iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** II **Month of publication:** February 2023

DOI: https://doi.org/10.22214/ijraset.2023.49291

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue II Feb 2023- Available at www.ijraset.com

A Review Paper on Reuse of Plastic Waste as Pavement Construction Material

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Abstract: The exponential rise in the production of plastic and the consequential surge in plastic waste have led the scientists and researchers look out for innovative and sustainable means to reuse/recycle the plastic waste in order to reduce its negative impact on environment. Construction material, converting waste plastic into fuel, household goods, fabric and clothing are some of the sectors where waste plastic is emerging as a viable option. Out of these, construction material modified with plastic waste has garnered lot of attention. Modification of construction material with plastic waste serves a dual purpose. It reduces the amount of plastic waste going to landfills or litter and secondly lessens the use of mined construction materials, thereby mitigating the negative impact of construction industry on environment. This article summarizes advances related to the use of plastic waste as a component of building materials. The inclusion of plastic waste as a binder, aggregate, fine aggregate, modifier or substitute for cement and sand in the production of bricks, tiles, concrete and roads has been comprehensively considered. The effect of the addition of plastic waste on strength properties, water absorption, durability, etc. was also discussed in detail. Studies reviewed for this review were categorized according to whether they used plastic waste to produce bricks and tiles or concrete for road construction.

I. INTRODUCTION

Accumulation of plastic waste over the years and the lack of suitable disposal techniques have given rise to a crucial and unparalleled crisis where plastic waste is clogging our water resources and waterways, overflowing the landfills, leaching into soil and transferring through air, thus polluting every natural resource in our environment. Longevity; which is one of the most beneficial features of plastic, is also a detrimental factor in its safe disposal. In reality, plastic materials never degrade completely but disintegrate into smaller pieces over hundreds of years. According to a report by the United Nations Environment Programme, around 300 mil- lion tonnes of plastic waste is generated every year globally, whereas plastic waste ever recycled merely counts to 9%. A statement by UNEP executive director Inger Andersen: 'By 2050, we will have about a billion metric tons of plastic in our landfills. We need to make a shift'. Owing to the beneficial properties such as longevity, lightweight, water resistant, high elasticity, strength, durability, resistant to corrosion, easy to transport and economical, plastics are otherwise highly useful materials. However, it is the overconsumption of plastic which is creating havoc. Plastics have become an indispensable part of our lives, so the only sustainable solution in sight to reduce plastic

II. PAST REVIEWS AND GAP

Recently, many reviews have emerged based on research on the utilization of various wastes at construction sites. In 2016 Tiwari et al. An overview of the assessment of whether various industrial wastes such as flooring ash, foundry waste, copper slag, plastic waste, recycled rubber waste and crushed glass aggregate can replace fine aggregate in concrete was outlined (Tiwari et al. 2016). Guand Özbakkaloglu summarized a study on plastic waste recycling methods and their additional effects on the properties and morphology of concrete (Gu and Özbakkaloglu, 2016). In 2018 Togroli et al. Consideration was given to the use of recycled waste in concrete pavements. Wastes considered include recycled crushed glass, steel slag, steel fibers, tires, plastics and recycled asphalt (Toghroli et al. 2018). Babafemi et al. An overview of the properties of concrete containing recycled plastic waste was presented. The effect of recycled plastic waste on mechanical properties and durability has been shown (Babafemi et al. 2018). A detailed review of the properties of mortar and concrete composites containing recycled plastics was also conducted (Mercante et al. 2018). Singh et al. critically reviewed the use of polyethylene terephthalate (PET) and marble dust in building composites (Singh et al. 2021). Another review reported that PET plastic blocks were used in Rohingya refugee camps (Haque 2019). Sally et al.The progress of brick production reinforced with fibers obtained from waste was analyzed (Salih et al., 2020).

Bejan et al. outlined lightweight concrete using a variety of waste materials such as fly ash, blast furnace slag, colloidal silica, tire waste, plastics and agricultural waste (Bejan et al. 2020).Avoyera and Adesina have published a detailed overview of using plastic waste as a component of cement composites. They also discussed the limitations and future prospects of using plastic waste (Awoyera and Adesina 2020). Mr. Lee. Others. The effect of adding rubber and plastic waste to concrete as aggregate was studied in detail (Li et al.2020). Another review was recently published on the use of plastic waste as aggregates in building materials and its effect on mechanical properties and durability (Zulkernain et al. 2021). Vishnu and Singh gave an overview of the suitability of various wastes.

TABLE I
DETAILS FROM ALL THE RESEARCH

S.no.	Application	Type of Plastic	Amount Used	Tests performed	Compressive strength	Author
1	In replacement of sand	PET	1, 3, 5, 7 and 10%	Flexural strength, Compressive strength and tensile strength	20.720	Hameed and Fatah Ahmed
2	Fine aggregate	PET waste	0–50%	Bulk density, porosity, water absorption, ultrasonic pulse velocity, compressive and flexural strength.	Reduced from 15 to 33%	Jaivignesh and Sofi (2017)
3	Fine aggregate	Plastic bags	10 to 40%	Compressive strength, workability, bulk density, UPV		Ghernouti et al. (2015)
4	Aggregate	HDPE	0 to 10% in an interval of 2%	Compressive strength	26.4 for paver blocks and 23	Vanitha et al. (2015)
5	Aggregate	Shredded plastic bags	0%, 0.5%, 1%, 2%, 3%, 5%	Workability, density, com-	26.1 MPa and maximum	Jain et al. (2018)
6	Aggregate	PVC powder and granules	10%, 20%, 30%	Slump, fresh and hardened densities, compressive strength, capillary water absorption and abrasiontest.		Bolat and Erkus (2016)
7	Aggregate	Plastic obtained from wrap-pers of chocolates, milk, grocery items, chips, etc		Marshall stability test, ductility, aggregate impactvalue, penetration		Singh et al. (2020)

				value, Los angles values and softening point		
8	Aggregate	Plastic bottles, cups, caps		Softening point, flash point, fire point,penetration value, ductility.		Chada Jithendra Sai Raja et al. (2020)
9	Binder	Waste polythene	5 to 11%	Stability value, flow value,		Sukaina et al. (2015)
10	Fine aggregate	Processed LDPE	1 to 5%	Marshall stability, porosity,		Pradeep Soyal (2015)
11	Substitute	E-waste and waste plastic	Waste plastic 4.5% to 6%, shredded electronic waste 7.5%, 10%, 12.5% and 15%	Marshall stability test, crush-ing value, effect value and loss abrasion value test		Dombe et al. (2020)
12	Aggregate	E-waste plastic	0%, 20% to 30%	Compressive strength, tensile strength and flexural strength, slump value test	Decreased from 47.18 to 22.15	Manjunath (2016)
13	Fine aggregate	Electronic plastic	0%, 10% and 20%	Compressive strength, flexural strength, tensile strength	Decreased from 18.55 to 10.72	Gavhane et al. (2016)
14	Aggregate	E-waste	7.5%, 14% and 21.5%	Compressive strength,	Decreased by 52.98%	Damal et al. (2015)
15	Modifier	Thermosets, elastomers, thermoplastics		Compressive strength, bending strength	320 MPa	Rokdey et al. (2015)
16	Modifier	Waste shredded plastic	6, 8, 10, 12 and 14%	Marshall stability, flow value, VFB		Rajput et al. 2016
17	Modifier	Thermosetting plastic		Dry density and reasonable compressive strength	Reasonable value	Panyakapo and Panyakapo(2008)

18	Coated over aggregates	Waste plastic		Marshall properties, impact values, abrasion, water absorption, soundness tests		Dawale et al. (2016)
19	Partial replacement of sand	High-impact polystyrene	0, 10, 30 and 50% by weight Workability, density and	0, 10, 30 and 50% by weight Workability, density and	30	Olofinnade et al. (2021)
20	Substitute	Recycled plastic aggregate(RPA)	(25, 50, 75 and 100%)	Compressive strength, thermal conductivity, flexuralstrength, bond strength	35	Basha et al. (2020)
21	*Coarse aggregate*	PET		Workability, compressive strength, slump value	30.3	Islam et al. (2016)
22		Polypropylene (PP)	From 0 to 2% by volume of mix	Workability, slump, com- pressive and splitting tensile strength and flexure strength values		*Ankur C.* Bhogaya ta and Arora (2017)
23	Partial replacement for fine aggregate	Six different plastic wastes	0, 2.5, 5, 7.5, 10 and 12.5%	Compressive strength	With 12.5% fine plastic Waste 47.0 12.5% coarse plastic waste 37.0, and with 12.5% mixed plastic42 MPa	Hama et al. (2017)

III. FUTURE SCOPE

Clearly, plastic waste can prove to be a sustainable additive and partial replacement of conventional construction materi- als thereby addressing the dual issue of management of plastic waste and helping in the reduction of footprints caused by construction industry on the environment. However, a long road is ahead before the commercial implementation of the idea can be realized.

More research is required to fully understand the advantages and limitations of plastic waste- based construction material qualitatively and quantitatively. Several issues to be addressed for commercialization and for future research are:

1) Optimum proportions of plastic waste as a constituent of construction materials are required.
2) Safe methods of sanitization of plastic waste in order to eliminate the potential contaminants.
3) Carbon life cycle analysis to validate sustainability requirements.
4) Profitability analysis for commercial production of such building material
5) Dedicated standards to evaluate the quality of plastic waste-based construction material.
6) Public awareness drives to communicate about the environmental and economic advantages of waste- based construction material are required for its accept- ance by consumers and public in general.

IV. CONCLUSIONS

Growing amounts of plastic waste in our ecosystem can be strategically tackled by its recycling/reuse in an effective and beneficial manner. This review gave a focussed summary of the research work being carried out to exploit plastic waste as a constituent of construction material. It is a meticulous study of utilization of waste plastic in construction bricks, blocks, tiles and concrete for road construction. It also touches the usage of medical plastic waste and admixtures of plastic waste with waste rubber in construction materials. On the basis of such an extensive study, the following are the conclusions:

Plastic waste from PET, PVC, PU, LDPE, HDPE, nylon 66, etc.

It can be used effectively with fly ash, sand, cement and other materials to produce bricks, blocks and tiles. However, PET waste is a profitable substitute.

1) Lightweight concrete with 10% HIPS and LDPE waste plastic achieved a compressive strength of 30 N/mm2 after 28 days of curing.
2) Concrete workability decreases as the plastic percentage increases. However, it can be maintained to some extent by increasing the water/cement ratio (W/C).
3) The workability of plastic waste concrete is highly dependent on the size, shape and roughness of plastic aggregate and the water/cement ratio.
4) Inclusion of waste plastics reduces the modulus of elasticity of concrete.
5) Waste plastic concrete is more resistant to chloride ion penetration and has less shrinkage when drying.
6) Recycled plastic cores can be successfully used in concrete brick/paving slab non-bearing panels.
7) Concrete with plastic bottle waste is useful for building makeshift shelters.
8) Plastic waste concrete can be very useful for low load structures such as partition walls and decorative tiles.
9) A mixture of plastic waste and crumb rubber serves as a modifier and binder in road construction.

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