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Feasibility of Manufacturing Paver Blocks Using Waste Materials

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Abstract:
The issue of increasing demand for building materials has provided a need for sustainable materials to be manufactured with proper waste usage. In this paper, an experimental investigation was carried out on a paver block to study characteristics of Ground granulated blast furnace (G.G.B.S.), Iron fillings & glass fibers. Ground granulated blast furnace (GGBS), Iron fillings, fly ash & glass fibers were used and the effect of their addition on paver block, behavior was studied. Results has given the addition of G.G.B.S., iron & glass fibers increased the compressive strength, flexural strength & water absorption as compared to conventional paper block. For the development of the paver block, G.G.B.S., Iron fillings, Glassfibre is used as a partial replacement of cement & fine aggregate (FA) & coarse aggregate (CA) respectively. The develop product was tested according to the Indian Standards (IS) & the effect of addition of GGBS, iron & glass fiber was tested. The combination of Iron fillings (4%) + Cement (21%) + F.A. (25%) + C.A. (50%) has given the compressive strength of 62.10 MPa & flexural strength 6.2 MPa. Water absorption is 4% which is also within the limit. Hence, the study concluded that the use of above waste materials, as an alternative raw materials for the production of paver block was feasible.

Keywords*: Ground granulated blast furnace (GGBS), paver block, Iron fillings and glass fibers*

Introduction:

When Portland cement is made, it has a major negati ve environmental impact, this is due to the emission of carbon-dioxide during production of Portland cement. Therefore, if quantity of Portland cement is reduced and content of cement is replaced by non-carbon-dioxide producing cementing materials, then the carbon footprints of concrete products will be reduced significantly without affecting the durability & physical characteristics. *Eshmaiel Ganjian et al [1].*

Cementitious components allow cements to be reduc ed in concrete mixes while maintaining and, in some cases, enhancing the properties of strength and dura bility. The pozzolanic materials generate strength pri marily through the reaction of pozzolanic materials b etween the initial hydration of cement.This results in a greater amount of

CaO – SiO2H2O (C – S – H)

formulation, which allows strength and durability to be produced. *Vireen Limbachiya et al [2].* Depending on the marble content of the mixture, the cement content is affected differently by the dry den sity of the blocks after use of waste marbles. As the marble content of the solution increases, the thicknes s decreases as the water content increases. Although the compressive strength decreases in concrete with an increased marble content, after 28 days, the block s provide adequate strength values.Abrasive resistan ce is heavily influenced by their cumulative content of marble. For marblefree control blocks (A0 and B0) the highest abrasion rates are obtained. Cement typ e is also an important factor in stabilizing the block f reezing. *Osman Gence et al [3].*Ternary mixes are a reaction to the monetary and natural strain to lessen the concrete substance of solid clearing squares. The cementitious materials used to supplant Ordinary Portland bond (OPC) were Ground Granulated Blast

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Furnace Slag (GGBS) and Silica flume (SF). The filtering investigation revealed that the higher porousness of blends containing concrete substitutions came about in these blends retaining less leachate, anyway gave fulfilling execution for assurance of leachate to ground sources. *Bennet Jose Mathew et al [4]*.Concrete paver squares were first proposed as a r eplacement for paver blocks in Holland in the fifties, which had become unusual due to the postwar buildi ng growth explosion. Such squares fit as a fiddle in a rectangular layout and had a scale identical to the bl ocks. *Eshmaiel Ganjian et al [5]*. The square shape has developed steadily over the pa st five decades from noninterlocking to incomplete i nterlocking in order to increase interlocking shapes. Consequently, asphalts in which noninterlocking squ ares are used are assigned as Concrete Block Pavem ent (CBP) or noninterlocking CBP, and those in whi ch interlocking squares are used slightly, absolutely or the are designated as ' Interlocking Solid Square Asphalt (ICBP).Using appropriate fine material, the square joints are filled. A suitably planned and devel oped CBP / ICBP provides fantastic performance in areas where customary frameworks have lower admi nistration life due to different land, traffic, ecological and operational constraints.*Masahide Nishigaki et al [6]*. Many number of such applications for light, medium, overwhelming and substantial traffic conditions are at present practically speaking far and wide. Clearing squares have made a quick advance into the development business, and have nearly become the true decision. Most development firms these days lean toward clearing obstructs over pieces, black-top, stone or earth. Large scale manufacturing of clearing squares has marked down their cost, and made it effectively reasonable. With the appearance of clearing square machines, it has gotten much more straightforward to finish their laying.*Tayfun Uygunog et al [7]*.

Table: Specification as per IS 15658: 2006

Sr. No.	Grade of Paver Block	Compressive Strength of 28 Days N/mm^2	Traffic Category	Thickness (mm)
1	M25 Grade	24.88	Non Traffic	40
2	M30 Grade	29.30	Non Traffic	50
3	M35 Grade	34.28	Light Traffic	60
4	M40 Grade	39.68	Medium Traffic	80
5	M50 Grade	50.27	Heavy Traffic	100
6	M55 Grade	55.45	Very Heavy Traffic	120

Materials used:

a) Ground granulated blast furnace (GGBS):

Ground Granulated Blast Furnace Slag (GGBS) is a result of iron making impact heaters. GGBS was acquired by pounding to fine powder the slag of the impact furnace. The smoother texture of the substrate and the polished structure of GGBS particles both increment the functionality.Lower temperature rise in early age, re ducing the chance of hot breakage in giant pours.*Isa mu Yoshitake et al [8]*. Disposal of the risk of harming internal response s, such as ASR. High chloride entry protection, redu cing the risk of consumption of aid.High sulfate and various chemical compounds defense from attack. E xtensive advantages in terms of maintainability. All by itself, ground granulated impact heater slag (GGB S) slowly solidifies and should be started by consoli dating it with Portland bond for solid use.A run of th e mill blend is half GGBS with half Portland concret e, but GGBS rates are generally used anywhere in th e range of 20% and 80%. The higher the GGBS freq uency, the greater the impact on solid properties.*Chu ng-Hsin [9]*

Chemical Composition of GGBS

Chemical presents	Percentage of Chemicals
Silicon dioxide	35 %
Aluminium Oxide	19%
Iron (III) Oxide	0.9%
Magnesium Oxide	9%

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b) Fly ash*:* Ash delivered in little dull specks by the consuming of powdered coal or different materials and conveyed into the air. Minimal effort side-effect of consumed coal. It is gotten from Thermal Power plant.*Aaron Darius Vaz et al [10].*While suspended in the fumes gasses, fly ash m aterial hardens and is collected by electrostatic preci pitators or channel sacks. Because the particles ceme nt quickly while suspended in the fumes, fly ash part icles are usually circular fit as a fiddle and range fro m 0.5 μm to 300 μm in size.Fly ash is therefore a het erogeneous material. SiO2, Al2O3, Fe2O3 and soma nytimes CaO are the main components of fly ash.

c) Glass fibres: Glass fiber (or glass fiber) is a material comprising of various incredibly fine strands of glass. Glassmakers from the beginning of time have explored different avenues regarding glass strands, yet mass production of glass fiber was just made conceivable with the creation of better machine tooling.*Serrano-Guzman et al [11]* The benefit of fiberglass is that it could be effectively be formed into any shape, has mechanical quality that is so solid and firm for its weight that it can out-perform a large portion of different materials. Fiberglass keep going quite a while, it tends to be hued, sparkly or dull. It is low upkeep, hostile to attractive, heat proof, great electrical protector and weatherproof.

The obstacles are that it should be covered by regel a t regular intervals and can lead to airborne filaments that could pose a problem for asthma sufferers.*P.R.K annanRajkumar[12].*Required gaps around lights an d electrical boxes decrease viability, lose adequacy when isolation is wet or damp and disturbance durin g establishment.

d) Iron Fillings:

Iron is an element of concoction with the Fe picture and the 26th nuclear number. It is a metal in the arra ngement of primary growth. It is by mass the most w elknown component on Earth, forming the outer and inward core of Earth quite a bit. It is the fourth most normal component in the Earth's outside layer. Unadulterated iron is a gleaming white metal that is anything but difficult to work and shape and it's sufficiently delicate to slice through (with a lot of trouble) utilizing a blade. You can pound iron into sheets and bring it into wires *Bhavin K. Kashiyani* et al [13]. Like most metals, iron behaviors power and warmth quite well and it's extremely simple to charge. The explanation we so once in a while observe unadulterated iron is that it consolidates promptly with oxygen (from the air). To be sure, iron's significant disadvantage as a development material is that it responds with soggy air (in a procedure called consumption) to shape the flaky, rosy darker oxide we call rust. Iron responds from various perspectives as well—with components going from carbon, sulfur, and silicon to incandescent light, for example, chlorine. Strong when contrasted with other auxiliary materials. Most flexible material that can be utilized for an assortment of purposes by engineers.Fe can be rebuilt through manufacturing, welding and so on. Iron are modest when contrasted with others.*Poon, C. S. [14]*. They are penny percent recyclable. It is accessible in plenitude. It is modest. In designing, cost is ALWAYS an issue. Ferrous composites are among the most practical amalgams to use.Fe is 100% recyclable. Consumes effectively. Excessively substantial because of high thickness. Fe's thickness is half Ti's and is just about five times higher than Al. There is a reason behind why in aviat ion aircraft there is not a lot of Metal. It consumes effectively. Since Fe is anything but difficult to change over from metal to local metal, it is anything but difficult to transform again into oxide, which it truly needs to do. A great deal of time, vitality, and cash are gone through consistently by individuals attempting to ward Iron and Steel from rusting off. It is an endless fight.

Tests performed on raw materials

a) (XRF) Spectrometry

X-beam fluorescence (XRF) spectrometry is a non-dangerous strategy utilized for substance investigation of materials. This technique is across the board in fields like plastic, polymer, oil, metal, concrete, mining, glass, pottery, topography, drug store, examine and so forth., because of its precise

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and quick attributes. A Philips PW 1840 XRF spectrometer was utilized for compound examination. The outflow of fluorescent (or auxiliary) X-beams from an example which has been energized through the assault of high vitality X-beams. *D. Wattanasiriwech [15]*. The synthetic or natural organization of the example is demonstrated by vitality/wavelength/shade of the fluorescent photons. The power of this fluorescent pillar i.e., various photons discharged every second gives the convergence of the component in the example. The point of the spectrometer is to gauge and break down this fluorescent shaft. Spectrometer is combined with programming which measures this data into focus' qualities.

b) Specific Gravity

As given in IS 1727: 1967 [61], kerosene volume displacement method is used for the evaluating the specific gravity. Specific gravity is defined as the weight of raw material to the weight of equal volume of known substance. The apparatus used is Le Chatelier flask as shown in Figure.

Figure: Le Chatelier flask

First, the kerosene is filled in flask up to a marked level. Then the flask is immersed in water bath, until the liquid inside the flask achieves a temperature of 0.2 less or more. Then those readings are noted in terms of ml of water. Know weight of ash is then laid into the flask ensuring any bubbles formed are removed. Then again, flask of ash was immersed in water bath and the reading in 0 terms of ml is noted. This variation of two reading is noted as volume displaced. From the above known data and formula below, the specific gravity can be calculated.

c) Particle Size Distribution

The particle size distribution of fine and coarser particles was used to determine the grading of materials proposed for use as aggregate or a binder. The material to be sieved is subjected to various sieve set. This set is the placed-on sieve shaker. The particles bounce and tumbles and shaker turn the particles to different orientation. The known and smaller volume of material is laid so that all particles have the opportunity to reach the sieve openings.*Kumar, A. et al [16]*. The sieving material is the dry sample, measure pan and tare weight, measure pan and sample weight, select sieves based on fineness of material, agitate sample in sieves, measure and record. The sieves are arranged in decreasing order of openings. The amount of material on each sieve are recorded and the graph is plotted for percentage passing of sieve against the diameter of particle. The fineness modulus was also calculated.

d) Mineralogical Characteristics

Xray diffraction is a method for studying the emiss ion of Xrays from crystalline materials. Each mater ial creates a specific X-ray "fingerprint" of X-ray strength versus dispersal angle characteristic of its crystalline atomic structure.

By comparing the XRD pattern of an unknown mat erial with a library of known patterns, ualitative an alysis is possibl.It is possible to describe about 95 percent of all solid materials as crystalline. One get s a diffraction pattern when Xrays interact with a cr ystalline substance (phase).Therefore, a pure substa nce's Xray diffraction pattern is like a substance's fi ngerprint. Therefore, the process of powder diffract ion is ideally suited for characterizing and distingui shing polycrystalline phases.Approximately 50,000 inorganic and 25,000 organic single parts, crystalli ne phases and diffraction

patterns are collected and stored as standards on m agnetic or optical materials.The primary use of po wder diffraction is

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to use a search / match technique to classify compo nents in a sample.*B. Carrasco (2014) [17].*

f) Concrete paver block

Test results conducted on concrete paver blocks are presented. The tested properties were compressive strength, flexural strength and water absorption. Maximum compressive strength for the paver block achieved was 62.10 MPa. As per standard IS 15658, the developed concrete paver block classifies for the road application of light traffic. As well as, the water absorption was within the specified limits (<6%) as per IS 15658. Hence, 4% Iron fillings inclusion as a replacement was found feasible in the development of concrete paver blocks.

Result:

Sr. No	Grade of Concrete	Material Used	Material Combination	Water absorption (WA) (%)	Compressive Strength(CS) (N/mm^2)	Flexural Strength (FS)(N/mm^2)
1.	M25	Fly Ash (7.5%) + Slag (7.5%) (Naman Industry, MIDC Nagpur)	Cement 10% + + FA (25%) + CA (50%)	2.87	26.23	4.76
2.	M25	Iron fillings (4%)	Cement 21% + F.A. 25% + C.A.50%	4.25	62.10	7.23
3.	M25	Fly ash (15%) + Iron fillings (2%)	Cement 6%+ FA 25%+ C.A 50%	3.20	45.19	6.28
4.	M25	GGBS (10%) + Fly ash (10%) + Iron fillings (2%)	Cement 3%+ FA 25% + C.A.50%	2.98	25.22	5.49
5.	M25	GGBS (8.75%) + Iron fillings (2%)	Cement 14.25 % + FA 25 %+ C.A 50%	3.94	48.45	4.22
6.	M25	GGBS (12.5%) + Fly ash (7.5%) + Glassfibre (0.2%)	Cement 5% + FA 25% + C.A 49.8%	2.80	20.36	5.06
7.	M25	GGBS (7.5%) + Iron fillings (2.5%) + Glass fiber (0.2%)	Cement 15% + FA 25%+ C.A 49.8%	4.08	51.78	6.33
8.	M25	Fly ash (15%) + Iron fillings (2%)	Cement 6%+ FA 25%+ C.A 50%	3.90	50.25	5.89

Graphical Representation of Results:

a) Strength Characterisation of paver Block

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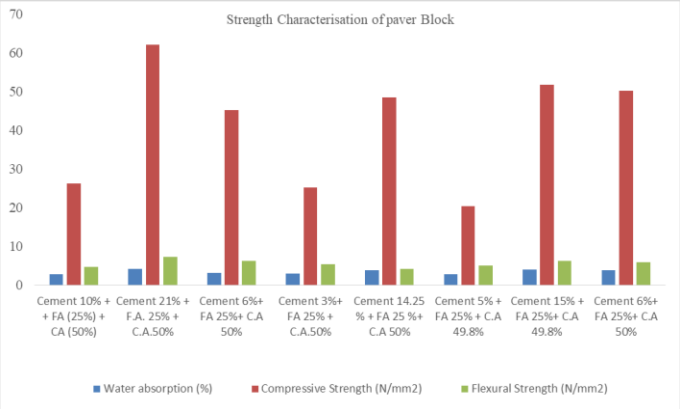
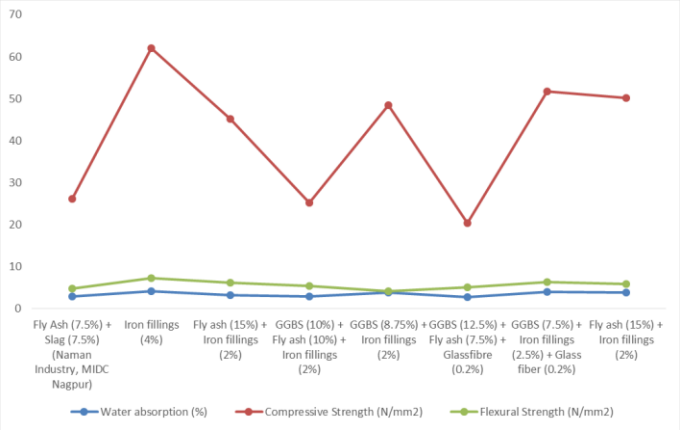


b) Strength Characterisation of paver block by materials used.



CONCLUSION

It has been found that….

- Maximum compressive strength & flexural strength of Paver block was found at *62.10 MPa & 7.23 MPa* at (*21% Cement & 4% Iron fillings)*, which is very high, can be used for very heavy traffic.

- It has been observed that there is decrease in compressive strength of paver block by using the combination of GGBS (12.5%) + Fly ash (7.5%) + Glassfibre (0.2%), therefore this combination of materials is not suitable for casting of paver block.

From the above results, compressive strength of paver blocks has been increased by addition of materials like Iron filling, Glass fiber etc. Also cost of construction is minimize by adding of waste materials like GGBS & fly ash. By addition of iron filling in paver block compressive strength is increased upto 20-40% as compared to conventional materials.

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