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An Experimental Investigation on Partial Replacement of Cement with Powdered Glass Wastes in Paver Block

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Abstract

There is now a significant world-wide interest to solve the environmental problems caused by industrial waste and other materials by including such materials in the manufacture of concrete. This technology has been introduced in India in construction, a decade ago, for specific requirement namely footpaths, parking areas etc. but now being adopted extensively in different uses where the conventional construction of pavement using bituminous mix or cement concrete technology is not feasible or desirable. The characteristics of concrete containing fine crushed glass during its process, the best ratio of fine crushed glass which leads to higher strength of concrete in order to produce concrete blocks, and the effect of waste glass replacement on the expansion caused by Alkali-silica reaction (ASR). This study looked at the feasibility of waste glass inclusion as partial Cement replacement systems. Properties of concrete incorporating waste glass as partial substitution for Cement amounts of 50% and 60% were investigated. The waste glass material used was obtained waste collectors. The results obtained show clearly that glass enhances the compressive strength properties of the final concrete product. The study indicated that waste glass can effectively be used as Cement replacement with little substantial change in strength.

Keywords: *Cement Replacement, Paver Block, Concrete Technology.*

1. Introduction

Paver is first introducing in European countries in 1925. The reason behind this invention is that the brick pavers were to much less durable and broken easily concrete. A lot of face lift is being is given to roads, footpaths along with roadside. Concrete paving blocks are ideal materials on the footpaths for easy laying, better look and finish. Cement concrete paving blocks are precast solid products made out of cement concrete. The product is made in various sizes and shapes viz. rectangular, square and round blocks of different dimensions with designs for interlocking of adjacent paving blocks.

The raw materials require for manufactures of the product are Portland cement and aggregate which are available locally in every part of the country market potential cement concretes paving blocks find applications in pavements, footpaths, gardens, passengers waiting shed bus Stops, industry and other public places. The product is commonly used in urban areas for the above applications. Hence, the unit may be set up in urban and semi urban areas, near the market. A concrete mix of 1:2:4 (cement: sand: stone chips) by volume may be used for cement concrete paving blocks with water to cement ratio of 0.5. Pavers also give different shape and design for attractive outdoor appearance. Now we are adding the agricultural waste like rice husk ash in the various percentage of to the concrete paver for property enhancement [2]. It takes a lot of minerals, energy, and water to make glass from raw materials. Fortunately, glass can be recycled endlessly without any loss in purity or quality. With the abundance of

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recycled glass, the demand for finely ground glass powder is rapidly increasing in the construction industry. Recycled glass can be turned into countertops, flooring, tile landscaping stones and bricks. For added strength and lower costs, glass powder is being used in cement as an alternative to Portland cement or fly ash. It can also be used to make light-weight aggregates/bricks with chemical resistant properties. Glass is one of the more difficult materials to process as it has a high hardness (Mohs hardness of ~5.5 to 7) and sharp edges upon fracture. Durable, field-proven, equipment and techniques are required for successful glass grinding, especially for ultra-fine milling requirements. For high quality, ultra-fine, glass powder production, Hosokawa Micron Powder Systems offers the Alpine Super-Orion Ball Mill in circuit with an Air Classifier. For glass applications, the ball mill will typically be constructed with hardened, high chrome, steel media and ball mill lining. A second option would be Aluminum Oxide media and lining [3, 4]

2. Literature Review

Dr. G Vijayakumar: The researcher was interested in finding out the mechanical properties like compressive strength and split tensile strength of concrete by replacing cement with waste glass powder. Cement manufacturing industry is one of the carbon dioxides emitting sources besides deforestation and burning of fossil fuels. The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. In order to address environmental effects associated with cement manufacturing, there is a need to develop alternative binders to make concrete. Consequently, extensive research is ongoing into the use of cement replacements, using many waste materials and industrial by products. Efforts have been made in the concrete industry to use waste glass as partial replacement of course or fine aggregates and cement. In this study, finely powdered waste glasses are used as a partial replacement of cement in concrete and compared it with conventional concrete. Glass powder was partially replaced as 10%, 20%, 30% and 40% and tested for its compressive, Tensile and flexural strength up to 60 days of age and were compared with those of conventional concrete; from the results obtained, it is found that glass powder can be used as cement replacement material up to particle size less than 75µm to prevent alkali silica reaction [5].

Tapkire et al. (2010): Investigated Recycled plastic used in the concrete paver block amount of plastic waste more and the problem for their disposal, so waste utilized in the construction industry, plastic waste like plastic bottles, pallets, carry bags: polypropylene (PP) and polyethylene Terephthalate (PET) were as alternative replacements of a part of the conventional aggregates of concrete. 20% Recycled plastic are used in place of aggregates in concrete, which does not affect the properties of concrete [6].

Vaz Aaron et al. (2012): Found that cement concrete is second most consumed commodity in the world someone generated a large amount of carbon dioxide it is responsible for global warming effect. Geopolymer concrete used as an option for OPC in precast concrete products, Geopolymer concrete is an eco-friendly option for waste stabilization. GPC paver blocks have high compressive strength compared to OPC. They also have high early strength gain curing time 24hours at 60°C and OPC is curing 28 days in water so geopolymer concrete used Benefitly in the manufacture paver block [7].

3. Properties of Materials

- Cement
- Fine Aggregate
- Course Aggregate
- Water
- Glass Powder

Cement: Ordinary Portland cement (OPC) is by far the most type of cement. As BIS requires the minimum, compressive strength of 43 grades OPC is 43 Mpa. OPC shared the following usages:

a. P.C.C works
b. Brick works
c. Plastering works etc.,

Fine Aggregate: Manufactured sand is artificial sand obtained from crushing hard stones into small

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sand-sized angular-shaped particles, washed and finely graded to be used as construction aggregate. It is an alternative to River Sand used for construction purposes.

Coarse Aggregate: Coarse aggregate hare massive structure entirely crystalline of wholly, glassy of in combination in between, depending upon the rate at which they were cooled during formation. Aggregates are the important constituent in concrete which reduce shrinkage of the concrete.

Water: Water is an important ingredient of concrete as its activity participated in the chemical reaction with cement. Since it helps to form the strength giving the cement get, the quantity and the quality of water is required to be looked into very careful

Glass Powder: Glass powders can improve the mechanical properties of concrete by the means of pozzolanic activity. It's noteworthy to mention that waste glass powder, with particle size of 100 micrometers or less, exhibits a reactive property similar to pozzolanic reaction in concrete.

Furthermore, in contrast to other industrial byproducts like slag which is obtained from large steel mills and fly ash that obtained from power stations, recycled glass powder offers several advantages as it is more readily available in nearly all urban areas since it is obtained from smaller, localized facilities. Waste glass powder was used successfully as well in producing geopolymer concrete as sand replacement [8, 9].

4. Types of Tests

4.1 Compressive Test

Compressive strength of paver blocks shall be determined. Paver block strength shall be specified in terms of 7 days and 28 days compressive strength as shown in Table 1 and 2. In case the compressive strength of paver blocks is determined for ages other than 28 days, the actual age at testing shall be reported. The compressive strength test, mechanical test measuring the maximum amount of compressive load a material can bear before fracturing. The test piece, usually in the form of a cube, prism, or cylinder, is compressed between the platens of a compression-testing machine by a gradually applied load [10].

Table 1 Results of Compressive Strength Test for Paver Blocks (7 days)

Glass Powder	Maximum Ultimate Load (KN)	Compressive Strength (N/mm2)	Mean (N/mm2)
0%	362.3 361.4	13.17 13.14	13.15
50%	314.4 307 286.5	11.43 11.16 10.41	11
60%	204.8 201.6 196.1	7.43 7.33 7.13	7.29

Table 2 Results of Compressive Strength Test for Paver Blocks (28 days)

Glass Powder	Maximum Ultimate Load (KN)	Compressive Strength (N/mm2)	Mean (N/mm2)
0%	386.7 380.6	14.6 13.84	13.95
50%	481.2 519.5 475.6	17.49 18.89 17.29	17.89
60%	365.6 324.1 360.3	13.29 11.78 13.10	12.7

4.2 Impact Test

Impact test is designed to evaluate the toughness of the paver block or the resistance of the paver block to fracture under repeated impact, as shown in Table 3. It consists of aggregate impact testing machine. The weight of hammer in aggregate impact testing machine is 14kg. During testing, steel plate was used at top surface of the paver block. Blows are applied on each paver blocks till failure occurs. The impact results for 28 days of paver blocks are tabulated below. In impact test we stop the blows once the paver blocks are broken and note the number of blows and find out the value of impact strength [11].

4.3 Water Absorption Test

Tests for water absorption were conducted on paver samples as per Annex C of IS: 15658-2006 [1]. The specimens stored in water for 24 hours at atmospheric temperatures were used for water absorption tests. Specimens for absorption tests

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were taken out of the water and kept aside to dry for one minute. Excess water seen on the specimen was wiped off using clean cotton. After noting down the wet weights, specimens were put in an electric oven with temperature control at 100°C for 24 hours and noted the weights. The specimens were put back in the oven for 2 hours and noted the weight again. These processes were repeated such that two consecutive masses of the same specimen showed a variation within 0.2%. The final mass of every sample was taken in Newton and recorded as the dry weight of the sample, as shown in Table 4 [12].

Table 3 Results of Impact Strength Test for Paver Blocks (28 days)

Glass Powder	Weight of paver block	Impact value (No. of. blows at which specimen fails)	Average
0%	5.074 5.02	3 3	3
50%	4.80 4.87 4.76	4 5 4	4
60%	4.73 4.53 4.62	2 3 3	2.7

Table 4 Results of Water Absorption Test for Paver Blocks (7 Days)

Glass Powder	Weight of which sample fails (A) gm	Weight of Oven sample (B) gm	Water Absorption = (A-B,) ÷B	Average
0%	5.05 5.00	4.80 4.87	0.052 0.026	0.039
50%	4.95 5.03 4.91	4.74 4.93 4.72	0.044 0.020 0.040	0.034
60%	4.72 4.52 4.61	4.52 4.30 4.43	0.044 0.051 0.040	0.045

5. Result and Discussion

Experiment was conducted on concrete prepared by partial replacement of cement by waste glass powder. The waste glass powder was replaced by,50% and 60%. Different tests for materials are conducted to check the suitability of available material. Tests on fine aggregate, coarse aggregate, cement, and waste glass powder was performed. According to mix design every material should possess the same property and same value. The compressive strength test on both conventional and glass powder added concrete was performed on standard compression testing machine. Totally 15 paver blocks were casted, cured and tested.

Conclusion

In this research which is based on the replacement of cement with glass powder in concrete paver blocks. These materials used exhibited good results in compression and water absorption [13, 14]. The results obtained varied based on the percentage of glass powder which was replaced with cement and the optimum result for compression and water absorption of paver block was obtained at 50%. The cost of paver block with the materials used is not very high and will produce highly durable blocks.

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