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THE USE OF RECYCLED PLASTICS AS INTERLOCK MATERIALS

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ABSTRACT

This research investigated the feasibility of using recycled plastics as an alternative material for interlock stones. The research focused on comparing the water absorption and compressive strength properties of recycled plastic interlocks with traditional concrete interlocks. Results indicated that recycled plastic interlocks exhibited significantly lower water absorption compared to concrete interlocks, with values of 3% and 27% respectively. In terms of compressive strength, concrete interlocks consistently outperformed recycled plastic interlocks. However, the recycled plastic interlocks demonstrated a notable increase in compressive strength with increasing plastic content. The findings suggest that recycled plastic interlocks offer a promising alternative to traditional concrete interlocks, particularly in applications where water resistance is a critical factor. Further research is needed to explore the long-term durability and environmental benefits of recycled plastic interlocks in various construction scenarios.

Keywords: Recycled plastics, interlocks, water absorption, compressive strength, concrete alternatives, sustainable construction, plastic waste, durability.

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I. INTRODUCTION

Plastic waste pollution is in the increase in global environmental crisis, causing harm and injury to the ecosystems, wildlife, and human health. The rapid increase in number of single-use plastics and inadequate waste management practices has led to the accumulation of plastic debris in landfills, water bodies, and even remote natural environments. In response to this urgent challenge, there is a growing imperative to explore innovative strategies for plastic waste reduction, recycling, and repurposing (Onimisi Dawodu et al., 2022).

-provides a comprehensive review of the existing literature pertaining to the utilization of recycled plastic as interlocking materials in construction applications. Drawing upon seminal studies and recent advancements, this review synthesizes key findings, identifies research gaps, and highlights the implications for sustainable development.

The mechanical properties of recycled plastic materials have been a subject of extensive investigation in the literature. Studies by S. Dai, H Wang, et al (2003) have explored the tensile strength, flexural modulus, and impact resistance of recycled plastic composites, elucidating the influence of factors such as particle size, polymer type, and processing techniques. These findings underscore the potential of recycled plastic to meet the performance requirements of interlocking systems while offering advantages such as lightweight, corrosion resistance, and ease of fabrication.

Durability and weather resistance are critical considerations for the long-term performance of interlocking materials in outdoor environments. Research by Hossain, Poon, and Lo (2019) has examined the weathering effects on recycled plastic aggregates in concrete, highlighting the importance of additives and surface treatments in enhancing resistance to UV radiation, moisture ingress, and thermal cycling. Similarly, investigations into the degradation mechanisms of recycled plastic interlocking components have emphasized the need for material formulation and design optimization to ensure structural integrity and service life.

Environmental sustainability is a driving force behind the adoption of recycled plastic in construction, necessitating a comprehensive life cycle assessment (LCA) of interlocking systems. Geyer, Jambeck, and Law (2017) conducted a seminal study quantifying the production, use, and fate of all plastics ever made, shedding light on the environmental footprint of conventional plastic production and disposal pathways. Building upon this foundation, recent research has focused on evaluating the embodied energy, carbon emissions, and resource savings associated with recycled plastic interlocking materials, offering insights into their potential contributions to carbon neutrality and circular economy objectives.

Despite the progress in understanding the technical and environmental aspects of recycled plastic interlocking materials, several challenges and research gaps persist. The variability in recycled plastic composition, lack of standardized testing protocols, and limited field data on performance under real-world conditions pose barriers to widespread adoption and regulatory acceptance. Additionally, the economic viability, scalability of production, and end-of-life considerations of recycled plastic interlocking systems warrant further investigation to inform decision-making and policy formulation.

In summary, the literature reviewed underscores the multifaceted benefits and complexities of utilizing recycled plastic as interlocking materials in construction. By integrating insights from materials science, engineering mechanics, environmental science, and sustainability assessment, this body of research offers a holistic perspective on the opportunities and challenges inherent in transitioning towards a circular economy model. Moving forward, interdisciplinary collaborations, technological innovations, and policy interventions will be essential to realizing the full potential of recycled plastic in fostering a more resilient, resource-efficient, and environmentally sustainable built environment.

The construction industry is a major contributor to global environmental concerns, with high resource consumption and waste generation. One pressing issue is plastic waste, estimated to reach 1.2 billion tons by 2050 if current trends continue (Borrelle et al., 2020). Landfills are overflowing with plastic, and traditional recycling methods are often inefficient. In this context, innovative solutions are needed to reduce plastic waste and promote more sustainable construction practices.

This literature review explores the potential of recycled plastic as a material for interlocking building components. Interlocking materials are designed to fit together without requiring additional fasteners like glue or nails, offering potential benefits in terms of ease of construction and reduced material waste. This Literature review examines the environmental benefits of using recycled plastic, explore different types of recycled plastic suitable for this application, and discuss current and potential applications of interlocking recycled plastic materials in construction. Production methods, challenges, and future directions are also addressed.

i. Environmental Benefits of Recycled Plastic as Interlocking Materials

Plastic pollution is a major environmental concern. One way to combat this issue is by using recycled plastic in construction materials like interlocking blocks. Here's how this can benefit the environment: Reduced Landfill Waste: Every ton of plastic recycled is a ton diverted from landfills. Landfills take up valuable space, and decomposing plastic can release harmful chemicals into the soil and air. So, recycled plastic interlocking materials help reduce plastic pollution; Lower Energy Consumption: Manufacturing interlocking materials from recycled plastic typically requires less energy than producing them from virgin materials. This translates to lower greenhouse gas emissions from the production process, helping to combat climate change; Conserved Natural Resources: Virgin plastic production relies on extracting fossil fuels. Recycled plastic interlocks reduce reliance on this process, helping to conserve these valuable natural resources; Decreased Mining Activities: Traditional interlocking materials like concrete rely on mining for resources. Recycled plastic interlocks can lessen dependence on mining, which can have negative impacts on ecosystems and biodiversity; Potential for Sustainable Construction: The use of recycled plastic in construction paves the way for more sustainable building practices. This can encourage innovation in the construction industry towards a greener future.

Life Cycle Assessment (LCA) Considerations: Life Cycle Assessment (LCA) is a method used to evaluate the environmental impact of a product throughout its life cycle, from material extraction to disposal. Research by Zia et al. (2020) suggests that recycled plastic interlocking materials can have a lower environmental impact compared to traditional construction materials like concrete, especially when considering energy consumption and waste reduction

Using recycled plastic for interlocking materials offers a multitude of environmental benefits. It reduces plastic waste, lowers energy consumption, conserves natural resources, and promotes sustainable construction practices. By incorporating recycled plastic into our built environment, we can create a more eco-friendly future.

ii. Mechanical Properties:

- Strength and Load Bearing Capacity: Strength is paramount for interlocking materials used in applications like pavements and walls. Studies by Dawodu et al. (2022) investigating HDPE (High-Density Polyethylene) interlocking pavers yielded promising results in terms of load-bearing capacity. However, further research is necessary to optimize strength based on the type of recycled

- Plastic, processing methods and the addition of reinforcing agents. This optimization will ensure the material can withstand the specific loads it will encounter in various applications.
- Stiffness and Flexibility: Interlocking materials require a balance between stiffness to resist deformation under load and some flexibility to accommodate minor ground movement or thermal expansion. Research by Zia et al. (2020)
- Suggests incorporating reinforcing fibers like glass or carbon fibers into recycled plastic can significantly improve stiffness. The type, quantity, and orientation of these fibers can be tailored to achieve the desired balance for specific applications.
- Durability and Weather Resistance: It has high ability to withstand wear, tear, and damage over an extended period of time than the traditional method.
- Long-Term Performance: Construction materials need to withstand environmental factors like UV radiation, rain, wind, and temperature fluctuations over extended periods. The long-term durability of recycled plastic interlocking materials depends on several factors, including the type of plastic used, processing methods, additives employed, and the specific environment they are exposed to. Studies are ongoing to assess these factors' combined effects on long-term performance, particularly on long-term performance, particularly regarding UV degradation and weathering resistance. Accelerated weathering tests can be employed to simulate real-world conditions and predict the material's lifespan.
- Impact Resistance: Interlocking materials may be subjected to impact loads, especially in high-traffic areas. Nup Living (2023) suggests that the design of the interlocking mechanism plays a crucial role in distributing impact forces and improving resistance. Optimizing the interlocking geometry can enhance the material's ability to handle unexpected impacts without compromising its structural integrity.

iii. Challenges and Considerations for Recycled Plastic Interlocking Materials

While recycled plastic (R-Plastic) presents a promising avenue for sustainable construction through interlocking materials, significant challenges and considerations need to be addressed for successful implementation. Here, we delve into these key aspects. Despite the promise of recycled plastic interlocking materials, challenges remain. Compared to traditional materials like concrete, the durability and structural strength of recycled plastic need further investigation (Onimisi Dawodu et al., 2022). Large-scale production costs must also be carefully considered to ensure economic feasibility (PLAEX, Canada Construct Connect Canada, 2021). Maintaining consistent material properties from recycled plastic requires effective quality control measures (Nup Living, 2023 optimizing the performance of recycled plastic interlocking materials requires careful attention to the type and processing of the plastic used. Studies by explore the impact of different recycled plastic blends on the mechanical properties of interlocking materials. The findings suggest that blending different types of recycled plastic can improve strength and durability.

Research by (Onimisi Dawodu et al., 2022) investigates the additives that can be incorporated during the production process to enhance the performance of recycled plastic interlocking materials. These additives improve properties like UV resistance and fire retardancy, broadening the potential applications of this material.

In simpler terms, using recycled plastic for interlocking building components benefits the environment by reducing plastic waste and lowering energy use in production. There are different types of recycled plastic suitable for these interlocking materials, with HDPE and PET being common choices. Currently, these recycled plastic materials are mostly used for paving stones but have the potential for use in walls and other construction applications. Several methods exist to produce these interlocking materials, and research is ongoing to improve their durability and affordability compared to traditional building materials.

Dawodu et al., (2022), the strength and durability varies compared to traditional construction materials like concrete, interlocking materials made from R-Plastic may exhibit lower strength and durability. Concerns lie in R-Plastic's susceptibility to long-term performance issues like creep (deformation under sustained load) and UV degradation. Long-term exposure to sunlight can lead to embrittlement and potential cracking of R-Plastic interlocking materials.

II. RESULT

i. Experimental Investigation of Recycled Plastics for Interlocking Pavers:

An experimental investigation was conducted to assess the feasibility of using recycled plastics as interlock materials for paving applications. This approach offers a sustainable alternative to conventional concrete or clay pavers, while potentially improving certain properties.

ii. Laboratory Testing:

A series of laboratory tests was conducted to evaluate the performance characteristics of the selected samples. The specific tests were chosen based on the key performance areas identified in the literature review and this include:

Mechanical Testing: This can include tensile tests to measure strength and elongation at break, flexural tests to assess bending behavior, and impact tests to evaluate resistance to sudden impacts. (ASTM D638, ASTM D790)

Durability Testing: Exposure to UV radiation, extreme temperatures, and chemicals (simulating de-icing salts or cleaning agents) can be used to assess long-term durability. (ASTM G154, ASTM D4329)

iii. Water Absorption Test:

The results of the water absorption tests indicated below shows a significant difference between recycled plastic and concrete interlock stones. Recycled plastic interlocks exhibited a remarkably low water absorption rate of 3%, while concrete interlocks absorbed a substantially higher amount of water, reaching 27%. This results implies that recycled plastic interlocks possess superior water resistance properties compared to their concrete counterparts.

The lower water absorption of recycled plastic interlocks can be attributed to the hydrophobic nature of plastic materials, which tend to repel water. This characteristic is particularly advantageous in applications where water infiltration can compromise the structural integrity or aesthetic appeal of interlock paving.

For plastic interlocking stone:

1^{st} stone

Let W.W = wet weight

D.W = dry weight

%.A = percentage of water absorbed.

D.W = 3.078kg = 3078g

W.W = 3.207KG = 3207g

%.A = [W.W – D.W]/D.W*100

%.A= [3.207-3.078]/3.078*100

= [0.129/3.078]*100

= **4%**

<u>2nd stone</u>

D.W = 3.661Kg = 3661g

W.W = 3.680kg = 3680g

%.A = $\frac{w.w-d.w}{D.w}$ x 100 = $\frac{3.680-3.661}{3.661}$ x 100

=$\frac{0.069}{3.661}$ x 100 = **2%**

Average. =$\frac{4\%+2\%}{2}$ = 3%

Water absorption for concrete interlocking stone:

<u>1st stone</u>

D.w =3.858 kg = 3858g

w.w = 4.982kg = 4982g

Where: D.w = dry weight

w.w = wet weight

%.A = percentage absorbed

%.A = $\frac{w.w-d.w}{d.w}$ x 100 = $\frac{4.982-3.858}{3.858}$ = x 100

= $\frac{1.124}{3.858}$ x 100 = **29%**

<u>2nd Stone:</u>

D.w = 3.858 = 3858g

w.w = 4.550 = 4850g

%.A = $\frac{4.850-3.858}{3.858}$ x 100 = $\frac{0.992}{3.858}$ x 100 = **25%**

Average $\frac{29\%+25\%}{2}$ = $\frac{54}{2}$ = 27%

iv. Comprehensive Strength Test:

Compressive strength test for plastic interlocking stones

1. **<u>At 7 days</u>**

   <u>1st stone</u>

Area = 24750mm^2

Load = 200.89KN

δ = P/A

$= \frac{200.89}{24750}$ = **8.12mpa**

2nd stone

Area = 24750mm^2

Load = 203.11 KN

δ = P/A = $\frac{203.11}{24750}$ = **8.17mpa**

Ave. $\frac{8.11+8.17}{2} = \frac{16.28}{2}$ **= 8.17mpa**

2. **At day 14**

1st stone

Area = 24750mm^2

Load = 355.60KN

$\delta = \frac{355.60}{24750}$ = **14.37mpa**

1st stone

Area = 24750mm^2

Load = 380.06 KN

$\delta = \frac{380.06}{24750}$ = **15.36mpa**

Ave. $\frac{14.37+15.36}{2} = \frac{29.73}{2}$ **= 14.89mpa**

3. **At 28 days**

1st stone

Area = 24750mm^2

Load =438.51KN

δ = P/A = $\frac{438.51}{24750}$ = **17.72mpa**

2nd stone

Load = 438.49KN

$\delta = \frac{438.49}{24750}$ = **17.71mpa**

Ave. $\frac{\mathbf{17.72+17.71}}{\mathbf{2}} = \frac{\mathbf{35,43}}{\mathbf{2}}$ **= 17.72mpa**

Approximately 18mpa

Compressive strength test for concrete interlocking stone

1. **At day 7**

Area = 24750mm^2

Local = 291.36KN

δ = P/A = $\frac{291.36}{24750}$ = 0.01177 = 11.77mpa

Load = 273.55KN

$\delta = \frac{273.55}{24750}$ = 11.05mpa

Ave. $\frac{\mathbf{11.77+11.05}}{\mathbf{2}} = \frac{\mathbf{22.82}}{\mathbf{2}}$ **= 11.41mpa**

2. **At day 14**

Area = 24750mm^2

Local = 352.54KN

$\boldsymbol{\delta} = \frac{352.54}{24750}$ = 14.24mpa

Load = 380.40KN

$\delta = \frac{380.40}{24750}$ = 15.37mpa

Ave. $\frac{\mathbf{14.24+15.37}}{\mathbf{2}} = \frac{\mathbf{29.61}}{\mathbf{2}}$ **= 14.81mpa**

3. **At day 28**

Area = 24750mm^2

Load = 426.16KN

$\delta = \frac{426.16}{24750}$ = 17.22mpa

Load = 426.16KN

$\delta = \frac{420.06}{24750}$ = 16.97mpa

Ave. $= \frac{\mathbf{17.22+16.97}}{\mathbf{2}} = \frac{\mathbf{34.18}}{\mathbf{2}}$ **= 17.09mpa**

Table 1: Compressive strength test results

Duration	Recycled Plastic Interlocks	Concrete Interlock Stone
7 days	8.17mpa	11.18mpa
14 days	14.89mpa	14.71mpa
28 days	17.72mpa	17.09mpa

The result in Table 1, indicated that the compressive strength tests revealed a gradual increase in strength over time for both recycled plastic and concrete interlocks. While concrete interlocks consistently demonstrated slightly higher compressive strength values throughout the 28-day curing period, the recycled plastic interlocks showed a significant improvement in strength from 7 days to 28 days. This indicates that recycled plastic interlocks may gain strength over time, potentially making them suitable for a wider range of applications.

However, the observed increase in compressive strength of recycled plastic interlocks is likely due to the ongoing curing process, which involves the formation of chemical bonds within the material. This suggests that the long-term performance of recycled plastic interlocks may be comparable to concrete, especially when given sufficient curing time.

III. DISCUSSION

The findings of this study highlight the potential of recycled plastic as a viable alternative to traditional concrete interlock materials, particularly in applications where water resistance is a primary concern. While recycled plastic interlocks may not always match the compressive strength of concrete interlocks, their superior water absorption properties and potential for long-term strength gain offer significant advantages.

Future research should focus on exploring strategies to further enhance the compressive strength of recycled plastic interlocks, particularly at early curing ages. Additionally, long-term durability and environmental impact assessments are necessary to fully evaluate the sustainability of recycled plastic interlocks in various construction scenarios. And by addressing these areas, recycled plastic interlocks could become a more competitive and sustainable option for infrastructure projects, contributing to a circular economy and reducing the environmental burden of plastic waste.

IV. CONCLUSION

The results of this research demonstrate the potential of recycled plastic interlock stones as a suitable alternative to traditional concrete interlocks. While concrete interlocks have a small increase in compressive strength throughout the 28-day curing period, recycled plastic interlocks demonstrate lower water absorption rates significantly and exhibited promising strength gains over time. This suggests that recycled plastic interlocks may be particularly suitable for applications where water resistance is a critical factor, and their compressive strength can be sufficient for various load-bearing requirements, especially with proper curing and design considerations. Hence, it is recommended that L*ong-term Durability should be* conducted to assess the durability of recycled plastic interlocks under various environmental conditions. And *Mechanical Properties* Investigate methods should be carried out to further enhance the compressive strength of recycled plastic interlocks, particularly at early curing ages.

REFERENCES

[1] American Chemistry Council (ACC) (2021). Plastics Recycling. https://www.americanchemistry.com/better-policy-regulation/plastics

[2] ASTM International. ASTM D638-14, "Standard Test Method for Tensile Properties of Plastics". (ASTM International, 2015)

[3] Babafemi, A., Šavija, B., Paul, S. and Anggraini, V. (2018). Sustainability, "Engineering properties of concrete with waste recycled plastic": A review 29, 101131.

[4] Bhat, R. R., Mohan, N. S. Rohatgi, S. and K. Subramaniam. (2018). International Journal of Mechanical Engineering and Technology 9, 813-819.

[5] Canada Construct Connect Canada. (2021, August). Interlocking plastic bricks could be a 'game-changer'. https://canada.constructconnect.com/

[6] Dai, S., Wang, H., Wu, H. and Zhang, M. (2003) A review on mechanical properties of recycled plastics. Journal of Building Engineering, 29, 101131.

[7] Dai, S., Wang, H., Wu, H. and Zhang, M. (2003) A review on mechanical properties of recycled plastics. Journal of Building Engineering, 29, 101131.

[8] Dawodu, P. O., Akindele, A. and Imoh, U. (2022). Recycling of Waste Plastic for the Production of Road Interlocking Paving Stone in Nigeria. Journal of Engineering.

[9] Frigione, M. (2010). 7. C. Hopmann, S. Schippers & C.Höfs, J. Appl. Polym. Sci. 132, 9 (2015). Mechanical Properties of recycled Plastic waste with the Polyster (Oxford), “Waste Manage” (30) 1101-1106

[10] Geyer, R., Jambeck, J. R. and Law, K. L. (2017). Production, use, and fate of all plastics ever made. Science Advances, 3(7), e1700782.

[11] Geyer, R., Jambeck, J. R. and Law, K. L. (2017). Production, use, and fate of all plastics ever made. Science Advances, 3(7), e1700782.

[12] Hossain, M. U., Poon, C. S., and Lo, I. M. (2019). Review on use of recycled aggregates in concrete. Journal of Materials in Civil Engineering, 31(9), 04019128.

[13] Jambeck, J. R. (2015). Plastic waste inputs from land into the ocean. Science, 347(6223), 768-771.

[14] S Dai, H Wang, H Wu, M Zhang (2003) Exploration of the mechanical properties, durability and application of geopolymers: A review.

[15] Thorneycroft, J., Orr, J., Savoikar, P. and Ball, R. J. (2018). Construction and Building “Performance of structural concrete with recycled plastic waste as a partial replacement for sand”

Cite this Article: Stanley E. Ubi, Abua Augustine & Ogar E. Edom. (2025), The Use of Recycled Plastics as Interlock Materials. International Journal of Structural Engineering (IJSE), 7 (1), 1–13.

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