A Study on Strength and Durability of Plastic Waste - Based Bituminous Bricks

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***Abstract*—This study focuses on the effective management and recycling of plastic waste by utilizing it in the production of paving bricks, thereby reducing the consumption and cost of conventional raw materials used in construction. A series of experimental investigations were carried out using different material combinations to develop an improved paving brick with maximum incorporation of shredded plastic waste as a partial aggregate. In this approach, bitumen is used as a binding material instead of conventional binders such as cement. The use of bitumen enhances important properties of the paving bricks, including flexibility, durability, and resistance to water penetration. Incorporation of plastic waste in the mix not only reduces the overall weight of the bricks but also improves their strength, reliability, and other physical characteristics when compared to conventional bricks. Additionally, small quantities of metal chips, M-sand, and aluminum mesh are included in the mix to further enhance the strength of the bricks. The prepared mixture is heated in a controlled environment at temperatures ranging from 150°C to 300°C until a semi-fluid state is achieved. This material is then poured into molds of the desired shape and allowed to cool, forming the final brick units.Subsequently, cost analysis and compressive strength tests were conducted to evaluate the performance of the developed bricks. The results demonstrate that this method provides a viable and sustainable solution for addressing the growing issue of plastic waste disposal while producing durable construction materials.**

***Index Terms*—Plastic waste bricks, Bituminous bricks, Sustainable construction materials, Waste plastic recycling, Compressive strength, Water absorption, Lightweight bricks, Polymer modified bricks, Eco friendly paving blocks, Construction waste utilization.**

I. INTRODUCTION

Rapid urbanization and industrial growth have resulted in a substantial increase in plastic waste generation across the world. Disposal of plastic materials has become one of the most critical environmental challenges because most plastics are non biodegradable and remain in the environment for several decades. Landfilling and open burning of plastic waste create severe ecological and health related problems including soil contamination, air pollution, and groundwater degradation. Researchers and engineers have therefore focused on identifying sustainable methods for recycling plastic waste into value added construction materials. Among various alternatives, the utilization of waste plastic in paving blocks and bricks has gained considerable attention because of its ability to improve material performance while reducing environmental burden. Plastic modified construction materials exhibit lower water absorption, enhanced durability, and improved resistance against chemical attack compared to conventional masonry units. The replacement of conventional binders with bituminous materials further improves flexibility and impact resistance of paving products intended for pedestrian and light traffic applications (Kognole et al., 2019; Verma et al., 2018).

Bitumen based composite bricks prepared using shredded plastic waste provide several engineering and economic advantages over traditional cement concrete bricks. Plastic waste acts as a reinforcing and binding component that enhances ductility and reduces brittleness of the brick matrix. The incorporation of M sand and metallic additives such as aluminum mesh and metal chips improves load distribution and crack resistance characteristics. Previous investigations reported that thermoplastic waste materials soften under controlled heating conditions and form a semi fluid matrix capable of encapsulating aggregate particles, thereby producing dense and durable composite units. The use of bitumen as a binder also

improves adhesion between plastic particles and aggregates, resulting in reduced porosity and enhanced moisture resistance. Although several studies have investigated plastic aggregate bricks and polymer composites, limited research has focused on the combined utilization of shredded plastic waste, bitumen, metal chips, aluminum mesh, and M sand for development of lightweight and durable paving bricks. Therefore, the present investigation evaluates the mechanical strength, water resistance, density characteristics, and economic feasibility of plastic waste based bituminous bricks produced under controlled heating conditions (Siddique et al., 2008; Saikia and Brito, 2012; IS 3495, 1992).

II. MATERIALS AND METHODS

Shredded plastic waste collected from domestic and commercial sources was used as the primary material for brick preparation. The plastic waste mainly consisted of polyethylene and polypropylene materials, which were cleaned, dried, and shredded into small pieces before use. Bitumen of VG 30 grade was utilized as the binding material because of its excellent adhesion and waterproofing properties. M sand was incorporated as a fine aggregate replacement material to improve particle packing and surface texture. Small quantities of metal chips and aluminum mesh were added to enhance structural stability, crack resistance, and load transfer characteristics within the brick matrix.

Different combinations of plastic waste, bitumen, M sand, and reinforcing additives were prepared to determine the optimum mix proportion. The materials were heated in a temperature controlled chamber between 150°C and 300°C until a semi fluid consistency was achieved. The heated mixture was then poured into metallic molds of standard dimensions and compacted manually before cooling under ambient laboratory conditions. After curing, the bricks were subjected to compressive strength test, water absorption test, impact resistance test, abrasion resistance test, and density measurements according to relevant IS specifications. Cost analysis was also carried out to evaluate the economic feasibility of the developed paving bricks in comparison with conventional cement concrete bricks.

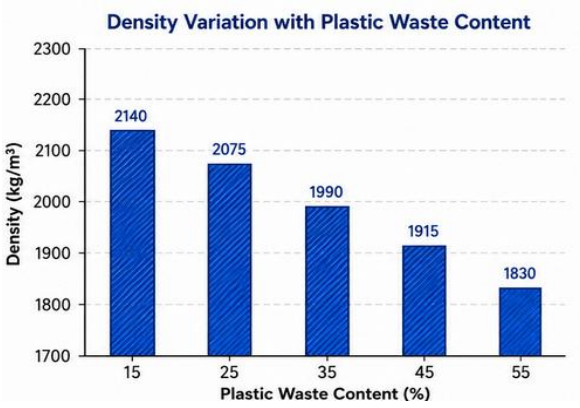
III. RESULTS AND DISCUSSION

The incorporation of plastic waste and bitumen significantly influenced the physical and mechanical characteristics of the paving bricks. Increasing plastic content improved flexibility and reduced the self weight of the bricks because of the lower density of polymer materials compared to conventional aggregates. The addition of M sand and metal chips enhanced internal bonding and reduced crack formation under loading conditions. The optimum performance was observed for the mix containing 35% plastic waste, 12% bitumen, 45% M sand, and 8% reinforcing additives.

Table 1. Physical Properties of Plastic Waste Based Bituminous Bricks

Plastic Waste (%)	Density (kg/m³)	Water Absorption (%)	Abrasion Loss (%)
15	2140	4.8	6.5
25	2075	4.1	5.8
35	1990	3.4	4.6
45	1915	3.1	4.3
55	1830	2.8	4.0

The results indicate that increasing plastic waste content reduced density and water absorption because the bitumen coated plastic matrix minimized pore connectivity and moisture penetration. Abrasion resistance also improved because the thermoplastic matrix absorbed impact energy and reduced surface wear during testing.



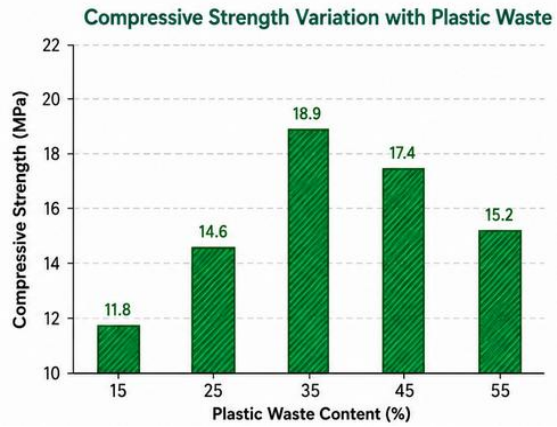
Compressive strength increased with increasing plastic content up to the optimum level because the melted plastic and bitumen formed a strong encapsulating matrix around aggregate particles.

However, excessive plastic content slightly reduced strength because of reduced rigidity and excessive flexibility within the brick structure. The inclusion of aluminum mesh and metal chips significantly improved crack resistance and load carrying capacity.

Table 2. Compressive Strength Characteristics of Bituminous Bricks

Plastic Waste (%)	Compressive Strength (MPa)	Impact Resistance (No. of Blows)
15	11.8	18
25	14.6	24
35	18.9	31
45	17.4	28
55	15.2	22

The highest compressive strength value of 18.9 MPa was observed at 35% plastic waste incorporation. The improvement in strength can be attributed to effective bonding between bitumen coated plastic particles and M sand aggregates. The reinforced composite structure distributed stresses more uniformly and delayed crack propagation under compressive loading conditions.

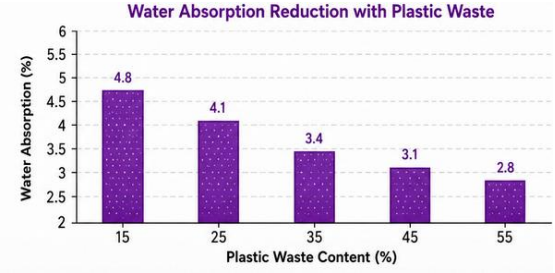


Water absorption characteristics demonstrated substantial improvement compared to conventional cement bricks because the plastic bitumen matrix significantly reduced permeability. The developed bricks exhibited excellent resistance against moisture penetration and maintained structural integrity under wet conditions. Cost analysis indicated that replacement of conventional materials with waste plastic reduced production costs by approximately 18% because of lower cement consumption and utilization of waste materials.

Table 3. Comparative Cost Analysis of Brick Production

Brick Type	Production Cost per 1000 Units (₹)	Average Service Life (Years)
Conventional Cement Brick	6200	12
Plastic Bituminous Brick	5080	18

The improved durability characteristics of plastic bituminous bricks can be attributed to the flexible and waterproof nature of the polymer bitumen matrix. Reduced porosity minimized water ingress and chemical attack, while the thermoplastic properties enhanced impact resistance and toughness under repeated loading conditions. The developed bricks demonstrated suitability for paving applications, pedestrian walkways, and low traffic zones where lightweight and durable construction materials are required.



IV. CONCLUSION

The present investigation demonstrates that plastic waste based bituminous bricks provide a sustainable and economical solution for recycling non biodegradable plastic waste into useful construction materials. The incorporation of shredded plastic waste, bitumen, M sand, metal chips, and aluminum mesh significantly improved compressive strength, impact resistance, abrasion resistance, and moisture resistance characteristics of the paving bricks. Increasing plastic content reduced density and water absorption because of the waterproof and flexible nature of the polymer bitumen matrix. The optimum mix containing 35% plastic waste produced the highest compressive strength and exhibited superior durability performance compared to conventional cement bricks. The inclusion of reinforcing additives further enhanced

crack resistance and load carrying capacity. Cost analysis confirmed that the developed bricks are economically viable because of reduced material consumption and utilization of waste resources. The findings indicate that plastic waste based bituminous bricks can serve as durable, lightweight, and environmentally sustainable alternatives for paving and non structural construction applications.

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