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EFFECT OF RECYCLED AGGREGATES IN ALKALI-ACTIVATED DUMBLE SHAPE PAVER BLOCKS USING FLYASH

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Abstract : Drastic growth in Demolition waste projects in India, there is tremendous amount of Construction Demolition Waste generated by milling and digging of existing demolition waste. Even though CDW gets recycled in new demolition waste, there is still large volume of this material that gets downgraded, especially in urban areas. Therefore, there is a need to effectively utilize the unused CDW in construction industries. The ultimate goal of the present study was to wider the current knowledge about the Construction Demolition Waste as aggregates in alkali-activated concrete paver blocks. The geopolymer paver blocks were then made and tested for compressive strength, dimension, water absorption and aspect ratio. The result was observed that the compressive strength of the blocks increases with increase in Molarity of Alkali solution. The water absorption was within limit. The results for dimensions and tolerances along with the limitations for length, width, and thickness are within the tolerance limits as per IS 15658–2021.

***IndexTerms* - Construction Demolition Waste, Fly ash, Alkali Activated, M-sand**

I. INTRODUCTION

Ordinary Portland cement (OPC) is most widely used in construction industries as binding materials. During the manufacture of OPC enormous amount of carbon dioxide released. Therefore there is a need to find new binders to produce more environmental friendly concrete. A hopeful alternative is the replacement of cement with by product material such as fly ash. In this study Alkali activated binder is used as an alternative for conventional cement. Alkali activated binder is formed through the reaction between alumina-silica materials and alkaline activators. The environmental benefits of using Alkali activated binder as a substitute for OPC include reducing CO2 emission up to 80%, minimizing raw material extraction. Every day a huge quantity of construction waste is produced in the construction field. Construction waste is mainly composed of concrete waste. The most common method of managing waste is through its disposal in landfills creating in that way huge deposits of waste. In this situation, recycling has the potential to reduce the amount of waste put into landfills and to preserve natural resources. Concrete paver blocks have recently developed as the most attractive and economically viable option for extensively recycling wastes. Block paving is one type of brick made with concrete, but instead of being used in the wall it is used for external flooring and road work. In this project, dumble shaped interlocking paver blocks for pedestrian traffic are produced using concrete waste aggregates as a replacement for fine aggregates (M-Sand) with fly ash based alkali activated binder. The test specimens are going to be evaluated for the mechanical and durability properties such as dimensions, tolerance and thickness of the wearing layer, water absorption, compressive strength, split tensile strength. The effectiveness of alkali activated binder is going to be addressed.

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II.MATERIAL METHODS

2.1 Flyash Material: Fly ash is one of the numerous substances that cause air, water and fossil pollution, disrupt ecological cycles and set off environmental hazards. The combustion of powdered coal in thermal power plant produces fly ash. The high temperature of burning coal Aluminium silicate. Fly ash produced thus possesses both ceramic and pozzolanic properties. When pulverized coal is burnt to generate heat, the residue contains 80 percent fly ash and 20 percent bottom ash. The ash is carried away by flue gas collected at economizer, air pre-heater and ESP hoppers. Clinker type ash collected in the water-impounded hopper below the boilers is called bottom ash. The World Bank has cautioned India that by 2015, disposal of coal ash would require 1000 square kilometers or one square meter of land per person. Since coal currently accounts for 70 percent of power production in the country, the bank has highlighted the need for new and innovative methods for reducing impacts on the environment. The process of coal combustion results in fly ash. The problem with fly ash lies in the fact that not only does its disposal require large quantities of land, water, and energy, its fine particles, if not managed well, by virtue of their weightlessness, can become airborne. Such a huge quantity does pose challenging problems, in the form of land usage, health hazards, and environmental dangers. Both in disposal, as well as in utilization, utmost care has to be taken, to safeguard the interest of human life, wild life, and environment.

2.2 Recycled Coarse Aggregate: The usage of construction and demolition wastes as an aggregate for the manufacture of concrete is considered in new research studies. The usage of construction and demolition waste aggregates helps in reducing the depletion of natural aggregates and problems related to mining the aggregates. It is found that the quality of natural aggregates is better compared to the construction and demolition waste aggregates. Thus, demolition waste aggregates have limited usage. But the reduced cost of manufacture of concrete with the help of construction and demolition waste aggregates must be gained appreciation. The rule over the reduction of disposal of demolition waste has prompted the usage of CDW as construction aggregates. The life cycle of construction materials can be made more performing with the help of recycled construction demolition waste. There is government laws and regulation that are put forward to increase the use of recycled construction demolition waste material. This has made the recycling amount of construction and demolition waste material by an amount of 90%.

2.3 Fine Aggregate: Manufactured sand (M-Sand) is a substitute of river sand for concrete construction. Manufactured sand is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word. Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of M-Sand is its availability and transportation cost. Since manufactured sand can be crushed from hard granite rocks, it can be readily available at the nearby place, reducing the cost of transportation from far-off river sand bed. Thus, the cost of construction can be controlled by the use of manufactured sand as an alternative material for construction. The other advantage of using M-Sand is, it can be dust free, the sizes of m-sand can be controlled easily so that it meets the required grading for the given construction.

2.4 Sodium Silicate: Sodium silicate is a generic name for chemical compounds with the formula Na2xSiyO2y+x or (Na2O) x· (SiO2) y, such as sodium metasilicate Na2SiO3, sodium orthosilicate Na4SiO4, and sodium pyrosilicate Na6Si2O7. The anions are often polymeric. These compounds are generally colorless transparent solids or white powders, and soluble in water in various amounts. Sodium silicate is also the technical and common name for a mixture of such compounds, chiefly the metasilicate, also called water glass, water glass, or liquid glass. The product has a wide variety of uses, including the formulation of cements, passive fire protection, textile and lumber processing, manufacture of refractory ceramics, as adhesives, and in the production of silica gel. The commercial product, available in water solution or in solid form, is often greenish or blue owing to the presence of iron containing impurities. In industry, the various grades of sodium silicate are characterized by their SiO2:Na2O weight ratio (which can be converted to molar ratio by multiplication with 1.032). The ratio can vary between 1:2 and 3.75:1. Grades with ratio below 2.85:1 are termed alkaline. Those with a higher SiO2:Na2O ratios are described as neutral.

2.5 Sodium Hydroxide: Sodium hydroxide, also known as lye and caustic soda, is an inorganic compound with the formula NaOH. It is a white solid ionic compound consisting of sodium cations Na+ and hydroxide anions OH. Sodium hydroxide is a highly caustic base and alkali that decomposes proteins at ordinary ambient temperatures and may cause severe chemical burns. It is highly soluble in water, and readily absorbs moisture and carbon dioxide from the air. It forms a series of hydrates NaOH·nH2O. The monohydrate NaOH·H2O crystallizes from water solutions between 12.3 and 61.8 °C. The commercially available "sodium hydroxide" is often this monohydrate, and published data may refer to it instead of the anhydrous compound.

2.6 Properties of materials

S.No	Properties	Specific gravity	Fineness of cement	Standard consistency	Sieve analysis	Impact tesy	Crushing strength
1	Cement	3.21	0.85	30%	-	-	-
2	Fly ash	2.63	-	-	-	-	-
3	M-sand	2.63	-	-	2.93	-	-
4	Recycled aggregates	2.74	-	-	-	54%	50.28%

2.7 Mix Proportion

TRIAL	Molarity (kg)	Fly ash (kg)	Cement (kg)	NaOH (ml)	$Na_2 SiO_3$ (ml)	River sand (kg)	m-sand (kg)	Coarse recycled aggregates (kg)
CPB	-	-	3.47	-	-	5.94	-	10.93
GPC6	6M	3.90	-	240	734.4	-	7.41	8.26
GPC8	8M	3.90	-	320	979.2	-	7.41	8.26
GPC10	10M	3.90	-	400	1224	-	7.41	8.26
GPC12	12M	3.90	-	480	1468.8	-	7.41	8.26

III. RESULTS AND DISCUSSION

3.1 Water absorption test

The test was carried out after 24 hour of being immersed in water and calculated the water absorption percentage. Water Absorption results of various mixes are given in Table. The water absorption test of Alkali activated dumble shaped paver blocks was done as per IS 15658: 2006. Water Absorption results of various mixes are given in Table 3.1. The results were found to be in the range of 2.74 to 5.48%. Pavers made of Molarity M12 were observed to have lower water absorption but slightly higher than control specimen.

Table 3.1 Water Absorption of PCCPB and GPC paver blocks

Specimens	Water absorption %
CPB	2.74
GPC6	5.48
GPC8	4.33
GPC10	3.10
GPC12	2.85

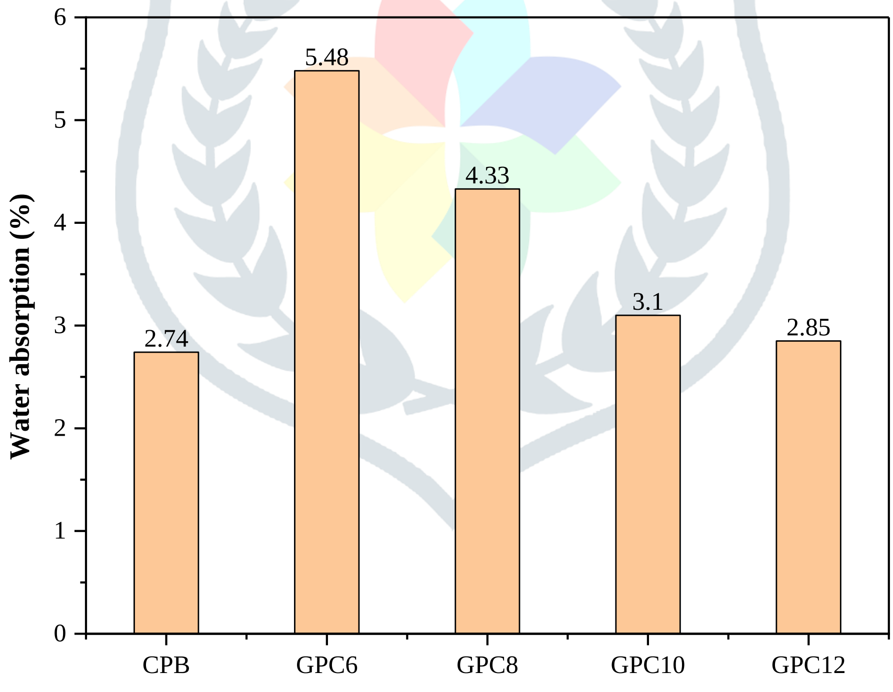

Figure 3.1 Water Absorption of PCCPB and GPC paver blocks

3.2 Visual Inspection, Dimensions and Tolerances

A visual evaluation of the quality of the paving blocks was conducted in natural daylight. The blocks were set out on a level floor in a chosen paving pattern, covering area of one square meter. The visible faults in paving blocks such as cracks and flaking were recorded by inspecting the paving blocks from a distance of approximately one metre. The observation revealed that all GEOPAV blocks were free of cracks and defects and showed high quality in finish and appearance.

Aspect ratio (ratio of overall length to thickness) should be less than 3.

The dimensions and tolerances of the pavers influence the structural efficiency of paving blocks. The maximum difference of + 1 mm in length was observed for GPCM8 and GPCM10.

The maximum decrease - 1 mm in length was observed for GPCM6. Similarly, the maximum difference of + 1 mm was observed in width for GPCM6 and a maximum difference of + 1 mm in thickness was observed for GPCM10, GPCM12 and + 2 mm in thickness was observed for GPCM6. The obtained result for all mix types was found to be within the tolerance limits. Table presents the details of results for dimensions and tolerances along with the limitations for length, width, and thickness as per IS 15658–2021.

Table 3.2 Dimensions tolerances and aspect ratio of conventional and GPC Paver block.

Mix type	Length (L, mm)	Width (W, mm)	Thickness (T, mm)	Aspect ratio (L/T)
CPB	200	160	80	2.5
GPC M6	199	161	82	2.43
GPC M8	201	160	80	2.51
GPC M10	201	160	81	2.48
GPC M12	200	160	81	2.46

Tolerances as per IS 15658–2021 for length and width = ± 2 mm, for thickness = ± 3 mm

3.3 Compressive Strength Test

Compressive strength of alkali activated blocks was tested as per the procedure mentioned in IS code. The paver blocks were cast with 6M, 8M, 10M and 12M of NaOH with replacement of coarse aggregate by recycled coarse aggregate. The compressive strength of a concrete was measured at 28 days. The compressive strength of blocks is observed to be increasing with the increase in molarity of the alkaline activator.
The compressive strength resulted as high as 48.91 N/mm^2 for GPCM12 and resulted lowest value of 45.13 N/mm^2 at 28 days.

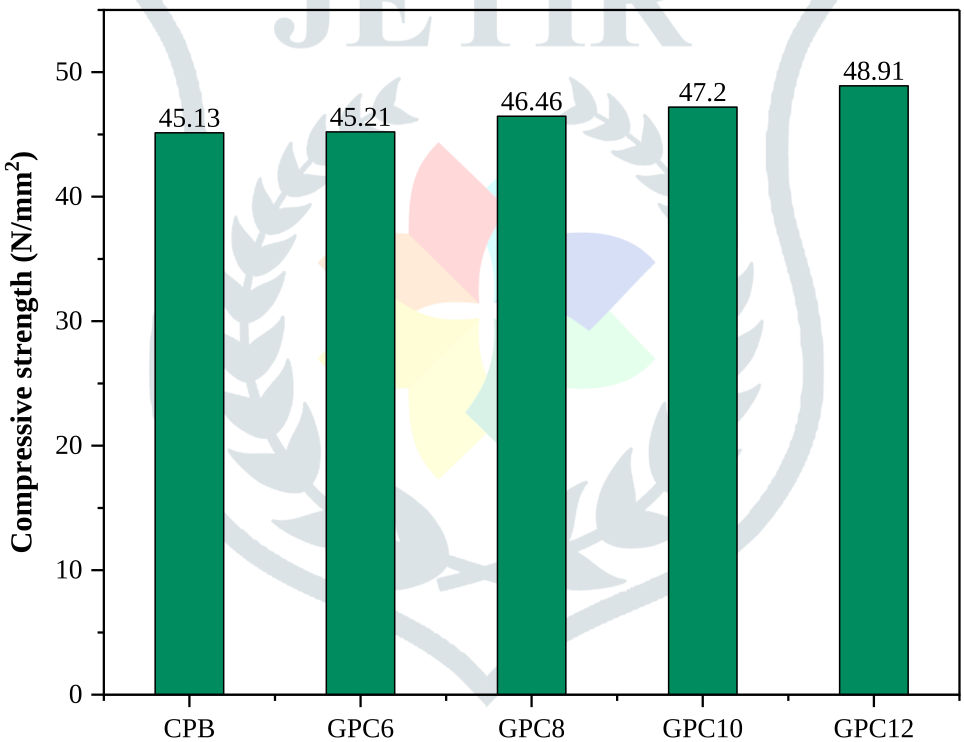

Figure 3.3 Compressive Strength of paver block

3.4 Split Tensile Strength Test

The tests on paver block were conducted according to IS: 15658-2006. Splitting tensile strength of the paving blocks at 28 days curing for conventional and Geopolymer concrete paver blocks. Split tensile strength result was increased with increase in molarity of NaOH. It shows the high bonding strength between the particles and increase in density of GPC.
For instance, GPC 6M demonstrated lower strength than control mix CPB. But remaining mix demonstrated higher strength than control mix. According to IS 15658–2021, M40 grade pavers should achieve a minimum split tensile strength of 3 N/mm2 after 28 days curing, and all the geopolymer concrete paver blocks have a strength at a range of 4.47 to 5.27 N/mm^2.

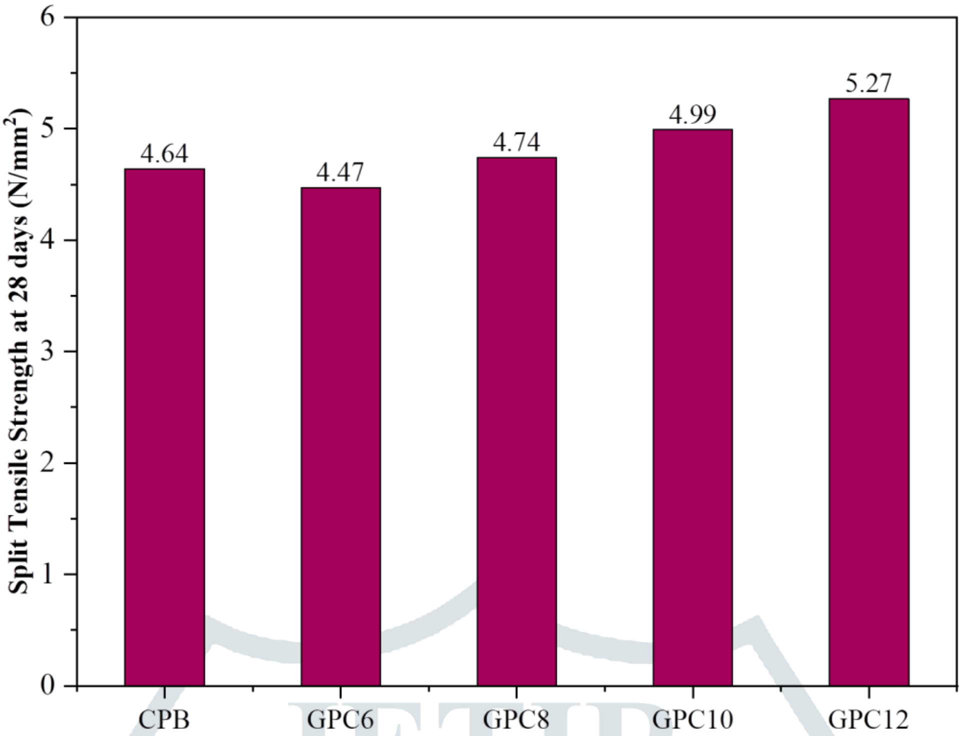

Figure 3.4 Split Tensile Strength of paver block

IV CONCLUSION

In this experimental study, geopolymer binder was prepared by combining recycled coarse aggregate, fly ash and alkaline activator which consisted of NaOH and Na2SiO3.
The compressive strength, absorption, visual inspection, dimensions and tolerances and split tensile strength were evaluated in this investigation. The following conclusions are drawn based on the investigation:

i. The mixture with low NaOH concentration of 6 M was insufficient to dissolve the fly ash particles to form aluminosilicate and calcium silicate compounds, resulting in formation of loose microstructure and reduced compressive strength and split tensile strength.
ii. When increase the molarity of NaOH for same mixes significant improvement in split tensile strength and compressive strength.
iii. Water absorption were mainly influenced by the concentration of NaOH Water absorption decreases with increase in NaOH concentration due to dense polymeric gel formations. The 12 M NaOH dissolved the more fly ash particle to form aluminosilicate and calcium silicate compounds, hence leaving behind unfilled internal pore in the particles.
iv. The Na_2SiO_3/NaOH ratio of 2.5 is determined to be optimum for the compressive strength development of fly ash based geopolymer. All specimens (without brick powder) with Na_2SiO_3/NaOH ratio of 2.5 achieved 28-day compressive strength exceeding 45 MPa. The highest 28-day compressive strength value was recorded 48.91 MPa, which composed Na_2SiO_3/NaOH ratio of 2.5 and 12 M NaOH.
v. This study may pave the way for formulation of guidelines for effective utilization of C&D Waste with the help of geopolymeric process.

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