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Experimental Analysis of Green Paver Block using Waste Material

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Abstract: — the concrete industry in India is expanding to meet the demand for systematic and cost-effective construction materials as a result of increased industrialization and urbanization processes. In this research work, we tried to find the replacement of cement and fine aggregate used in conventional concrete paver block, by industrial wastes like fly ash and wood powder, as a huge amount of construction work has been led to the shortage of natural aggregates and also, we all are aware of the harmful carbon emission due to cement construction. Cement was partially mixed with fly ash and sand (specifically the organic content) was replaced with wood powder. The materials were replaced in the proportion of 5%, 8% and 10%. This concrete paver block was made up of M-25 grade and the mix ratio of 1: 1.74: 2.11 was calculated. Three cubes for each percent replacement were prepared, placed in curing for 7, 14, and 28 days, and then different tests like compressive strength tests, slump cone test, etc. were performed. The water-cement ratios required for 5%, 8% and 10% were 0.48, 0.55 and 0.58. The strength found out by testing was found to be sufficient and was similar to the nominal strength of concrete paver block of similar ratio, and hence it is convenient to use. This will solve the problem of shortage of natural aggregates as well as the waste management.

Keywords— Sustainable construction materials; Waste utilization; Green paver blocks fly-ash; wood powder.

1. Introduction

Due to rapid industrialization and urbanization country, the leading challenge for the concrete industry in India is to meet the demand for construction materials that are economical as well as systematic [1]. All of these appeals demand the use of higher-quality concrete while utilizing the fewest resources such as limestone, energy and money and maximizing strength, durability and other intended concrete attributes [2].

As we know that due to cement production a significant amount of CO2 emission is produced and this carbon dioxide emission by industrial and energy sources contributes to 2.4% of total CO2 emission in the world [3]. The demand for paver blocks for use in footpaths, roads, and airfields has been increasing worldwide and due to this, there has been a depletion in the amount of locally available aggregates [4]. In most of the urban areas, most of the number of aggregates has already been used and that leads to a shortage of aggregates, the shortfall has to be done up by bringing in the same from some other locations [5]. We are using waste material as a replacement in our concrete paver block this will help in the conservation of natural resources as well as it will give a better way of waste disposal [6].

Fly ash is easier to work with in cold weather and uses less water than Portland cement. Apart from these advantages of fly ash, we decided to replace it partially due to the following drawbacks [7]. Products made from fly ash might not be well known to small builders and building-and-loans. Fly ash applications may also encounter opposition from conventional contractors due to their tendency to blossom and worries about freezing and thawing [8]. By increasing the replacement rate of sand and wood grain particles to the optimum value of 30%, the workability of mortar has been improved. However, the problem of inhibiting the hydration reaction was revealed by slowing and reducing heat release, leading to a significant reduction in the compressive strength of these mortars. Based on these results, the application choice was based on semi-dry concrete blocks [9].

In our research work, we partially replaced wood flour with fine aggregate and fly ash with cement ratios of 5%, 8%, and 10%. The mould was made in the laboratory and the size was 210mm x 110mm x 60mm [10]. Due to the compound design, the compound ratio is 1: 1.74: 2.11. Three cubes for each per cent replacement were prepared, placed to cure after 7, 14, and 28 days, and then subjected to compressive strength tests. At the same time, we also conducted tests such as water absorption by specific gravity, cement sieving analysis, and slump cone test to confirm workability [11]. The water-cement ratios required for 5%, 8% and 10% were 0.48, 0.55 and 0.58.

Fig1: Concrete Paver Block.

2. Materials And Methodology

II.A. MATERIALS USED

Cement- Cement acts as adhesive material which binds concrete material (I.e., sand and aggregates). Cement is a finely grinded powder which is grey in colour. Calcium silica and marl is used as raw material which is mixed with water. For the production of cement. Generally, cement is used in the form of dry bulk material. To ensure its stability, sustainability, reliability and durability I.S code has specified some parameters. We are using O.P.C.33 grade concrete [12].

Coarse Aggregates- One of the components of the concrete is aggregate which is angular in shape and mixed with the cement. Aggregates act as the body of concrete that provides strength. Aggregates are obtained from natural sources by breaking mountains and rocks into smaller pieces. Compaction of concrete is effectively done with the help of aggregates. The amount of cement and sand can also be effectively reduced by using coarse aggregates. Aggregates also provide internal strength to concrete which helps to make the stable and structure. Approximately 60-70% of the volume of concrete is filled by aggregates [13].

Fine Aggregates- Sand is an important ingredient of concrete. Since the surface of the sand is rough, therefore it easily gets bind with water-cement and coarse aggregates to produce stable and hard concrete. Sand which passes from a 1.18micron sieve has been used to prepare paver block. Sand is an important ingredient of concrete. Since the surface of the sand is rough, therefore it easily get binds with water-cement and coarse aggregates to produce stable and hard concrete. Sand which passes from a 1.18micron sieve has been used to prepare paver block.

Fly ash - Fly ash is a by-product of coal-fired power plants and is a fine, grey powder that is primarily made up of spherical, glassy particles. Ash contains pozzolanic characteristics, which cause it to interact with lime to form compounds that are used to make construction materials. Fly-ash considerably improves concrete performance and additionally provides several advantages in cement and non-cement applications. In our project, we tend to buy the ash from a nearby producing place.(Kumar et al., 2014)

Wood powder- Additionally, the employment of wood as a partial replacement of sand has nice importance within the manufacture of light-weight masonry units. The replacement of fine mixture by wood powder employed in our project was from a wood workshop and it absolutely was a waste matter generated from there.(Singh & Sahu, 2021)

Fig2: Wood powder.

Water- The water used to mix and solidify concrete should be devoid of dangerous substances and surface-objectionable strain. Some portion of mixed water used for hydration of cement whereas remaining portion is used as lubrication between the fine and coarse aggregates so that concrete mix become workable. 0.3 to 0.8 w/c ratios are needed for hydration and extra water act as a lubricant to the mix. The additional water added to mix causes bleeding, less effective bond formation, outpouring

through formwork, honeycomb formation etc. Water cement quantitative relation calculated for five days and 100% were 0.48, 0.55 and 0.58.

II.B. TESTS PERFORMED

1. Fineness modulus test- The Fineness Modulus (FM) is an empirical quantity that can be calculated by summing the percentages of aggregate samples that were retained on each of a given set of sieves, then multiplying the result by 100. Sieve sizes range from 150 microns (No. 100), 300 microns (No. 50), 600 microns (No. 30), 1.18 microns (No. 16), 2.36 microns (No. 8), 4.75 microns (No. 4), 9.5 microns (1/8 inch), 19.0 microns (3/4 inch), 37.5 microns (11/2 inch), and greater, increasing in a 2 to 1 ratio. Therefore, a variety of particle size distributions can provide the same result for the fineness modulus. A lesser value, however, typically denotes a finer aggregate. FM values for coarse aggregates smaller than 38.1 mm vary from 6.75 to 8.00, while FM values for fine aggregates range from 2.00 to 4.00.

An index value called the fineness modulus shows what a particle's typical size is. The sieve analysis test using typical IS sieves is used to calculate it.

2. Slump cone test - A Slump cone test, also known as a concrete Slump test, is used to evaluate the consistency or workability of a concrete mixture that has been created in a laboratory or on a building site.

To ensure that the concrete is of a consistent quality throughout the construction process, a concrete Slump test is carried out on each batch. The Slump test is the simplest and least expensive method of determining if concrete is suitable for use. This has led to its widespread use in workability testing.

3. Compressive strength test- A mechanical test that determines the maximum compressive load that a material can withstand before breaking. A gradually applied load compresses the test item, which often takes the shape of a cube, prism, or cylinder, between the platens of a compression-testing machine. Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates.

The load applied at the point of failure to the cross-section area of the face on which load was applied is the formula for compressive strength for any material.

Compressive Strength = Load / Cross-sectional Area

The paver blocks' average 28-day compressive strength must meet the requirements. The strength of each paver block must be at least 85% of the required strength.

Preparation of Test Sample

In this experiment, we prepared total 4 sample in which each sample have 3 block percentage of waste material was varied from 0%to 10%. 27 This concrete is properly tempered before being placed into the mould, which has dimensions of 200 mm by 100 mm by 100 mm. Moulds are removed after 24 hours, and test specimens are then submerged in water to cure. These specimens' top surfaces ought to be level

and smooth. To accomplish this, apply cement paste evenly throughout the whole surface of the specimen. Each block was placed in curing tank for curing up to 7days, 14days, & 28 days and then compressive strength was checked after curing of each block.

Fig3: Paver Block Mould

Table I: Sampling of Mix

Sample name	%Replaced	Amount of wood powder replaced	Amount of fly ash replaced
S1	5%	2% of total replacement	3% of total replacement.
S2	8%	3% of total replacement	5% of total replacement.
S3	10%	4% of total replacement	6% of total replacement.

3. Results & Discussions

Results obtained by performing different tests on material and paver block are as follows-

A) Results of slump cone-

The slump cone results for different partial replacements of fly ash and wood powder were as follows-

Table II: Slump cone test results.

Samples	% Replaced	Slump (mm)	Type of slump
S1	0	60	Shear
S2	5	56	Shear
S3	8	54	Shear
S4	10	52	Shear

B) Compressive Strength Test Results -

The results of compressive strength for various fly-ash and wood powder substitution percentages were as follows-

Table III: Compressive strength test results.

Sample	Curing period (days)	Compressive strength of concrete in MPa
S1	7	18.25
	14	25.86
	28	28.60
S2	7	15.45
	14	22.23
	28	27.05
S3	7	13.45
	14	20.88
	28	24.90
S4	7	7.5
	14	11.11
	28	15.70

S1, S2, S3 and, S4- Samples with 0%,5%,8% and, 10% replacement.

The strength of paver block tends to decrease with an increase in waste products, although the strength till 10% of replacement is almost similar to the conventional paver block and hence it can be used.

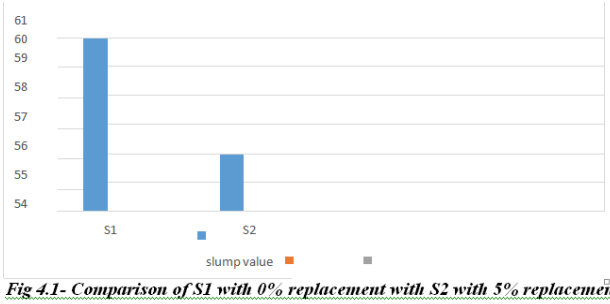

Fig 4.1- Comparison of S1 with 0% replacement with S2 with 5% replacement.

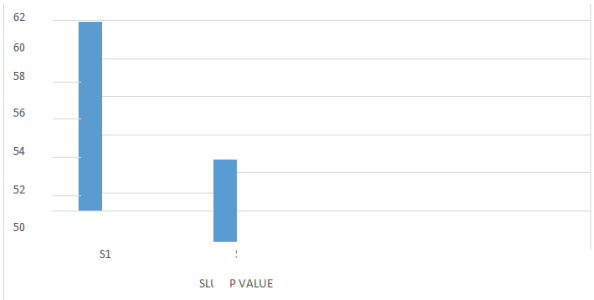

Fig4.2- Comparison of S1 with 0% replacement with S3 with 8% replacement.

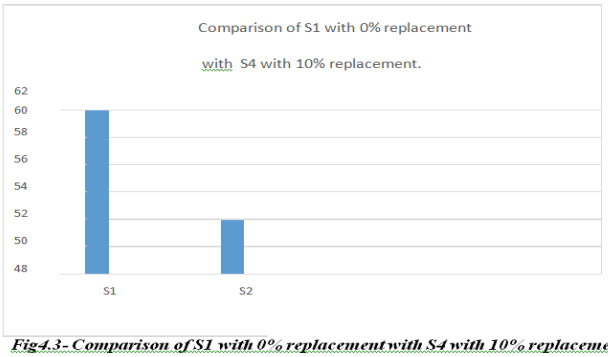

Fig4.3- Comparison of S1 with 0% replacement with S4 with 10% replacement.

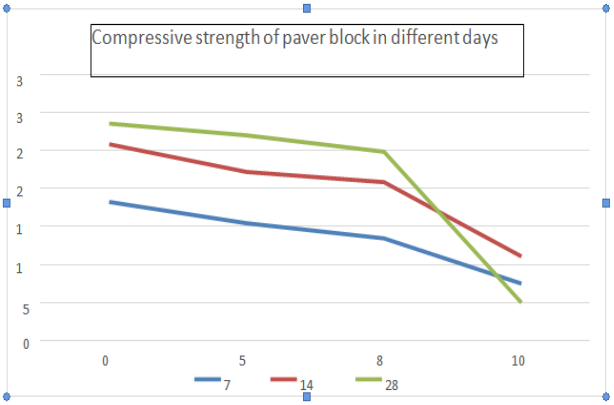

Fig 4.4- Chart representing compressive strength of paver block.

Fig4: Shear Slump

4. Conclusions

The proposed paver block is likewise predicted to be value efficient (powerful) compared to cement concrete paver block power as we're going to use the 0 value, fly ash, and wooden powder. In the proposed paver block as we're the use of mild weight waste fabric like wooden powder, changing heavier cement fabric generating mild weight, clean portable paver blocks. Hence, we're presenting a technique a good way to lessen the dangerous substances inside the surroundings like, fly ash and wooden powder, etc. Also, the compressive power at extraordinary days and proportions finished is identical to that of traditional M-25 grade concrete so it will likely be effortlessly usable in the region in which M-25 grade paver block is used. We also can say with the aid of using the check effects that the alternative as much as simplest 10% is useful because the power has a tendency to lower similarly research may be completed to growth the power of concrete with a better percent alternative. Though wooden powder decreases the power after sure alternative however it additionally reduces the load of paver block, additionally, the water absorption potential appears to grow with growth in the quantity of wooden powder. Therefore, with the aid of using the use of this paver block; we're successful to provide inexperienced technology, sustainable production, and surroundings pleasant product to society.

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