them from the water. In order to remove any water that may be visible on the specimen, a wet cloth may be employed. Immediately after collection, the specimens must be weighed, and the weight of each specimen must be provided to the nearest hundredths (N).

The following formula will be used to estimate the sample's volume: 01N (WW):

Volume = (WW – Wa) 10-3 m3

The volume should be partitioned by utilizing thickness to obtain arrange put in mm2.

Volume = 0.0018 m^3
Area= 0.03 m^2 = 30000 mm^2

1.2 Plan Area (A_{sp})(Method 2): The specimen should be placed on a piece of cardboard with its sporting face facing up, and its perimeter should be sketched with a pencil. The shape must be reduced precisely with the scissors and weighted to the nearest 0.0001N, with the result recorded as mass in the appropriate place (msp).

In addition, a rectangle measuring 200mm x 100mm cut out of similar cardboard should be weighted to the closest 0.0001 N and the result recorded as mass (mstd).

The plan area for the block shall be computed using the formula:

$$A_{sp} = \frac{20000\, m_{sp}}{m_{std}} mm^2$$

Msp= 0.2062 N
Mstd= 0.1373 N
Area (Asp) = 30036.41 mm^2

2. Materials:
Cement, fine aggregate, coarse aggregate, sand stone chips, and other materials used in the projects to make concrete mixtures are described in detail below:

2.1 Cement: The cement used in this experimental investigation was OPC 43 grade and Properties of OPC Cement are as listed below in table 1.

Table 1. Testing on Cement.

Sr. No.	Physical Property	Results
1.	Initial setting Time	41 minutes
2.	Final Setting Time	390 minutes
3.	Specific Gravity	3.168
4.	Compressive strength 21 days	32 N/mm^2

2.2 Fine aggregates: The fine aggregate (FA) employed in this study was natural river sand that passed fully through a 4.75 mm aperture size sieve and met the IS: 383-1970 zone II criteria. Table 2 lists the characteristics of fine aggregates.

Table 2. Properties of Fine Aggregates.

S. No.	Test	Result
1.	Specific gravity	2.62
2.	Fineness Modulus	2.64
3.	Water Absorption	0.5%

2.3 Fly Ash: Fly ash is a by-product of pulverized coal combustion in thermal power plants. It is collected as a fine particulate residue from the combustion gases by the dust collecting system before they are released into the environment.

The range of particle sizes in any fly ash is mostly dictated by the dust series equipment that is employed. The fly ash from boilers at certain older facilities, where I work as a mechanical creditor, is coarser than fly ash from plants that use electrostatic precipitators.

Table 3. Physical properties of fly ash.

Sr. No.	Physical Property	Results
1.	Specific Gravity	2.34
2.	Bulk Density	1110 kg/m^3

2.4 Water: Potable water was used for mixing the concrete mix in entire investigation and for curing the mixture in the determination of the optimal percentage of as fly ash replacement.

III. EXPERIMENTAL PROCEDURE

Before beginning the findings, all items were brought to room temperature. All of the components (Cement, Fly Ash, Sand, and Water) are weighed for a 1m3 amount according to the specified density, and then the weights are translated into volume by dividing the weights of the materials by their specific gravity. The first stage in making paver blocks is blending, and in this Endeavour, hand mixing is preferred for paver block assembly.

The components, which include water, cement, aggregates, and e-waste, are mixed by weight. The quantity of cement, aggregate, e-waste, and water for each group could be calculated by weight to within 0.1 percent of the bunch's total weight. To avoid loss of water or other ingredients, the concrete should be mixed by hand or, preferably, in a clump blender at a research centre.

The concrete clump should be mixed using a scoop, trowel, or comparable suitable implement on a watertight, non-retentive stage for hand blending. The approach acknowledged for mixing is, cement and fine aggregate is usually integrated till the mix gives uniform shade. Fly ash, mixed with cement and fine aggregate, is used uniformly throughout the cluster.

Fig 3. Casting of paver block.

IV. RESULTS AND ANALYSIS

The casted paver block was examined under a variety of conditions in order to assess the strength and other attributes of the casted paver blocks. The investigation's main goal is to improve the established strength of the material mix after numerous days of curing testing. The strength of a block is usually enhanced by proper manufacture and curing of concrete cubes.

For this experiment, three samples of each mix ratio were evaluated independently and at the appropriate curing days. The phases of curing were 7 days, 21 days, and 28 days. The analysis is then conducted using the average values. Below are the specifics of the trials that were carried out:

1. Slump Cone Test:
This test is carried out to ensure that the freshly cast paver block material is workable. This test was carried out separately on freshly cast paver blocks with the fly ash replaced with cement to determine workability. This test is done just after the concrete has been poured. Workability is the ease with which concrete can be worked, and the results are displayed in table 12 and graph 1-2.

The workability of concrete was tested using a slump cone, and it was discovered that adding Fly ash to concrete reduces its workability. The workability of concrete decreases as the amount of Fly ash in the mix rises. A control concrete mix (CC) has a 92 mm slump, however when sand is totally replaced by Fly ash, the slump drops to 42 mm. The slump cone test procedure used in this research is outlined below.

Table 4. Slump value of Concrete Mix.

% Replacement	Slump Value
0%	92 mm
10%	91 mm
20%	91 mm
30%	90 mm
40%	88 mm
50%	86 mm

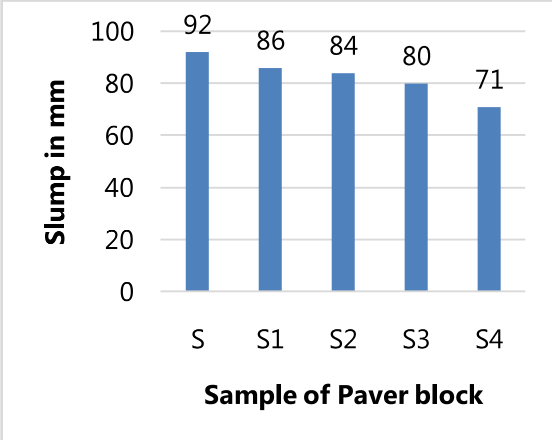

Fig 4. Slump Test values.

Several tests were carried out on concrete paver blocks. Paver blocks were cast in accordance with the mix percentage and in accordance with the guidelines in IS 15658:2006. Paver block dimensions are 250 x 125 x 60. There were a total of 56 paver blocks cast. Water was used to cure the samples for 7 days, 21 days, and 28 days.

According to codal recommendations, compressive strength, water absorption test, and flexural strength test are performed. According to IS: 15658, the test specimen needed for the specific test.

Table 5. Minimum Specimen for Test.

Test	Minimumspecimen
Compressive strength test	4
Water absorption test	3
Flexural strength test	4

ANNEXURE C, D, and F include the test procedures for the water absorption, compressive strength, and flexural strength tests that are done in accordance with IS: 15658:2006, which are listed in ANNEXURE C, D, and F.

2. Compressive Strength Test:
The average strength of paver blocks was investigated in this experiment, and the results were

compared to the nominal mix of M35 Mix. The heavy compressive force that a material can withstand below the fracture limit was determined via compressive strength testing. The combined compressive strength at 7 days, 21 days, and 28 days is indicated in the table, and the same is shown graphically in the graph.

Table 6. Comparison of compressive Strength Analysis.

Mix	Compressive Strength at 7 days (N/mm^2)	Compressive Strength at 21 days (N/mm^2)	Compressive Strength at 28 days (N/mm^2)
S	32.75	36.59	38.40
S1	41.39	42.03	38.83
S2	51.52	54.83	51.20
S3	45.22	46.51	42.45
S4	21.12	27.41	24.96

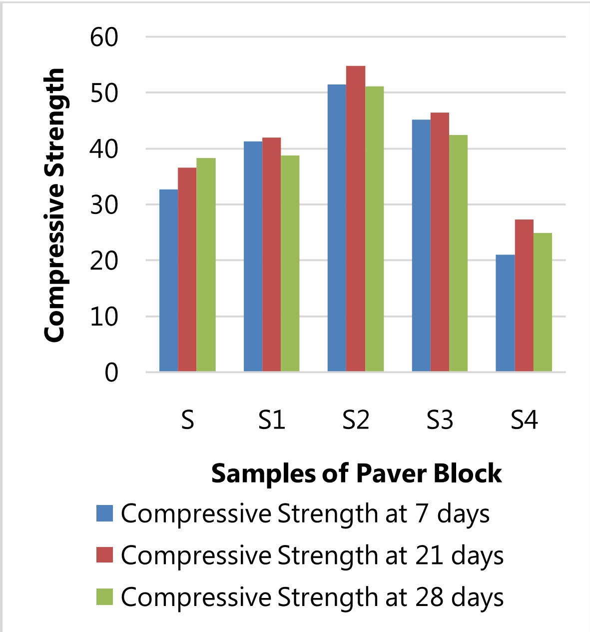

Fig 5. Comparison of compressive Strength Analysis.

3. Water Absorption Test [IS15658:2006]:
After casting, the paver blocks were placed in water for 28 days to cure. They were then weighed, and the wet weight of the paver block was recorded. These specimens were then oven dried at 110^{0}C until the bulk was consistent, then weighed again. This weight was recorded as the paver block's dry weight.

%Water Absorption = [(WW –DW)/DW] x100

Where, WW = Wet Weight of paver block,
DW =Dry Weight of paver block.

Table 7. Comparison of water Absorption test results

Mix	Water Absorption at 7 days	Water Absorption at 21 days	Water Absorption at 28 days
S	0.593	0.596	0.596
S1	0.646	0.676	0.66
S2	0.54	0.566	0.556
S3	0.593	0.646	0.646
S4	0.54	0.673	0.683

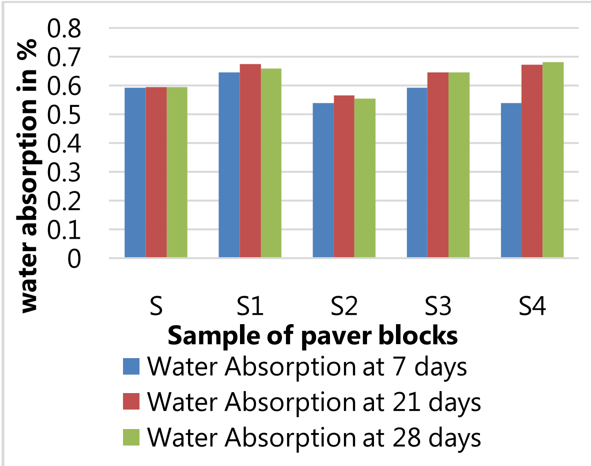

Fig 6. Comparison of water Absorption test results.

4. Flexural strength:
The modulus of rupture is another name for flexural strength. The bending moment induced by the applied load in a paver block with compression at the top and tensile tension at the bottom is known as flexure.

Table 8. Flexural Strength Test Results at 28 Days.

Mix	Load (KN)	Average Load (KN)	Flexural Strength (N/mm^2)
S	11.3		
	11	11.13	4.17
	11.1		
S1	12.8		
	13.3	13.03	4.89
	13		
S2	15.6		
	15	15.36	5.76
	15.5		
S3	14.2		
	14.7	14.3	5.36
	14		
S4	11.1		
	10.3	10.73	4.024
	10.8		

At 28 days of age, the flexural strength of concrete paver block specimens was assessed. For each age group, four specimens were tested. The load was applied to the specimen from the centre. As per codal requirements, this test is subjected to three points of loading.

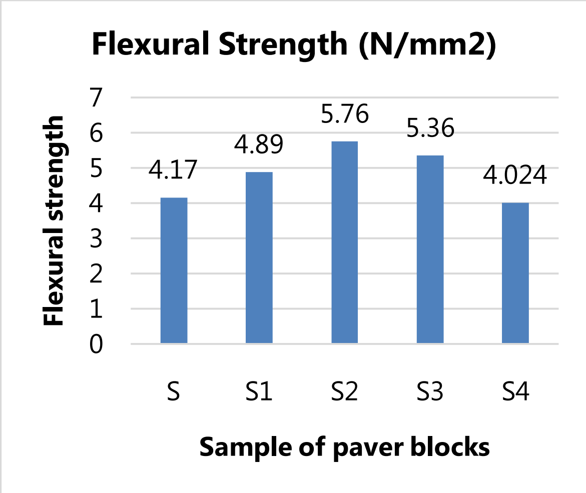

Fig 7. Flexural Strength at 28 Days.

V. CONCLUSION

Conclusion drawn from this study is given below. The slump cone test is used to determine the workability of the concrete; it has been discovered that replacing Fly ash with sand reduces the slump value of the concrete; for this project, the concrete is designed for a 100 mm slump, but the control concrete mix (CC) produces a slump value of 92 mm, which decreases as the percentage of Fly ash in the concrete composition increases. It has a 71-millimeter slump. Water absorption of the block was determined to be optimal on S2, i.e. a 50% replacement of fly ash in the block.

Water absorption values on 7 days are 0.593 percent, up from 0.54 percent, on 21 days is 0.646 percent, up from 0.566 percent, and on 28 days are 0.556 percent, up from 0.646 percent. The findings demonstrate that when fly ash is replaced by cement in the composition of paver blocks, the compressive strength of the paver blocks improves, and after rectification according to IS 15658 recommendations, the compressive strength of the paver blocks reaches an optimal value of 50%. When 50 percent fly ash is added by the weight of the cement, it achieves maximum compressive strength of 47.24 N/mm2, giving optimum value of fly ash 50 percent, further fly ash added in the composition compressive strength goes down to 42.45 N/mm2 at 28 days as a whole, it is concluded that for M35 characteristic mean strength is 51.20 N/mm2. When fly ash is added to the paver block composition, the flexural strength of the blocks improves and reaches a maximum value of 50%. When 50 percent fly ash is added to the weight of the cement, it achieves maximum compressive strength of 5.76 N/mm2, giving the optimal value of fly ash 50 percent.

As more fly ash is added to the composition, the compressive strength drops to 5.36 N/mm2. According to IS 15658: 2006, the minimal breaking load is 10.73 kN, and the flexural load derived from this breaking load is 4.024 N/mm2, indicating that the whole composition is acceptable. From the foregoing points on flexural and compressive strength, it is obvious that Fly ash will replace 90 percent of cement in paver block concrete.

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