Utilization of waste plastics with alternative materials in the production of paver blocks: A Review

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Abstract –The use of non-biodegradable materials such as plastic can cause issues for both humans and the environment. Every year, approximately 350 million tons of plastic waste are produced. Plastic wastes are usually disposed of in traditional ways, such as landfill and incineration. Though it can be recycled, but it is not as much as effective. It is necessary to take measures to reduce the amount of plastic waste that is disposed in the environment. Concrete paver blocks play a major role in the transportation industry due to their ease of installation and affordability. Melting or shredding waste plastics during the manufacturing of paver blocks can replace them with cement or aggregates. Effective waste management is achieved through the application of plastic waste. There are other substitutes some are ground granulated blast furnace slag, sugarcane bagasse ash, tea waste ash and metakaolin. They can be added topaver blocks made from plastic waste to improve their structural and durability properties.The focus of this paper is on replacing plastic waste with other materials in concrete paver blocks, which results in sustainability approaches and to increase the demand for alternative materials in the construction industry, rather than conventional ones.

Keywords - plastic waste, concrete paver blocks, waste management, alternative materials, sustainability.

I. INTRODUCTION

Plastics are a versatile material that has a wide range of uses and is connected to human life from beginning to end. There are different types of plastics used, such as polyethylene terephthalate (PET), polystyrene (PS), high-density polyethylene (HDPE), low-density polyethylene (LDPE), polyvinyl chloride (PVC) and polypropylene (PP) and after their usage, they turn into waste that affects the inhabitants and surroundings directly and indirectly. Tons of plastic waste are generated annually. Each type of plastic has its own property that may vary from others. Research has been done on the usage of plastic waste in the construction industry, especially with polyethylene terephthalate and polyethylene**,** since they have their own capability to maintain their properties when they are deformed and can be used on light-traffic roads.

Nowadays, concrete paver blocks are mostly used in pavements that are functional, attractive, cost-effective, and durable. In concrete paver blocks, the main elements used are cement, aggregates and water. Cement is a binding agent that is used to set a bond between other materials and generally Ordinary Portland Cement (OPC) is used worldwide in manufacturing concrete. Cement is manufactured from natural materials such as limestone and clay that turns into a fine powder and it is burned at 1300℃ to 1500℃ where it abundantly releases carbon dioxide (CO_2) that creates environmental issues leading to global warming. Aggregates are of two types: fine aggregates and coarse aggregates. These are made from natural resources, and their usage in construction reduces the availability of aggregates. Since natural resources are depleting worldwide while at the same time waste generation is increasing substantially.

Sustainable development in construction involves the use of nonconventional and innovative materials and the recycling of waste materials in order to compensate for the lack of natural resources and find alternative ways to conserve the environment. The cementitious and aggregate phases can be replaced with plastic and other alternative materials so that the finished product can be changed to suit its application with varying density, strength, durability, and thermal resistance properties. The alternative materials are fly ash, silica fume, rice husk ash, ground granulated blast furnace slag, sugarcane bagasse ash, tea waste ash and metakaolin. Many experiments are ongoing and thus these materials can be effectively used in the replacement of cement or aggregates. With plastic, they can be added to increase the strength and other properties where they are proven effective in various proportions.

II. LITERATURE REVIEW

Salman Ahmad, et.al (2023), "***Effect of coconut fiber on low-density polyethylene plastic-sand paver blocks",***This research is based on the low-density polyethylene (LDPE) waste plastic used as a binding material with coconut fiber. The wastes are melted by collecting, washing, cleaning and drying and then the melted sample is shredded into small pieces and mixed with sand to form paver blocks. About 36 paver block specimens of

LDPE to sand at proportions of 40:60, 30:70, 25:75, 20:80 were cast without coconut fiber. Another 45 paver block specimens were cast with 5 mm of coconut fiber at 1%, 2%, 3%, 4% and 5%. The tests conducted were compression strength, water absorption and density. With the results of the tests conducted, another 27 blocks were cast. Thus, no water is required in the manufacturing of paver blocks as it turns into an eco-friendly substitute for cement. With LDPE-sand blocks, 30:70 yielded the overall best result with 19.62MPa, 2.16% water absorption and 1.45% g/cm^3 in density. At 3%, the coconut fiber achieves a higher compressive strength of 23.23MPa, 0.99% water absorption and 1.54 g/cm^3 density. Thus, the incorporation of both leads to minimal water-absorbing capacity and can reduce the absorptive strength of paver blocks, making them most suitable to be used in waterlogged areas.

Bawar Iftikhar, et.al (2023), "*Experimental study on the eco-friendly plastic-sand paver blocks by utilising plastic waste and basalt fibers*", This case study investigated plastic waste (low-density polyethylene (LDPE)) and basalt fibers used in paver blocks. The LDPE is used for the production of plastic sand paver blocks by melting the plastic, where the cement can be completely replaced. The basalt fibers of 4mm and 12mm at 0.1%, 0.3%, 0.5%, 0.7% and 1% are used. At various proportions, paver blocks are manufactured with LDPE-sand and basalt fibers. The tests evaluated are compressive strength, water absorption and temperature efforts at 0°C to 60°C, such that LDPE-sand of 30:70 with basalt fiber of 4mm at 0.5% is mixed to improve the strength and reduce water absorption. The compression strengths of these blocks are 17.04 MPa and 1.15% water absorption. The effect of temperature on LDPE-sand was that at 0°C the strength decreased to 30.5% and at 60°C the strength decreased to 29.5% without basalt fibers. The replacement of plastic waste with sand and basalt fiber was eco-friendly and they are used in pedestrian, light-traffic areas.

G. Anusha,et.al, (2022), "*Study on paver blocks using waste plastics and sugarcane bagasse ash*", In this research paper, they lead to a sustainable environment where waste materials can be effectively used to produce paver blocks. Polyethylene Terephthalate (PET) plastic waste can be used in an effective way by being used as a filler material in paver blocks, which can be used in low-traffic locations. In addition to it, sugarcane bagasse ash (SCBA) is partially replaced with cement in paver block making. Thus, 30% of PET is maintained constant with varying percentages of sugarcane bagasse ash. To achieve sustainability by utilizing plastic in paver blocks, cement can also be replaced with sugarcane bagasse ash. Compression tests were done for 7 days, 14 days, and 28 days. At 40% of SCBA, the compression strength suddenly decreased. Thus, to a certain limit, these blocks can provide a strength similar to that of conventional concrete paver blocks.

Karma Tempa, et.al (2021), "*An experimental study and sustainability assessment of plastic waste as a binding material for producing economical cement-less paver blocks*",This paper shows that plastic waste acts as a binder that can be a complete alternative to cement. The plastic waste with fine aggregate is added in varying proportions of 40%, 50%, 60% and 70% to replace cement. In this paver block production, it produces cement-less paver blocks that do not require any direct water usage. The plastics are collected, shredded, melted and molded in prefabricated steel molds. The compressive strength increases with an increase in the proportion of plastic content. However, when exposed to very high temperatures, its strength is reduced by 31.17%. These paver blocks have a low water absorption potential. The production of one cement-less paver block utilizes 1.8 kg of plastic waste without cement and direct water usage. The cement-less paver blocks were 29.39% to 32.15% lower than conventional paver blocks, which indicates economic sustainability where the cost of paver blocks is lower when compared to normal paver blocks.

O.S. Abiola, et.al (2021),*"Performance evaluation of polypropylene granules: A partial replacement for sand in a steel slag concrete block pavement",* In this study, they investigated the exploration of utilizing polypropylene (PP) granules as a partial substitute for sand in steel slag-mixed concrete block pavement. The study involved preparing concrete samples with 0%, 4%, 8% and 12% polypropylene, and the specimens produced were 48 paver blocks, 48 cylinders and 48 beams, subjecting them to compressive, split tensile and flexural strength tests over curing periods of 7 days, 28 days, 56 days and 90 days. The mix design is 1:1.17:3.56 (cement:sand:granite) at a water-to-cement ratio of 0.5. Results indicated an increase in strength with curing days but a decrease with a higher addition of polypropylene. Therefore, the optimum strength was at 4% polypropylene at 90 days of 34.11, 0.66, 4.73 MPa, respectively, with compressive, split tensile and flexural strength values. Thus, the findings suggest that replacing 4% and 8% of sand with polypropylene in concrete block pavement (CBP) can reduce natural resource depletion and environmental pollution, achieving a desirable strength.

V. Punitha, et.al, (2020), *"Experimental investigation of concrete incorporating HDPE plastic waste and metakaolin",*This paper investigates high-density polyethylene (HDPE) and metakaolin with the partial replacement of fine aggregate and cement. At 5%, 10%, 20%, 25%, 30%, 35%, 40%, 45%, and 50%, HDPE and 10% metakaolin are added to the weight of cement and that has been compared with conventional concrete. The tests performed are slump cone, compression test, split tensile test, flexural test, water absorption test for 7 days and 28 days. The result shows that the mechanical and strength properties are improved. Workability and water absorption decrease with an increase in HDPE. The compression strength of 15% HDPE with 10% metakaolin attains 106% as compared to conventional concrete. The flexural strength and split tensile strength at 5% HDPE and 10% metakaolin attain 80% and 90% of conventional concrete, respectively. Hence, 5% of HDPE with 10% metakaolin is achieved in the conventional mix.

S. Agyeman, et.al, (2019), *"Exploiting recycled plastic waste as an alternative binder for paving blocks production",* In this study, they use plastic waste as a binding material for paving block production. The recycled plastic waste is collected from the surroundings and washed, cleaned and dried. Then they were heated and mixed with concrete. With a mix design of 1:1:2 for conventional, 1:1:2 for low-density plastic paver blocks, and 1:0.5:1 for high-density plastic paver blocks. The tests done are compressive strength, water absorption, density and porosity for 7 to 21 days. The compressive strengths of high-density plastic blocks are 7.31MPa to 8.53MPa, low-density plastic paver blocks are 5.96MPa to 8.39MPa and for water absorption, high-density plastic paver blocks have 0.5% and low-density plastic paver blocks have 2.7%. A significant time- savings in the manufacturing process is an added advantage, as they attain more than 80% of their final strength within a day. They can be used in fast construction and in waterlogged areas. These paving blocks would have an advantage over those produced from ordinary concrete paving blocks due to their fast curing and low water absorption properties, making them relatively less prone to chemical attack, physical stress and mechanical damage as compared to other light-weight concrete.

Ridham Dhawan, et.al, (2019), ***"Recycling of plastic waste into tiles with reduced flammability and improved tensile strength",*** This paper explores finding an effective alternative for the disposal of waste plastic bags by designing tiles so that they can be used for paver tiles for societal usage. As the plastic bags are collected, washed, and cut into pieces, traditional technologies for waste plastic disposal have failed to cope with the increased generation of plastic waste and fly ash, a by-product generated by the combustion of coal in thermal power plants, so here they use a waste plastic reinforced matrix with fly ash to reduce the flammability and improve the tensile strength. With varying plastic (100%, 95%, 90%, 85%, 80%, 79%, 78%, 75%) and fly ash (0%, 5%, 10%, 15%, 20%, 20%, 20%, 20%). At 75% of plastic and 20% of paving tiles, they have appropriate flame retardant and reduced flammability. The tensile strength improved to 9.68MPa. These can be used to build structures that are light weight, resistant to corrosion, chemically resistant, low cost of production, have an increased service life, and most importantly, put into use what is a menace to society: plastic waste.

Mohammadinia, et.al (2018), *"Strength evaluation of utilizing recycled plastic waste and recycled crushed glass in concrete footpaths",* In this study, they incorporate recycled plastic waste (RPW) and recycled crushed glass (RCG) as coarse aggregate replacements in concrete and evaluate their feasibility as concrete footpath construction. At 0%, 10%, 20%, 30%, 40%, and 50%, recycled plastic waste and recycled crushed glass nominally at 3–8 mm in diameter were utilized. With the combination of both, 5% + 5%, 10% + 10%, 15% + 15%, 20% + 20% and 25% + 25% of recycled plastic waste and recycled crushed glass are also done. The properties of concrete evaluated in this study include unconfined compression strength (UCS), tensile strength and capillary water uptake. The UCS result shows that 10% RPW was 38 MPa and 10% RCG was 55 MPa and for mixed, 5% RPW and 5% RCG, the UCS was 43MPa. Tensile strength results show that 10% RPW was 3.1 MPa and 10% RCG was 4.0 MPa, respectively. For the mixed 5% RPW and 5% RCG, the indirect tensile strength was 3.5 MPa. The uptake of water by capillary pipes in all the samples shows a moderate increment, with very little difference between the control RPW and RCG samples. Results from this investigation showed that the incorporation of RPW at 50% and RCG at 10% in concrete can be a viable solution for the recycling of plastic waste and crushed glass.

III. CONCLUSION

Wastes from plastics can be efficiently used in paver blocks for low and moderate traffic areas.

- There are various techniques such as fillers, binders and fibers to use plastic waste in paver blocks with many alternatives that lead to effective waste management.
- The use of plastic waste can reduce the solid waste and the demand of conventional materials in construction industry with various alternatives.
- The use of plastic waste with natural fibers improve the strength and durability properties with a short period of time.
- As compared to conventional materials these are lower cost materials that can increase the revenue generation.
- When plastic is used as binder the water absorption is lesser than conventional paver block.
- The unit weight of plastic paver blocks are also decreases.
- With many additives such as sugarcane bagasse ash and metakaolin structural and durability properties are improved.

Thus plastics with alternative materials can be a most effective way and it also gives best results.

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