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Utilization of Fly Ash and Quarry Dust as a Partial Replacement of Cement and Sand along with Waste Plastic in Paving Blocks

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ABSTRACT

The rapid development of housing and infrastructure from last one decade continuously takes place in India. Along with that naturally, the product required to overcome this development produce in mass quantities like Pavement blocks, which are known as industrial products of precast made up by concrete, having various shapes and sizes utilizes in huge quantity in housing and infrastructure construction. The conventional materials to manufacturing these blocks utilize in large quantity, which may create an impact on natural recourses. Paver blocks unit generally used for diverse traffic classes i.e., Non-traffic, Light-traffic, Medium-traffic, Heavy-traffic and really important traffic. Most concrete block paving created in country has performed satisfactorily but there are two main areas of concern: occasional failure thanks to excessive surface wear, and variability inside the strength of blocks. To overcome this impact, we can use different materials such as, Fly Ash, Quarry Dust, Waste Plastic's, etc. Fly ash and Quarry dust are the industrial outgrowth which we used in these projects. Using these byproducts, the pollution and disposal problems of materials be reduced. Concrete paving blocks are exemplary materials on the footpaths for easy laying, better look and finish.

***Key Words*:** Conventional materials, Compressive strength, tensile strength, workability.

1.INTRODUCTION

As today's world is focusing on sustainability for the betterment of future world, researchers were focusing on reducing or replacing the existing available pollutants which are dumped on earth surface and spoiling the lifecycle of inhabitants of the earth. Plastic has become an irreplaceable material in our day-to-day life which leads to immense threatening in the environmental life including humans, wildlife by replacing its resources by accumulating their population and habitats. The challenge of finding an alternative for plastics is a biggest and expensive way instead of reusing and recycling it in a sustainable manner.

In general, paver blocks were used as a flooring material in parking areas, pavements and pedestrian paths, etc., These paver blocks were made up of cement concrete and are bonded with one another using interlocking's provided on the edges were available in various shapes. For the purpose of binding, cement is the main ingredient in the concrete, which consumes large number of raw materials and energy required for the production results in the emission of greenhouse gases like CO2. In order to find an alternative option for binding, fly ash emerge as a supplementary product for the cement in the concrete. Fly as is the outgrowth of hydroelectric power plants. The quarry dust used as a replacement with sand. Because of scarcity of sand the requirement as the supplementary material for sand.

1.1 RESEARCH SIGNIFICANCE

A parametric experimental study for producing paving blocks using fly ash and quarry dust is presented. Some of the physical and mechanical properties of paving blocks with cement and fine aggregate (sand) are partially replaced by various percentages of fly ash and quarry dust are investigated. The use of Fly ash and Quarry dust as partial replacement with cement and sand unto 30% in the concrete that increases the workability of the concrete. In addition, it increases the compressive strength of the concrete.

1.2 OBJECTIVE OF STUDY

The primary objectives of utilizing Fly ash, Quarry dust, and waste plastic in paver blocks by partially replacing cement and sand are:

•To study the effect of Fly Ash as a partial replacement of cement.
•To study the effect of Quarry Dust as a substitute of sand.
•To check the effect of Fly Ash and Quarry Dust along with waste plastic on proposed mixes.
•To check the effect of Fly Ash and Quarry Dust along with waste plastic on fresh and hardened properties.

2. LITERATURE REVIEW

The extensive literature survey has been carried out through various sources. The comprehensive review of literature is presented below:

A) Z.T. Yao et.al (2015) They, first describes the generation, physicochemical properties and hazards of coal fly ash at the global level, and then focuses on its current and potential applications, including use in the soil betterment, construction industry, ceramic industry, catalysis, depth separation, zeolite synthesis, and many more.

B) Sarang Shashikant Pawar (2017) In this study aims at evaluating the performance of plastic concrete for paver blocks for use in pavements and other application areas. As compressive and durability are the most significant properties for concrete paver blocks, the same have been studied for various concrete mixes with diversified percentages of material.

C) Rajat Agrawal, et.al, (2023) This study suggest that the compressive strength of the waste plastic cube is contingent on the ratio of plastic waste to M-sand, as well as the thoroughness of the mixing process. The 1:4 ratio demonstrated superior compressive strength, while reducing plastic waste resulted in diminished strength. The study indicates that recycling plastic

waste, specifically Polyethylene Terephthalate (PET), into road pavers, possesses considerable potential as a sustainable construction material in India. Capitalize on plastic waste in the form of road pavers brings several benefits, including waste diminution, resource preservation, and environmental advantages.

3. MATERIAL USED IN THE RESEARCH

3.1 CONCRETE MIX CONSTITUENTS

Concrete is a composite material that is made through mixing cement, water, fly ash, sand, quarry dust.

3.1.1. CEMENT

Ordinary Portland Cement (53 Grade) was used in the entire experimental study.

3.1.2. WATER

In this study, concrete was mixed and cured using potable water which is free from organic impurities.

3.1.3. FLY ASH

Fly ash is a fine powder generated by the burning of pulverized coal in electric power plants. The content as per IS:3812-1981 is used for the Fly Ash. It is a pozzolana, a substance combining aluminous & siliceous material that makes cement when mixed with water. When combined with water and lime, fly ash produces a chemical that is comparable to Portland cement.

3.1.4. SAND

Sand is a grainy material composed of finely divided mineral particles. Sand has various composition but is defined by its grain size. Sand grains are smaller than gravel and coarser than silt. Sand can also refer to a textural class of soil type: i.e., a soil containing more than 85 percent small by mass. ISO 14688 grades sands as fine, medium, and coarse with ranges 0.063 mm to 0.2 mm to 0.63 mm to 2.0 mm.

3.1.5 QUARRY DUST

Quarry dust, an outgrowth of the crushing process, is a concentrated material that can be used as aggregates for concrete, particularly fine aggregates. The rock is crushed into varying sizes during quarrying activities; the dust produced during the process is referred to as quarry dust and is created as waste.

3.1.6 WASTE PLASTIC

A plastic bottle is a bottle constructed from high-density or low-density plastic. Plastic bottles are mostly used to store liquids such as water, soft drinks, motor oil, cooking oil, medicine, shampoo, milk, ink, and many more. They come in a range of sizes, from very small bottles to large carboys. Consumer blow molded containers often have integral handles or are shaped to easier for grasping.

4. METHODOLOGY

In accordance with the Indian Standard (IS: 10262-2009), the design mix for M25 grade concrete was made by substituting two different weight percentages of Quarry Dust (10% and 20%).

4.1 RATIOS USED IN THE STUDY

TABLE -1 NORMAL PAVER BLOCK

Mix proportions for Normal Paver Block				
Cement (Kg)	Sand (Kg)	1 Cube	W/C RATIO	Water (Litre)
0.889	2.67	3.559	0.45	0.4

TABLE 2 - PAVER BLOCK WITH MATERIAL REPLACEMENT

Mix Proportion of Paver Block with Material Replacement							
Fly Ash	Quarry Dust	Cement (Kg)	Fly Ash (Kg)	Sand (Kg)	Quarry Dust	Waste Plastic	1 Paver Block Volume(M^3)
10%	10%	0.80	0.08	2.4	0.27	0.2	3.75
20%	20%	0.71	0.18	2.13	0.53	0.2	3.75

We casted the concrete paver blocks by the ratio of 1:3. The industrial byproducts such as fly ash and quarry dust used as the partial replacement with the cement and sand along with crushed waste plastic in paving blocks.

1.Physical properties of all materials are checked.

2.Batching the proportion by weighting the materials as per the calculation.

3.The fly ash and quarry dust replaced 10% by weight with cement and sand in the 1 proportion mix 1:3.

4.The fly ash and quarry dust replaced 20% by weight with cement and sand in another proportion mix 1:3.

5.Add waste plastic crushed of high density as 2% weight of cement, material mixed dry properly.

6. Add the water as per w/c ratio used 0.45- and 5-ml hardener by mix with water, Wet mix is formed, Now the mixture is transferred to the mound, Compact and vibrate it to reduce all internal pore present in mix. Then the mould is allowed to dry for 24 hours so that they hardened. After drying the paver block is removed from the moulds and ready for the use.

•Cement sieve test be performed to calculate the fineness of cement. Take 100 gm weight of cement (W1).

•Sieve that cement from IS-Sieve of size 90 micron.

•Weight the retained cement in the sieve (W2).

•Use the following formula to calculate fineness of cement:

Fineness of cement=W2/W1x 100

•Pycnometer test be performed to calculate the specific gravity of sand.

•Take the empty pycnometer and weight it (W1).

•Fill the dry sand in the empty pycnometer and weight it (W2).

•Add the water in that pycnometer up to fully filled and weight it (W3).

•Clean the pycnometer and fully filled with water and weight it (W4).

•Calculate the specific gravity of sand by following formula:

Specific gravity of sand= (W2-W1) /(W2-W1) *(W3-W4)

•Slump cone test be performed to measure the workability of fresh concrete.

•Weight the material by the mix proportion and dry mix properly. Add the water as per w/c ratio and wet mix formed.
•Apply oil on the slump concerned place it on the base plate.
•Fill the mix in the slump cone in three layers and each layer tamped with tamping rod of 25 blows.
•Lift the slump cone properly and measure the height of the slump collapse. That value is the slump value.
•After batching of material, the dry mix of material properly.
•Add the water in the dry mix as per the w/c ratio used.
•The wet mix formed after adding the water in the dry mix.
•This mix be ready for the moulding purpose. Then vibrate the mould after moulding the mix in it.
•It reduces the air voids formed in the paver block after drying.
•The mould is ready and stay it 24 hr. for drying purpose
•After drying, unmould the blocks and take that in lab
•After completion of 7 days compressive test is measured.

5. RESULT

A) COMPRESSIVE STRENGTH

In this test, a paver block specimen is put on compression testing machine and applied pressure till it breaks. The ultimate pressure at which is crushed is taken into account. All three-paver block specimen's average result is taken as paver block's compressive strength.

TABLE 3 – Result of Compressive Strength Test

Compressive Strength	7 Day's (N/mm^2)		14 Day's (N/mm^2)		28 Day's (N/mm^2)	
Normal Mix of cement and sand	36.80	36.57	34.93	37.09	48.90	40.54
	33.68		37.50		36.49	
	39.24		38.85		39.24	
10% replacement of cement and sand	35.52	33.67	35.24	40.82	40.97	43.17
	31.60		41.25		46.87	
	33.90		45.97		41.67	
20% replacement of cement and sand	35.42	36.79	36.28	38.71	42.01	42.09
	38.54		37.15		37.85	
	36.42		42.70		43.40	

B) REBOUND HAMMER TEST

When the plunger of rebound hammer is pressed against the surface of the paver block, the spring-controlled mass rebounds and the extent of such rebound depends upon the surface hardness of paver block. The surface hardness and therefore the rebound is taken to be related to the compressive strength of the paver block. The rebound is read off along a graduated scale and is called as the rebound number or rebound index.

TABLE 4: Rebound Hammer Test

Ratio	Compressive strength	Rebound Number (N_R)	Average of rebound number (N_R)
Normal block of cement and sand	48.90	22	21
	36.49	20	
	39.24	21	
10% replacement of cement and sand	40.97	18	18
	46.87	19	
	41.67	17	
20% replacement of cement and sand	42.01	14	13.66
	37.85	12	
	43.40	15	

3) ULTRASONIC PULSE VELOCITY TEST

Ultrasonic pulse velocity method is a non-destructive test to appraise the quality of concrete. This test is conducted in accordance with IS: 13311 (Part 1) – 1992. The underlying principle involves calculating the time it takes for an ultrasonic pulse to traverse the concrete under examination. A higher velocity is representative of superior concrete quality in terms of density, uniformity, and homogeneity. This convertible Ultrasonic Pulse Velocity test extends its application to the examination of natural rocks and concrete.

TABLE 5: Ultrasonic Pulse Velocity

Ratio	Pulse Velocity (m/sec)
Normal mix of cement and sand	6896.5
10% Replacement of cement and sand	7229
20% Replacement of cement and sand	6767

D)WATER ABSORPTION TEST

In this test, paver block is weighed in dry condition and let them added in fresh water for 24 hours. After 24 hours of immersion, those are taken out from water and clean with cloth. Then, brick is weighed in wet condition. The difference between weights is the water absorbed by brick. The percentage of water absorption is then calculated. The less water absorbed by brick the greater its quality. Good quality brick doesn't absorb more than 20% water of its own weight.

TABLE 6: Water Absorption Test

Ratio	Weight of block after curing (W1) Kg	Weight of block after oven dry (W2) Kg	Water Absorption (%)
Normal mix of cement and sand	3.700	3.750	4
10% Replacement of cement and sand	3.670	3.566	2.91
20% Replacement of cement and sand	3.616	3.486	3.7

6. CONCLUSION

•Water absorption test be less than 20% paver blocks are better. The plastic paver block is so much economical than concrete paver block.
•It has been observed that by replacing 10% cement with fly ash along with waste plastic the workability reduced by 8 % over normal mix.
•It has been observed that by replacing 20% cement with fly ash along with waste plastic the workability reduced by 15 % over normal mix.
•It has been observed that by replacing 10% cement and 10% sand with fly ash and quarry dust respectively along with waste plastic the compressive strength increased by 5 % over normal mix.
•It has been observed that by replacing 20% cement and sand with fly ash and quarry dust along with waste plastic the compressive strength nearly equal to normal mix.
•Water absorption of the 10 % replacing cement and sand with fly ash and quarry dust along with waste plastic be decreased by 27.25 % over normal mix.
•Water absorption of the 10 % replacing cement and sand with fly ash and quarry dust along with waste plastic be decreased by 7.5 % over normal mix.
•The 10 % replacing cement and sand with fly ash and quarry dust along with waste plastic be excellent quality than normal mix.
•The 20 % replacing cement and sand with fly ash and quarry dust along with waste plastic be good quality over normal mix.
•The 10 % replacing cement and sand with fly ash and quarry dust along with waste plastic be less hardened than normal mix.
•The 20 % replacing cement and sand with fly ash and quarry dust along with waste plastic be less hardened than normal mix.

PHOTOGRAPHS OF THE STUDY

Fig 1 – Cement Sieve Test

Fig 2 – Pycnometer Test

Fig 3 – Slump Cone Test

Fig. 4 – Dry Mix of Material

Fig 5 – Vibration of Mould

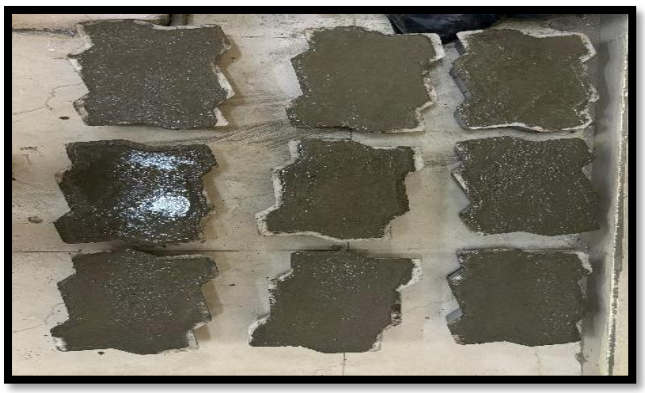

Fig 6 – Moulding blocks

Fig 7 – Pavement Blocks

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