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Geopolymer Concrete Paver Blocks: A Review

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Abstract. Geopolymer Concrete is one of the emerging concretes with zero cement. Zero percent usage and hundred percentage utilization of pozzolanic material as source material increases the interest of researchers towards geopolymer concrete day by day. Also, reduction of emission of Co2 rate in environment by the less usage of cement consumption increase the thirst of utilizing geopolymer concrete towards academicians, environmentalists and researches. In geopolymer concrete the main source material which is highly embedded with huge percentage of silica and alumina is utilized instead cement. Stimulator solution, combined with Na_2Si0_3 and NaOH is used for processing and activating polymerization process. As a result of polymerization process, chain links and bonds of Silicon-Oxygen-Aluminum are formed to stimulate the strength properties of concrete. Steam, oven and ambient temperature curing methods are preferred in this concrete. Nowadays, interest of geopolymer concrete turn over to applications of geopolymer products rather than construction of structural elements. Applications of geopolymer concrete include paver blocks, precast slabs, pipes, bricks, tiles, etc. Construction of paver blocks in geopolymer concrete plays an important role. This paper describes the review of GPC paver blocks for the past two to three decades which will help to update the knowledge of GPC paver blocks in all aspects.

Introduction

Ordinary Portland Cement (OPC)-a prime most key ingredient in the manufacture of concrete and construction industry. Production of Portland Cement increases in a higher rate due to modernization and development of infrastructure. A well-known unavoidable fact in the production of cement is that limestone which is found to be greedier in releasing CO_2 into the universe, which highly relates to greater environmental issues such as global warming, green house effects, etc. Reduction in usage of cement is the only solution to reduce environmental hazards.

Utilization of waste materials into the concrete is yet another good solution to rejuvenate the environment to be more eco-friendly. Hence GPC could be mentioned as green concrete since prepared with waste materials and zero cement. Only by these alternate solutions we can build greener environment with quality air for respiration. Such replacement also preserves the natural resources in concrete with the usage of waste material providing a better way for the possibility of replacing concrete. This alternate solution in replacement to cement and concrete helps to develop sustainable environment.

Cement Replacement Materials

Many efforts have been made to choose an alternative material to Portland cement as waste material which overcomes all the above known problems is one of the best remedies to alter normal cement with zero percent cement and hundred percent usage of fly ash or material abundant in silica and alumina. All thermal power plants generate huge quantity of fly ash which is dumped into the soil without any use. This fly ash hinders the interest of researches in the past few decades, which becomes an extra ordinary replacement to cement in the past years. And thirst of eco-friendly environment increases considerable research towards GPC. Since it possesses excellent strength and durability properties, low cost, eco-friendly nature increases its demand day by day. Unlike Portland cement, it has no environmental effects since $CO_2$is not let into the atmosphere.

Application of GPC

GPC can be used as sustainable binders in precast industries in the manufacturing of various products such as bricks, pavers, slabs, hollow block units, pipes, roofing tiles etc. Also, GPC can act as binders in the manufacturing of light weight components in both cement and concrete field. The combination of Silicon-Oxo-Aluminate is called “Sialate” since geopolymer possesses good durability properties so that it can be used in severe environmental applications such as bridges, fiber composites, sealant for industrial ceramics, foundry components etc. Also, GPC is highly resistant to acidic and alkali resistance, hence utilized in mining and sewer systems.

Utility of Geopolymer Technology provides the opportunity for sustainable development by converting waste materials into useful and valuable products and also by reducing greenhouse gas emissions, particularly in the cement industry. Its application also involves the manufacturing of geopolymer pastes and geopolymer coating materials, geopolymer aggregates. Applications of GPC are almost similar to ordinary Portland cement concrete applications.

Paver Blocks

Paver blocks are used to improve the aesthetic looks of paved areas. These pavers are best suited for all areas. Coloured blocks provide more aesthetic beauty to pavers. The paver blocks are cast in different sizes and thickness. These paver blocks act as wearing surface by reducing the stresses acting on subgrade and also help in resisting pavement deformations and elastic deflections similar to base course of flexible pavement. These paver blocks are used for various applications in toll plaza, city streets, bus depots, intersections, road repairs during monsoon, car parks, truck parking areas, roads in high altitude areas, footpaths, cycle tracks, residential streets, sidewalks, level crossings, petroleum bunks, parks, and in many other areas. Blocks are used in light traffic, medium traffic and heavy traffic areas. The blocks are cast into various colours, shape and sizes to suit to the requirement to satisfy the norms of IS: 15658-2006.

Literature Review

Geopolymer Concrete Paver Properties

Mechanical Strength

[1] Illustrate the various methods used to develop mortar specimens for the determination of optimum dry density. Strength properties using various parameters were analyzed using experimental data. It supports to develop a phenomenol model to create with different combinations of ingredients to form geopolymer blocks to reach the desired strength of results. Using set of various experimental data, the validity of models was evaluated. The result reveals the same predicted values compared with experimental data. [2] Investigated composite geopolymer matrix embedded with reinforcement and basalt fibers. To evaluate the improvement

in mechanical properties with respect to material cast with no reinforcement. Tests were conducted with basalt fabrics reinforced geopolymer material. Tests were carried out with the evaluation of strength properties. There was a significant impact between the strength properties of tested composite geopolymer matrix and developed basalt fabric matrix. [3] Revealed the mechanical strength properties with different mixing ratios of fly ash and rice husk ash. Different ratios between these two combinations were considered for casting and testing. Results indicate WA that specimens with more amount of fly ash ratio possess more compressive strength, water absorption, minimum thermal conductivity, bulk density and minimum porosity compared to addition of more percentage of rice husk ash. [4] Discussed manufacturing process of geopolymer cement by mixing with various proportions of calcium carbonate. These combinations of calcium carbonate cast specimens were tested for its compressive strength, water absorption and other durability properties. [5] Investigated with basalt fibre reinforced geopolymer concrete with different ratios of alkaline activator solution, ratio of source material to alkaline solution. [6] It was found that workability of concrete increases with increase in ratio of superplasticizer and rice husk ash. [7] Examined foundry waste sand, fly ash and GGBS as replacement to aggregates and cement in paver blocks. Different tests were performed to determine strength and durability properties of geopolymer concrete with the maximum utilization replacement percentage of waste materials. It was found that by increasing percentage of GGBS strength results increase in excellent percentage compared to increase in foundry sand and fly ash. [8, 9] Investigated the improvement of building envelope using sustainable material. The main aim behind this research is to develop an eco-friendly, low thermal transmittance material. Research was carried out using aluminate silicate source material to develop foam geopolymer concrete. Further it was compared with normal conventional building construction materials. They were tested for its physical, thermal and mechanical performance of glass powder geopolymer blocks.

Durability

[10] Investigated Geopolymer foamed block with more inter connected pores by adding H2O2 solution and oleic acid. Adsorption capacity gets increased due to the formation of pores. Also test results revealed that zeolites can be used as low cost replacement material in waste water treatment units. [11] Examined the different combinations of mixture with metakaolin and NaOH solution. Development of bricks was achieved through laterite. Research develops compressed earth bricks with and without stabilizers using 8% of Portland cement. After the process of curing both stabilized and unstabilized bricks were subjected to testing. [12] investigated the utilization of recycled asphalt pavement aggregates in paver blocks. More percentage of recycled waste aggregates were generated from digging existing bituminous roads due to tremendous growth in road development projects. Still more percentage of aggregates were dumped in urban areas without utilization. [13, 14] Investigated utilizing DWTS as replacement of sand in paver blocks. Five different ratios of concrete paver blocks were designed and tested for its compressive strength, leachability, abrasion resistance, and acid and sulphate attack. Micro structure analysis indicates that addition of DWTS result in the formation of ettringite. [15] Describes the paver blocks manufactured using alkali activated and clayey soil binders. The binder was generated from fly ash with more percentage of unburned material. Lime and slag was utilized as calcium sources. Research revealed that the texture of the soil is the most key element for manufacturing compacted soil masonry blocks. Highest sand content, high dry density indicates the lower percentage of pores and water absorption with lowest compressive strength. [16] Explained that increasing alumina content develops properties of GPC whereas decreases its strength properties. Strength of the concrete differs with different ratios of Silica to alumina ratio. [17] Investigated energy efficiency

of the developed material produced by foam alkali activated blend fly ash and glass powder. The energy and thermal efficiency of the material was evaluated. A detailed thermal analysis was carried out using an incompressible conjugate heat. [18] Explained the workability and strength nature of paver blocks in addition of BKRHA particles. It results with increase in strength. Excellent results were found with flexural and tensile strength too. Also, durability properties, resistance to acid and frost attack showed better results in GEOPAV blocks.

Economic Benefits of Geopolymer Concrete Pavers

[19] Investigated the mechanism, typical cooling techniques to develop cool pavements in thermal environment. Cost benefits, policies towards application of cool pavements were analyzed in this research. It was found that the applications of cool pavements remain incomplete in this research. Author suggested that cool pavements towards air temperature is unknown. [20] Explained the technologies suited to connect pathways towards development of Nador village. Also author describes the social- economic activities that influence the rural life. [21] Many difficulties regarding various disagreeable conditions in connecting the pathways were identified. [22] Investigated numerically obtained pertinent quantities with average, normal temperature iso-surface variation through the solid zone and liquid zone and profile of temperature along axis direction. Compressive strength test along with cost analysis and energy demand was carried out on the materials. It could be attained in incorporating glass powder in foamed geopolymer blocks.

Applications of Geopolymer Concrete Pavers

[23] Explained the techniques adopted to reduce the temperature of water retaining blocks in wet and dry conditions at different temperature. Author described the methodology adopted to maintain permeability of water retaining block in heavy rain condition and the process of draining excess water from the blocks. [24] Described the difference between the performance of conventional cement and metakaolin geopolymer blocks. Test results of GPC blocks revealed excellent leaching property, good resistance to acid and sulphate solution. After freeze-thaw cycles and high temperature retention tests geopolymer blocks resulted with low compressive strength. [25] Developed low cost, light weighted non aerated geopolymer blocks using various proportions of GGBS to fly ash ratio. These NAG blocks were durable in nature and resistance to acid. Maximum industrial waste material was utilized for the development of light-weight NAG blocks with minimum concentration of alkaline solution.

Conclusion

From the review, it was found that more researches were carried out with fly ash as source material. In recent articles, basalt fabrics were added into GPC to achieve more strength and durability. More researches were carried out in the recent years in geopolymer blocks and bricks. Researches must be carried out using different alkaline solution and source material.

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