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Experimental Investigation on Waste-plastic Reinforced Concrete Brick

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Abstract:- The accumulation of plastic waste is a growing concern as disposable plastic products such as bags and water bottles, PVC pipes continue to be produced and discarded regularly. Disposing of plastic is challenging since it is not biodegradable and has a lower recycling rate than other materials. One promising solution is to manufacture concrete blocks using plastic flakes as an alternative material aggregate. This study sought to develop and test these blocks' compressive strength, taking into account factors such as the cement to aggregate ratio, water to cement ratio, size of plastic flakes, and proportion of plastic flakes replacing sand. The optimal mix for achieving high compressive strength was found to be a ratio of 1:3 cement to aggregate, with 20% small and medium-sized plastic flakes mixed with 80% sand and a water to cement ratio of 0.5. The goal of this study is to reduce plastic waste pollution while also providing an alternative to traditional fine aggregate.

Keywords:- *Plastic Waste, Concrete, Economic Plastic waste, Sustainability, Lightweight concrete Insulation.*

I. INTRODUCTION

The Since the 1920s, plastic materials have become an integral part of modern-day life, permeating various aspects, from microchips in computers to shopping bags. Plastics, which are polymers and not just one material, are widely used in diverse industrial sectors, with packaging being the largest consumer (36%) (Fig. 1). The versatility and usefulness of different types of plastics with their unique properties are evident in Table 1, which highlights their mechanical properties at room temperature. [1]-[6]

One of the most advantageous characteristics of plastics is their durability and resilience, allowing for the fabrication of long-lasting products that require minimal maintenance, making them cost-effective over their lifespan (Ragaert et al., 2017).[8] This widespread use of plastics in daily interactions is due to their advantages over other materials, resulting in a projected doubling of plastic production in the next ten to twenty years, with an estimated 700 million tons of plastic to be produced by 2050. Asia, North America, and Europe are expected to be the major producers, accounting for 50%, 10%, and 16% of the global supply, respectively (Truchot et al., 2018).[10]-[12].

However, the accumulation of plastic waste on the Earth's surface is a significant environmental challenge, arising from sources such as packaging industries and households, resulting in around 6.5 billion tons of plastic waste being generated worldwide each year (Jnr et al., 2018). Non-biodegradable nature of most plastics, with a degradation period of over 400 years, leads to their accumulation in landfills, causing space constraints and impacting landfill sites (Da Costa et al., 2016). Moreover, plastic waste has become a threat to marine habitats, biomes, and human health, as studies have shown that the degradation of plastic waste produces nanoparticles that negatively affect animal health and are added to the food chain (Prata et al., 2019; Singh and Ruj, 2015) [9].

To address the growing environmental burden, concrete actions need to be taken. Currently, incineration and recycling are the main methods employed to reduce plastic waste (Jassim, 2017; Eriksson and Finnveden, 2009). [14] Incineration involves burning plastic waste to generate energy, while recycling aims to reuse and convert plastics into new products, thereby reducing their accumulation in the environment. [15]

- *PLASTIC BRICK*

A sustainable and durable building material known as plastic reinforced concrete bricks is created by blending plastic waste, such as plastic bottles or plastic bags, with cement and other additives to form brick-shaped molds. The plastic waste functions as reinforcement, enhancing the strength and durability of the concrete, resulting in an environmentally friendly solution.

- *REPLACING PLASTIC WITH BRICK*

Substituting plastic-reinforced concrete bricks with conventional concrete bricks can potentially affect environmental impact, durability, cost, sustainability, and compliance with regulations. Thorough evaluation of these aspects, in addition to adhering to sound engineering and construction practices, is imperative in selecting construction materials. Keeping abreast of sustainable construction materials and technologies advancements is equally vital for making well-informed decisions and staying current with industry best practices.

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➢ *CHARACTERISTICS OF PLASTIC*

- **Tensile strength:** Tensile strength refers to the ability of a material to withstand stretching or pulling forces without breaking. Waste plastic can have varying tensile strength depending on the type of plastic, with some plastics exhibiting higher tensile strength than others.
- **Flexibility:** Flexibility refers to the capacity of a material to bend or undergo deformation without fracturing. Certain forms of plastic waste, like polyethylene and polypropylene, are recognized for their inherent flexibility and are widely used in various applications where plastic needs to exhibit flexibility, such as in the manufacturing of plastic bags or films.
- **Reactivity towards chemical:** Plastics exhibit higher chemical inertness compared to natural polymers like cotton and wool, as they are not reactive towards acids and alkaline.
- **Hardness:** Hardness refers to a material's ability to withstand indentation or scratching. The hardness of waste plastic varies depending on the type of plastic, with certain plastics like polyethylene being relatively soft, while others like polystyrene are harder.

➢ *PLASTIC BRICK*

- A **Waste reductio**n: Utilizing waste plastic in concrete bricks helps in reducing the environmental impact of plastic waste by diverting it from landfills or oceans and incorporating it into a useful construction material.
- **Improved mechanical properties:** Incorporating waste plastic in concrete bricks can enhance their mechanical properties such as strength, durability, and toughness, leading to improved performance and longevity of the bricks.
- **Cost-effective:** Utilizing waste plastic as a reinforcement in concrete bricks can potentially reduce the production cost of bricks, as plastic waste may be available at low or no cost.
- **Sustainable construction:** The use of waste plastic in concrete bricks aligns with sustainable construction practices by reducing the consumption of natural resources and promoting recycling and reuse of plastic waste.
- **Environmental benefits**: Incorporating waste plastic in concrete bricks can contribute to reducing the carbon footprint of construction materials, as the production of traditional bricks often involves energy-intensive processes and emissions of greenhouse gases.

II. METHODOLOGY

The methodology which is adopted in this experimental study is discussed in this chapter has explained by a flow chart diagram Fig 1.

- Collect waste plastic materials from local sources, such as plastic bags, bottles, or containers. Ensure that the collected plastic is clean and free from any contaminants.
- Tests (Physical) on collected materials: Conduct physical tests on the collected plastic materials to determine their properties, such as tensile strength, flexibility, hardness, and impact resistance. This information will help in determining the appropriate ratio of plastic powder to be used in the concrete mix.
- Once the plastic materials are collected, they need to be converted into a powdered form. This can be done by shredding or grinding the plastic materials using appropriate equipment. The resulting plastic powder should be of a consistent size and texture.
- Determine the appropriate ratio of plastic powder to be added to the concrete mix based on the physical test results and desired properties of the final bricks. Mix the plastic powder with the concrete in a predetermined ratio, typically by weight or volume. Thoroughly blend the materials to ensure uniform distribution of plastic powder in the concrete mix.
- Prepare a mold box of standard dimensions for the brick size desired. Place the mixed concrete with plastic powder into the mold box and compact it using appropriate techniques, such as vibrating or pressing, to achieve proper compaction and eliminate air voids.
- Allow the molded bricks to cure and dry for a specific period of time, typically under controlled environmental conditions. This will ensure proper setting and hardening of the concrete. After drying, carefully remove the bricks from the mold box and stack them for further curing, if required.
- Once the bricks are cured and dried, conduct various tests to evaluate their properties, such as compressive strength, water absorption, and durability. Compare the test results with standard specifications for bricks to assess the quality and performance of the waste plastic reinforced concrete bricks.

➢ *FLOW CHART OF METHODOLOGY*

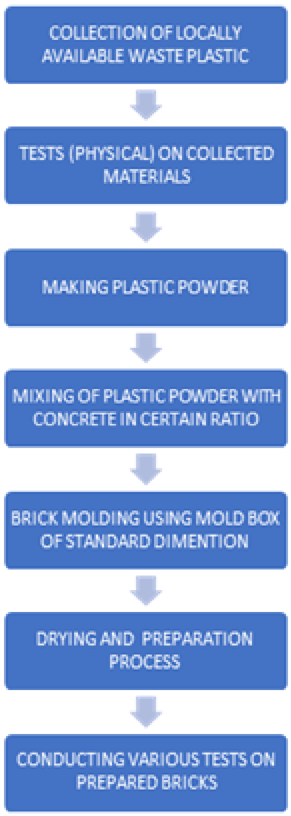

Fig 1 Flow Chart of Methodology

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➢ *PREPARATION PROCESS*

Fig 2 Preparation Process

III. MATERIALS USED

There are different types of materials used for the manufacture of plastic brick are,

- Cement
- Gravel
- Plastic
- Sand

➢ *Cement*

Cement, a fundamental material in the construction sector, serves as a binder in the production of concrete, which is extensively utilized in global construction projects. The origins of cement production can be traced back to ancient times, with the utilization of lime-based cement as early as 700 BC. However, modern cement production commenced in the 19th century with the invention of Portland cement, the most widely used type of cement today.

The process of cement manufacturing typically involves clinker production, wherein raw materials like limestone, clay, shale, and silica are quarried, crushed, and blended with small quantities of additional materials, such as gypsum, to create a homogeneous powder. This powder is then subjected to high temperatures of up to 1450°C in a kiln, resulting in the formation of clinker. Subsequently, the clinker is finely ground to produce cement, which is utilized in construction. Cement is renowned for its exceptional binding properties, enabling it to solidify and harden upon mixing with water to create concrete. Concrete, which is made by combining cement with aggregates (such as sand and gravel) and water, finds wide-ranging applications in construction, including foundations, roads, bridges, dams, and more. Cement imparts strength, durability, and versatility to concrete, rendering it an indispensable component of contemporary construction practices.

However, cement production is associated with environmental concerns, such as carbon emissions from fossil fuel combustion in kilns, as well as potential impacts on land and water resources due to quarrying and mining. In recent years, concerted efforts have been undertaken to develop sustainable and eco-friendly cement production methods, including the utilization of alternative raw materials, optimization of kiln processes, and exploration of carbon capture and utilization technologies.

In conclusion, cement plays a pivotal role in the construction industry by providing crucial binding properties for the production of durable and versatile concrete. While environmental challenges persist, ongoing research and development endeavors in cement production aim to mitigate the impacts and promote sustainable practices for the future of construction.

➢ *Gravel*

Gravel, which comprises small, rounded rocks or pebbles and falls in size between sand and cobblestones, ranging from 2mm to 75mm in diameter, is a granular material. It exhibits a range of colors and textures, influenced by the type of rocks from which it originates. Due to its durability, excellent drainage properties, and versatility, gravel is widely utilized in construction, landscaping, and road building. Its interlocking characteristics make it ideal for creating stable foundations, road bases, and pathways. Moreover, gravel is commonly employed in decorative applications, such as in gardens, driveways, and pathways, owing to its aesthetic appeal and ability to enhance outdoor spaces. Gravel is often graded based on size, shape, and quality, catering to specific uses. It is a readily available natural resource that serves as a valuable asset to various industries worldwide. Regulations are in place for gravel extraction and production to mitigate environmental impacts, such as habitat disruption and erosion.

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➢ *Plastic*

Plastic, being a man-made material, presents numerous environmental challenges due to its non-biodegradable nature. Despite its wide-ranging applications driven by its durability and low-cost production, plastic persists in the environment for extended periods, resulting in pollution and detrimental effects on wildlife. The accumulation of plastic waste, including single-use items like straws and plastic bags, in landfills and oceans leads to habitat destruction, water pollution, and threats to marine life. Moreover, plastic production contributes to greenhouse gas emissions and relies on fossil fuels, exacerbating climate change. To address the issues associated with plastic pollution, it is imperative to focus on reducing plastic consumption, improving waste

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management, promoting recycling and sustainable alternatives, and raising awareness about the detrimental impacts of plastic on the environment.

- *Sand*

The composition of sand is highly diverse, consisting of various rocks and minerals, resulting in differences in its chemical properties. The predominant component of sand is typically quartz, which is primarily composed of silicon oxide. In terms of physical characteristics, sand is comprised of small, loosely packed grains that are larger than silt but smaller than gravel.

Sand is categorized as a granular material composed of finely divided particles derived from rocks and minerals. It is differentiated by its size, falling between the coarser texture of gravel and the finer texture of silt. Additionally, sand can refer to a specific textural class of soil that contains more than 85 percent of sand-sized particles by mass. Silica, specifically in the form of quartz, is the most common constituent of sand, although the composition may vary depending on the local sources and environmental conditions. Notably, sand is considered a non-renewable resource on human timescales, and the demand for sand suitable for concrete production is high.

In accordance with Indian standards set by IS, the collection and utilization of sand for concrete typically involves using sand that passes through a 4.75mm sieve. River sand is commonly employed for paving purposes.

IV. TESTS ON BRICK

- *Compressive strength test*

The cube specimens were positioned in a compression testing machine, and the load was gradually applied without any sudden impact, steadily increasing at a rate of about 15kN/mm^2 per minute until the specimen's resistance gave way and could no longer withstand additional load. The maximum load endured by the specimens was documented, and any peculiar characteristics or atypical forms of failure in the brick's appearance were carefully observed and recorded.

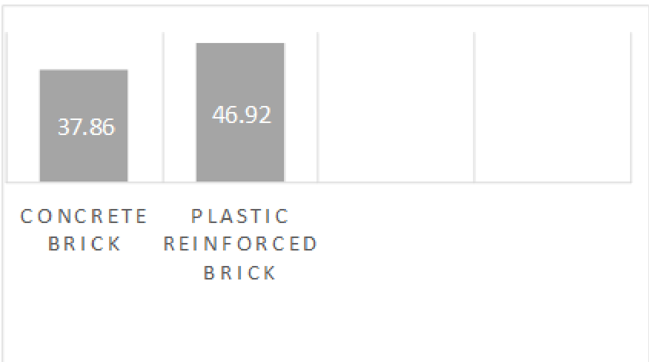

Fig 3 Compression Strength (kN/mm^2)

Fig 4 Compressive Strength Test in UTM

- *Water absorption test*

In this examination, bricks are first weighed when dry, and then immersed in fresh water for 24 hours. After being removed from the water and wiped with a cloth, the bricks are weighed again while wet. The disparity between the two weights represents the amount of water absorbed by the bricks. The percentage of water absorption is subsequently calculated, with lower values indicating higher quality bricks. A good quality brick should not absorb more than 20% of its own weight in water.

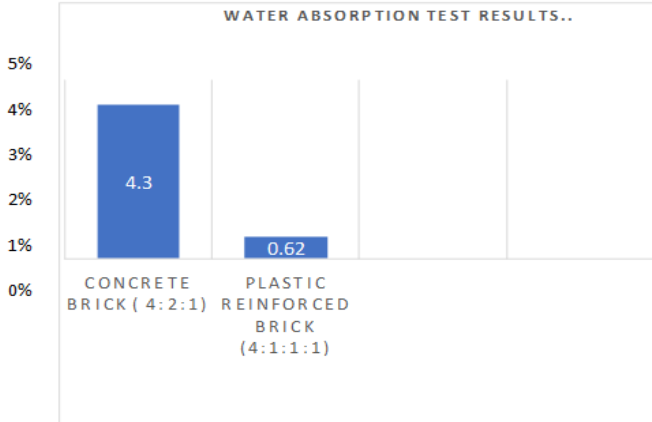

Fig 5 Water Absorption Test Results..

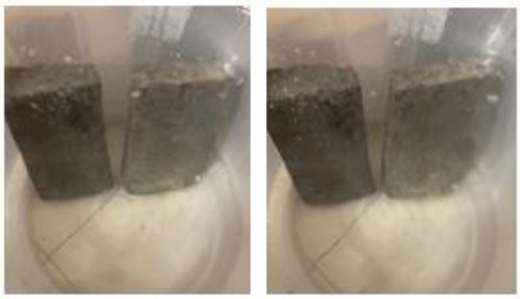

Fig 6: Immersed bricks in water for 24hrs

- *Water absorption test*

The Plastic material is prone to catching fire easily, but when it is used to make sand bricks or paver blocks, the sand content provides insulation. The structural properties of the bricks remain unchanged up to a temperature of 180˚C, beyond which visible cracks start appearing and the bricks degrade further with increasing temperature, as observed.

V. APPLICATIONS (OR) USES

- Used to marine work.
- Used to water tank construction.
- Construction the walls and building.
- Used to sewer pipe construction.

VI. CONCLUSION

Effective utilization of plastic waste, readily available in abundance, in the production of bricks can significantly reduce plastic waste in the environment, thereby mitigating environmental pollution. Incorporating plastic powder in bricks not only offers a sustainable solution to plastic disposal, but also reduces the usage of sand in concrete bricks, making it a cost-effective alternative. Additionally, plastic bricks exhibit low water absorption. The systematic use of plastic powder aggregate in the construction industry has the potential to curb the harmful environmental impact of slow-degrading plastic, which is currently a major concern. Emphasizing on the quality and biodegradability of plastic, integrating plastic powder in brick production can be a viable approach towards addressing this environmental issue.

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