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REVIEW ON USE OF PLASTIC WASTE IN CIVIL CONSTRUCTION

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ABSTRACT
The utilization of waste plastics in construction has garnered significant attention as a sustainable approach to address environmental concerns while enhancing construction practices. This review delves into the multifaceted applications of waste plastics across various construction sectors, highlighting their potential to mitigate plastic pollution and contribute to resource efficiency. From incorporating recycled plastic aggregates in concrete to utilizing plastic waste for road construction and insulation materials, diverse avenues are explored. Additionally, advancements in technology, such as plastic-based composites and additive manufacturing, are examined for their role in repurposing waste plastics in construction. Furthermore, the review evaluates the environmental implications, including the reduction of carbon footprint and landfill diversion, associated with the adoption of waste plastics in construction projects. By synthesizing current research and case studies, this review elucidates the challenges, opportunities, and future prospects for integrating waste plastics into sustainable construction practices.

Keywords: Waste Plastics, construction

I. INTRODUCTION
Plastic, a highly valuable resource that was first developed as a byproduct of petrochemicals in 1907, has the ability to significantly impact an individual's life. The composition of this substance consists of a variety of semisynthetic or synthetic organic compounds that have a significant molecular weight. It also includes other materials that are malleable and flexible in their solid-state form. The production of these substances, such as cellulose, coal, natural gas, salt, crude oil, minerals, and plants, involves the use of polymerization or polycondensation processes. The material exhibits a high degree of adaptability and can be effectively employed in diverse contexts. Plastic offers several advantages compared to alternative materials such as rubber, paper, and natural fibers like cotton and wool. These advantages include its lightweight nature, durability, flexibility, diverse range of applications, and cost-effectiveness. The mass production of this material has led to its status as the most economically viable option currently available in the market [1]. However, the characteristics that contribute to its advantages have also exacerbated the global issue of waste [2]. The utilization of this material by individuals is not effective [3, 4]. The global manufacturing capacity of plastic reaches approximately 380 million tons on an annual basis. In 2017, the global production of polyethylene polymers reached approximately one hundred million tons, accounting for 34% of the total plastics industry [5]. Every year, countries around the world dispose of millions of tons of plastic waste. The recycling rate for plastic waste used in the production of new polymers is only 16%. A further 19% of the material is discarded, while 25% undergoes incineration and is subsequently deposited in landfills [6]. The exponential growth in the generation of plastic waste poses a significant environmental threat [7]. The main concern causing damage to the marine ecosystem, land, and atmosphere is plastic contamination. Plastic is comprised of large, harmful particles that possess the capability to contaminate the air, water, and soil, leading to significant environmental harm [8]. In addition, it poses a significant risk to climate change, human health, coastal tourism, food quality and safety, and oceanic health. Moreover, plastic waste serves as a contributing factor to the occurrence of the global warming phenomenon. The combustion of plastic waste leads to increased carbon emissions as a result of the release of carbon dioxide into the Earth's atmosphere. The aesthetic appeal of tourist destinations is negatively impacted by the presence of plastic waste, leading to a decrease in revenue generated from tourism and increased financial responsibilities for site

maintenance and cleaning [9]. The management of plastic waste can pose challenges, even in developed countries [10]. Comprehensive waste management systems and recycling are considered to be two effective and efficient approaches for the management of solid waste. In order to explore alternative methods, efforts have been undertaken to incorporate waste materials into the brick manufacturing process. The utilization of plastic sand pavers has the potential to offer various benefits and contribute to waste reduction. The pavers have the capability to support sustainable growth while simultaneously improving plastic management in the future. The advancement of sustainable development is achieved by simultaneously promoting environmental preservation through the utilization of plastic pavers [11].

II. LITERATURE REVIEW

According to Zhang et al. [12], there have been challenges in the public and industry's acceptance of brick or concrete made from waste materials. These challenges arise from concerns about the potential release or generation of pollutants. During the manufacturing process, contaminants may be released through leaching or other chemical degradation mechanisms, which could pose a potential hazard when using construction materials. Environmental impact assessments, such as leachate investigations, are necessary to analyze the properties of construction materials that contain aggregate derived from plastic waste.

In their study, Rai et al. [13] examined how the inclusion of plastic waste impacted the densities of both fresh and dried concrete. Upon adding plastic granules, the initial density of the concrete mixture decreased. There was a noticeable decrease in the fresh density of all plastic substitutes when the plastic percentages were at 5%, 10%, and 15%. The reductions in density were 5.75%, 8.7%, and 10.75%, respectively. In addition, the concrete's dried density increased as more plastic was added to it. It is possible that the decrease in concrete density is due to the lower density of the plastic granules used as aggregate.

A study conducted by Chowdhury et al. [14] examined the potential use of polyethylene terephthalate (PET) as an alternative to traditional construction materials. For the creation of the concrete samples, different proportions of traditional aggregate (ranging from 0.5 percent to 6 percent) were replaced with PET and mixed with cement. The findings of this study showed a notable decrease in the weight and bulk density of the concrete.The issue can be attributed to the relatively low density of plastic, which is closely linked to the amount of plastic added to the concrete mixture.

In a study conducted by Cadere et al. [15], the engineering properties of concrete were evaluated by incorporating varying percentages of polypropylene granules. These percentages ranged from 20% to 100% of the plastic content. The study's results indicate that the densities of fly ash concrete and polystyrene granules ranged from 1880 to 2131 kg/m3, which is noticeably lower than the density of the control mix at 2250 kg/m3.

Alan et al. [16] observed a gradual reduction in the bulk density of fly ash bricks when PET strips were added in varying proportions: 0%, 0.5%, 1%, 1.5%, and 2%.

The fly ash bricks containing PET had an average bulk density of 1.77 kg/m3, which was lower than the density of the control brick (2 kg/m3).

In their study, Ahmad et al. [17] examined the utilization of high-density polyethylene (HDPE) plastic waste in the manufacturing of cement bricks. Using HDPE instead led to a decrease in the weight of cement bricks. Bricks with 10% and 20% HDPE had an average mass of 2.4 kg, while conventional cement bricks weighed 2.9 kg. The density of regular cement bricks was impacted in a comparable way when 10% and 20% HDPE bricks were introduced, without incorporating any additional HDPE. The density experienced a decrease of 15.78% and 12.96%, respectively.

In a study by Rubio-de Hita et al. [18], the researchers noted the utilization of mixed polypropylene as aggregate in mortars for the construction of jack arch flooring with wood beams. The density data revealed a clear link between the quantity of plastic waste incorporated into the mortar and a decrease in its density. With an increase in plastic percentages, the density of the mortar decreased, leading to a noticeable increase in the hardness of the mortar when plastic was used as a replacement.

In a study conducted by Makri et al. [19], it was discovered that when plastic was replaced with mortar, there were only minor variations in the densities of the specimens. When using different replacement ratios, it was observed that the density of the mortar appeared to be lower than usual at 2.5%, 5%, and 12.5%. However, specimens containing 7.5% and 10% plastic showed slightly higher densities.

As per the research conducted by Saikia and Brito [20], the density of a material can be affected by the size of the particles of plastic or replacement material. Research findings showed that cement composites with larger plastic particles tended to have lower densities in comparison to smaller particles. Thus, it was determined that the inclusion of different kinds and dimensions of plastic resulted in a decrease in the density and unit weight of construction materials.

In a study conducted by Wahid et al. [21], plastic trash was examined as a potential replacement for a portion of the aggregate in sand bricks. Studies have shown that as the amount of plastic waste increases, the compressive strength tends to decrease. This finding could be attributed to the limited bonding capacity between plastic and cement paste, leading to a reduction in the compressive strength of the materials when plastic waste is added. The bricks with different percentages of plastic waste showed varying compression strengths. The brick with 5% plastic waste had a compression strength of 11.61 N/mm2, while the one with 10% had a strength of 5.96 N/mm2. The brick with the highest percentage, 15%, had the lowest compression strength of 2.98 N/mm2. The control brick, which did not include any plastic, demonstrated the highest compressive strength at 12.40 N/mm2. Therefore, it was determined that the limited bond between plastic and cement paste, along with the water-resistant properties of plastic that impeded the hydration process, could potentially be the cause of the decrease in compressive strength.

Hossain et al. [22] conducted a study to explore the use of PET in concrete as a constituent material. Using PET in the concrete resulted in a decrease in compressive strength. After 28 days, the compressive strength of the 10% PET concrete matched that of the reference concrete, measuring 16.55 MPa. As per the guidelines set by the American Concrete Institute (ACI) Committee (1987), it is recommended that the compressive strength of lightweight structural concrete falls within the range of 15.2 to 17.2 MPa after 28 days.

In a study conducted by Coppola et al. [23], the use of lightweight plastic aggregate (LWA) was proven to be a viable alternative to natural aggregate. The creation of LWA involved the combination of two different types of plastic waste, PP and PET, through the extrusion method. It was observed that increasing the concentration of lightweight aggregate (LWA) led to a decrease in the mechanical properties of the resulting concrete. The compressive strength of mortar with 25% and 10% substitution of plastic aggregate was found to be 22.86 MPa and 35.12 MPa, respectively. Nevertheless, the mortar containing plastic inclusion surpassed the standard threshold for structural concrete established by the American Concrete Institute (ACI) committee, which is 17.25 MPa.

In their study, Bhogayata et al. [25] examined the tensile properties of concrete enhanced with metalized plastic waste (MPW). For the concrete mixture, different proportions of two plastic diameters of MPW—1 mm and 5 mm—were added based on the volume of the mixture (ranging from 0% to 2%). There was a noticeable decrease in compressive strength linked to an increase in the amount of plastic waste. It is expected that the plastic's expansion will result in a decrease in its compressive strength.

For cement bricks, Mahzuz and Tahsin [26] made a substitution by using high density polyethylene (HDPE) instead of coarse aggregate. The researchers used HDPE instead of a portion of the coarse aggregate, incorporating stone fragments at three different concentrations: 0%, 25%, and 50%. Studies have shown that when the amount of plastic is increased in various ratios, it leads to a reduction in both compressive strength and unit weight. With a compressive strength of 20.62 MPa (1:1:1 with 25% plastic substitution), the first-class brickwork surpassed the LGED 2005 brick requirement.

In their study, Kumar et al. [27] used the toxicity characteristics leaching technique (TCLP) to assess the release of heavy metals from concrete that contained e-plastics. Upon analyzing the concrete samples, it was discovered that the levels of heavy metals, including Cd, Cu, Zn, and Pb, exceeded the thresholds set by the Resource Conservation and Recovery Act (RCRA) and the United States Environmental Protection Agency (USEPA). In addition, the results clearly showed that the curing time decreases as pollution levels increase.

The researchers in the study by Lasiyal et al. [28] calculated the cost of the primary materials needed to produce 1 m3 of concrete with different percentages of PET replacement. It was found that the production cost of 1 cubic meter of conventional concrete was slightly higher compared to concrete with plastic particles. By incorporating 1%, 2%, or 3% PET replacement, the cost of producing one meter of concrete can be reduced by 4.7246 rupees (USD 0.064), 9.449 rupees (USD 0.13), and 14.1378 rupees (USD 0.19) respectively.

As per research conducted by Habib et al. [29], the production cost of $1m^3$ of concrete with plastic replacement is higher than that of traditional concrete. Based on the calculations, using 15% plastic as aggregate in concrete would result in an estimated cost of around USD 340. Compared to the standard price of USD 185 per cubic meter for conventional concrete, this item comes at a much higher cost.

According to Zhao et al. [30], utilizing waste resources in the production of construction materials can help reduce manufacturing costs. However, there have been situations where using alternative materials has led to increased production expenses. Several factors, such as treatment methods and the rate of plastic replacement, can potentially impact production expenses and lead to an increase in the cost of the manufactured material.

III. CONCLUSION

The integration of plastics in construction materials presents both opportunities and challenges for the industry. The utilization of plastics offers potential benefits such as enhanced durability, improved insulation properties, and reduced environmental impact through the recycling of waste plastics. However, challenges remain in terms of ensuring compatibility with existing construction practices, addressing concerns regarding long-term performance and environmental sustainability, and establishing efficient recycling and waste management systems. Moving forward, collaborative efforts involving researchers, industry stakeholders, policymakers, and the public will be essential in advancing the development and adoption of plastics in construction materials while mitigating associated risks and maximizing benefits. By embracing innovation, fostering interdisciplinary collaborations, and implementing effective regulations and standards, the construction industry can leverage the versatility of plastics to create sustainable and resilient built environments for future generations.

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