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Investigation of Geopolymer Paver Block using Plastic Waste

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Abstract - The Paver blocks have been in use since many years. Due to rapid infrastructure development the necessity of cement is increasing day by day and it emits large amount of co^2 which leads to global warming. The other major engineering trouble today with more stringent environmental law is disposing the solid waste. Today research has combined with waste management leading to an eco-friendly product called geopolymer mortar and concrete. Recently the research is to develop alkali activated fly ash which is complete alternate to conventional cement. Fly ash, aggregate from of sodium hydroxide were mixed together then, distilled water were added to form alkaline solution. Similarly, High Density Polyethylene plastic waste was added to mix in the volume of concrete. Based on test results, it was observed that geopolymer paver blocks using plastic waste have higher strength then OPC pavers, and it can be sun light –cured

***Key Words*: Geopolymer paver block, plastic waste, M-sand, fly ash, super plasticizer(Conplast SP430), sodium hydroxide, sodium silicate, compressive strength.**

1. INTRODUCTION

Ordinary Portland cement (OPC) is most widely used concrete material. But the amount of carbon dioxide released during the manufacture of OPC due to calcinations of lime stone and burning of fossil fuel is in the order of 600kg for every ton of OPC produced. It has high heat of hydration as compared to geo-polymer concrete. Fly ash is mainly produced from coal-fired electric and steam generating plants. Therefore there is a need to find another type of binders to produce more environmentally friendly concrete. A promising alternative is the replacement of cement with by product material such as fly ash. Disposal of plastic waste in environment is measured to be a big problem due to its very low biodegradability and occurrence in large quantities. The waste plastic could reduce the weight by 2–6% of normal weight concrete.

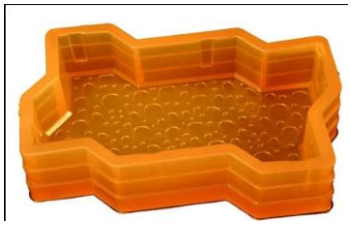
In the late 1970's, Joseph Davidovits, the creator and developer of geopolymerization, coined the term "geopolymer" to classify the newly discovered geosynthesis that produces inorganic polymeric materials now used for a number of industrial applications. He also set a logical scientific terminology based on different chemical units, essentially for silicate and aluminosilicate materials.

1.1 Paver Block

Block paving is one type of brick made with made with concrete, but instead of used in the wall it is used for external flooring and road work. Generally, concrete paver block has one smooth face and one rough, although some paving blocks so come with reversible surfaces (can be used both sides). The long-lasting performance of paving blocks make it suitable for the heaviest duty applications, able to support substantial loads and resist shearing and braking forces.

It is also recognized as Interlocking paver blocks have been extensively used in a number of countries for quite some time as a specialized problem-solving technique for providing pavement in areas where traditional paving systems are less durable due to many operational and environmental constraints. A Concrete paver block first used in Holland in the 1950s as the replacement of paver bricks which had become popular then onwards due to its large scale application scope. Paver blocks are rectangular in shape and had more or less the same size as the bricks. The last five decades are extremely noticeable the paver block and the block shape has steadily evolved from non-interlocking to partially interlocking to fully interlocking to multiply interlocking shapes.

Concrete paving includes connecting small piece, solid un-reinforced pre-cast concrete paver blocks lay on a thin, compacted bedding material which is constructed over a properly designed base course and is fixed by edge restraints/curbs stones. The gap left between the paver block is then filled using suitable fine material. A properly designed and constructed interlocking paver blocks gives excellent performance when applied at locations where conventional systems have lower service life due to a number of geological, traffic, environmental and operational constraints. There are different uses for light, medium, heavy and very heavy traffic conditions are currently in practice around the world.



2. MATERIALS

2.1 Fly ash

Fly ash is an inorganic, non-combustible by product of coal burning power plants. As coal is burnt at high temperatures, carbon is burnt off and most of the mineral impurities are carried away by the flue gas in form of ash. Fly ash is pozzolanic material possesses on cementitious value but which will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties. In the presence of moisture, alumino-silicates within the fly ash react with calcium ions to form calcium silicate hydrates. In today's construction world, there is an increased pressure to use higher levels of fly ash in concrete is due to three main aspects.

The first feature is economics. In most markets fly ash is less expansive than Portland cement. Therefore, as the replacement level of fly ash increases, the cost to produce concrete decreases. The second aspect is the environment. Fly ash is an industrial by-product, much of which is deposited in landfills if not used in concrete. From environmental perspective, if more fly ash is used in concrete, the demand for Portland cement will decreases in the less production of Portland cement, and therefore lowering the CO_2 emissions.

2.2 fine aggregate

Quarry dust consist on finely crushed rock, processed by natural or mechanical means, containing minerals and trace elements widely used in organic farming practices. The crushed sand is cubical shape. The sand size is less than 4.75 mm. in this used of sand is zone-II.

Table.1. properties of fine aggregate

SI.NO	PROPERTIES	VALUES
1	Specific gravity	3.16
2	Fineness modulus	3.2

2.3 Coarse aggregate

Crushed granite aggregate particles passing through 6.3 mm and retaining on 4.75 mm IS sieve used as natural aggregate which met the grading requirement.

Table.2. properties of coarse aggregate

SI.NO	PROPERTIES	VALUES
1	Specific gravity	2.36
2	Crushing strenth	24.4%

2.4 Alkaline solution

Generally alkaline liquids are prepared by mixing of the sodium hydroxide solution and sodium silicate at room temperature. When the solution mixed together both solution start to react i.e (polymerization takes place) it liberates large amount of heat so it is recommended to leave it for about 24 hours thus the alkaline liquid is get ready as binding agent sodium-based solution were chosen because they were cheaper then potassium-based solution. The sodium hydroxide solids were either a technical grade in flakes form (3mm), with a specific gravity of 2.130 with 98% purity, the sodium hydroxide(NaOH) solution was prepared by dissolving either the flakes or the pellets in water. The mass of NaOH solids in a solution varied depending on the concentration of solution expressed in term of molar, M for instance, NaOH solution with a concentration of 8M consisted of 8x40 =320 grams of NaOH solids per liter of solution, where 40 is the moleculer weight of NaOH . The mass of NaOH solids was measured as 262 grams per kg of NaOH solution of 8M concentration. Similarly, the mass of NaOH solids per kg of the solution for other concentration were measured as 10M: 314grams, 12M:361 grams,14M:404 grams and 16M:444 grams. Note that the mass of NaOH solids was only a fraction of the mass of the NaOH solution and water is the major component. The chemical composition of the sodium silicate solution was Na2O=14.7%,SiO2=29.4%, and water 55.9% by mass. The other charecteristics of the sodium silicate solution were specific gravity=1.53g/cc.

Sodium hydroxide

Generally the sodium hydroxide are available in solid state in the form of pellets and flakes as shown in figure. The cost of sodium hydroxide is mainly varied according to the purity of the substance. Since our geopoymer concrete is homogeneous material and its main process to activate the sodium silicate it is recommended to use lowest cost i.e. up to 94% to 96% purity. In this investigation the sodium hydroxide pellets in 14 molar concentration are used

Fig -1: Sodium hydroxide

SODIUM SILICATE

Sodium silicate, shown in figure is the common name for a compound sodum metasilicate, Na2siO3, also known as water or liquid glass. It is available in aqueous and in solid form and is used in cement, passive fire protection, refractories, textile and lumber processing, and automobile sodium carbonate and silicon dioxide react when molten to form sodium silicate and carbon dioxide. In present investigation aqueous sodium silicate solution used.

Fig -2: Sodium silicate

2.5 Conplast SP430

Conplast SP430 has been used where a high degree of workability and its retention are likely or when high ambient temperature cause rapid slump loss. It facilitates production of high quality concrete. Figure shown the conplast SP430 which was readily available super plasticizer.

Fig -3: Conplast SP430

2.6 High-density polyethylene plastic waste

HDPE is the number 2 plastic. It is sturdy and commonly used in jugs for milk or laundry detergent and bleach bottles. Its toughness makes it difficult to tear and helps it resist bursting. It can be made translucent or opaque. Colored HDPE containers tend to have greater strength than see-through bottles and jugs made from HDPE. The opaque, colored plastic resists cracking or corrosion, which makes it a good receptacle for detergents and household cleaners. It is a food-grade plastic that is safe for storing perishable goods such as milk, but it is not designed for long-term food storage. It is difficult to remove odors and residues from high-density polyethylene. HDPE is relatively inexpensive to make and can be easily recycled. Recycled HDPE plastic is used to make many products such as toys, soda bottles, trash cans, traffic cones and plastic "lumber" for decks and outdoor furniture.

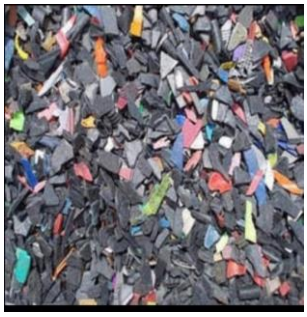


Fig -4: HDPE Plastic waste

3. MIX DESIGN

M_{40} Mix proportions

Weight of fly ash = 1.50 kg

Weight of fine aggregate = 1.54 kg

Weight of coarse aggregate = 1.62 kg

NaOH = 0.3 kg

Na_2SiO_3 = 450 ml

Conplast SP430 = 15 ml

For 20 % of plastic = 0.3 kg

For 25 % of plastic = 0.375 kg

For 30 % of plastic = 0.45 kg

For 35 % of plastic = 0.525 kg

4. RESULT AND DISCUSSION

COMPRESSIVE STRENGTH TEST

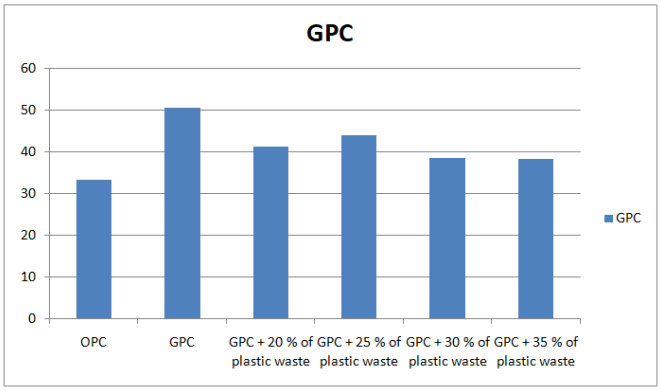
Higher compressive strength when heat activated .slag addition improves compressive strength at ambient temperature curing compressive strength of GPC decreased with increasing fly ash content. it increased with higher aggregate content higher strength at lower alkali content compressive strength increased with age.

Table.3. compressive strength

S.No	Concrete mix proportion	Sample-1 (N/mm^2)	Sample-2 (N/mm^2)	Average (N/mm^2)
1	OPC	33.7	32.6	33.15
2	GPC	49.79	51.27	50.53
3	GPC + 20 % of plastic waste	40.91	41.30	41.10
4	GPC + 25 % of plastic waste	44.18	43.6	43.89

5	GPC + 30 % of plastic waste	35.67	36.19	38.43
6	GPC + 35 % of plastic waste	32.69	34.83	38.26

Fig -5: compressive strength chart



WATER ABSORPTION TEST

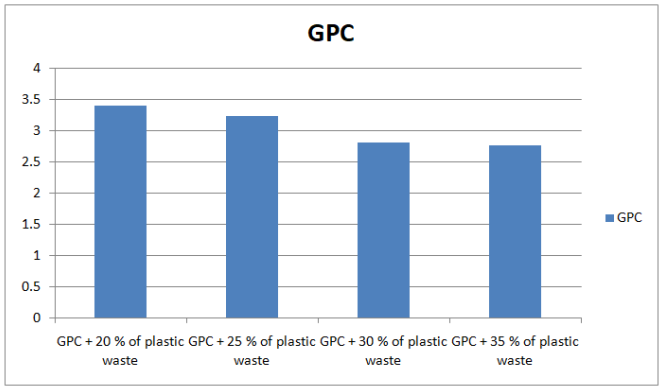
Determine the amount of water absorbed under specified conditions. Factors affecting water absorption include type of plastic, additives used temperature and length of exposure. The data sheds light on the performance of the material in water or humid environments.

As per IS 15658:2006, 24 hours water absorbtion should be less then 7%. The water absorbtion for GPC paver blocks are very less.

Table.4. water absorption

S.No	Concrete mix proportion	Water absorption %
1	GPC + 20 % of plastic waste	3.4
2	GPC + 25 % of plastic waste	3.23
3	GPC + 30 % of plastic waste	2.8
4	GPC + 35 % of plastic waste	2.76

Fig -6: water absorption chart



CONCLUSIONS

Based on the experimental investigation conducted on geopolymer concrete paver block test result obtained the following conclusion were drawn.

- The paper presents brief details of geo polymer concrete using sustainable material
- Higher concentration of sodium hydroxide solution and plastic waste used results in higher compressive strength of fly ash and quarry dust based geopolymer concrete.
- Compressive strength test were conducted such as geopolymer concrete paver block using plastic. Paver block are casted in various proportions likes(20%, 25%, 30%, 35%) using plastic waste. compared with the all proportions in 20% of using plastic waste give more strength.
- The plastic waste using paver block is compared to conventional paver block for 5% weight less.

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