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Application of plastic wastes as construction material for sustainable development: A review

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Abstract

The development of a sustainable ecosystem in the present period is seriously threatened by the effective disposal of plastic waste. This work aims to reduce the burning issue that leads to environmental pollution by reusing plastic waste bags as building materials for sustainable development. In this review study, a modified plastic mixer is created by combining shredded plastic waste bags with hot aggregates, and sand. Comprehensive research has been done on the use of plastic waste as a binder, aggregate, fine aggregate, modifier, or replacement for cement and sand in the production of bricks, tiles, concrete, and roadways. Additionally, the review of impact of plastic waste addition on tensile characteristics, water absorption, durability, etc. has been extensively examined.

Keywords: Waste plastic; Environment; Compression; Water absorption

1. Introduction

Plastic is a versatile material, most products today, likely have a plastic component to it. Plastics are being used today in the construction industry thanks to several of their properties. The wide variety of uses for plastic in the construction industry range from thermal insulation to plumbing, sinks, and baths to roof coverings. Plastic can be a chemically resistant, ductile, stable, and fire-resistant material. Its shape shifting abilities allow it to be used in electric insulation, and wall finishing, suitable pigments can also be added in the process of manufacturing of plastic materials to get a more attractive result for a building structure [1].

Currently, plastic materials find use in buildings, mainly in thin coverings, panels, sheets, foams, pipes, etc. However, more skillful use of plastics can one day expand the usefulness and durability of conventional building materials and help them to function more efficiently and economically [1]. Plastic is even being used to reinforce concrete. The next evolution in the technology of cement and demands for 18 delivering more eco-friendly and sustainable construction projects paved the way to the idea of disposing of post-consumer waste plastics into structural concrete. The raw plastic granulate is used as a partial substitute for sand aggregate, which treats concrete as a medium for disposal of waste in the amounts that do not significantly affect its strength. Previous research has proven that concrete reinforced with plastic fibers is a more resilient building material than plain concrete, opening the door to the recycling of plastic to produce fibers to be used as secondary reinforcement for concrete along the traditional steel rebars[2].

In India, management of plastic waste is a big challenge, which mostly constitutes PET and PE waste, hence this study considered these two major plastic wastes. The primary objective of this study is to evaluate the impacts on the environment due to various plastic waste management options. This study also considered collection and transportation phase of PET and PE waste recycling and included its impacts in all the four scenarios. The results of this study will show the impacts on the environment for collection and transportation of PET and PE waste and the four

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plastic waste management scenarios (land filling, incineration without energy recovery, recycling of PET and PE waste and incineration with energy recovery). This study also analyzed role of informal sectors and recycling industries in the process of PET and PE recycling[3].

60% of the plastic waste collected in India gets recycled back into raw materials for further processing into consumer products, while the remaining is left unutilized. This is problematic since 1 to 4 percent of India's municipal solid waste by weight is made of plastic waste. The plastic waste that is generated is collected informally, traded, and reprocessed by known methods into useful products [4].

2. Previous research on utilization of plastic waste

One of the main contaminants in solid waste around the world is plastic garbage. In marine and terrestrial habitats, billions of live animals perish as a result of the gradual decomposition of plastic garbage. To get rid of the plastic People from all over the world tried to break down or transform plastic garbage into useable form. The creation of gasoline from plastic and the construction of roads using plastic and bitumen as a construction material are likely better uses for plastic trash. the most economical and environmentally benign technique of plastic disintegration among all of them is thought to be biodegradation [5].

The environment faces a serious threat from waste plastic and its disposal, which causes pollution and global warming. The characteristics and strength of bituminous mixtures are improved when plastic garbage is added1. In addition it will also be a solution to plastic disposal & various defects in pavement viz., pot holes, corrugation, ruts, etc. Polyethylene, Polystyrene, and Polypropylene make up the used waste plastic. The waste plastic is crushed, covered with gravel, and combined with hot bitumen to create a mixture that is used to create pavement. The pavement will be strengthened and become more durable as a result. The titanium dioxide is employed as a smoke-absorbing substance, absorbing the smoke produced by the vehicles.The hot, humid atmosphere of India will benefit from this cutting-edge technology. In this paper, the authors of this paper had discussed about the soil properties to be considered in design of pavement, pavement design, process of construction flexible and plastic-smoke absorbent pavement[6].

The field experiments showed that plastic wastes could withstand pressure and be used in road construction. Using an additive after proper processing would lengthen the life of the roads and address environmental issues. Road construction has long used plastic. As PVC or HDPE pipe mat crossings constructed by connecting PVC (polyvinyl chloride) or HDPE (high-density poly-ethylene) pipes to create plastic mats, it is already in use. 3 to 4% of the bitumen is combined with powdered waste plastic that has been pulverised and processed. When compared to roads made of asphalt made from regular mix, the durability of roads made of shred plastic waste is substantially greater[7].

Waste disposal, especially the use of waste plastic bags, has become a significant issue. Waste plastics are burned for apparent disposal, which pollutes the environment. The use of used plastic bags in bituminous mixtures has shown that they improve the mix's characteristics as well as provide a disposal solution. Using a shredding machine, cleaned plastic trash is reduced in size till it can fit through a 2-3 mm sieve. When the aggregate mixture is heated, the plastic coats the aggregate efficiently. This plastic-coated gravel is combined with hot bitumen to create a mixture that is used to build roads[8].

Due to its non-biodegradability and unsightly appearance, waste plastic disposal is a threat and has grown into a severe problem on a global scale. To increase the needed mechanical properties for a particular road mix, waste plastic was used to partially replace the standard material. The developed methods for using plastic trash in the creation of flexible pavements and roads have been evaluated in the current paper. Bitumen is used as a binder in the traditional road construction process. Such bitumen can be altered by adding scrap plastic, and the resulting bitumen mixture can be utilized as the top coat of flexible pavement. This modified bitumen made from discarded plastic exhibits enhanced adhesion, stability, density, and water resistance[9].

Nearly 5% of municipal solid waste is discovered to include plastic, which is harmful by nature (MSW). Today, properly disposing of plastic garbage is a big issue.Plastic can be used to pave roadways with asphalt. India produces several million metric tonnes of plastic garbage annually. The disposal and pollution issues can be greatly reduced if these wastes can be used effectively in road construction. Bitumen is a binding agent used in the construction of roads. The bitumen can be altered by adding scrap plastic, creating a mixture that can be used as the top layer of flexible pavement and exhibits enhanced binding properties, stability, density, and water resistance[10].

By including waste plastic into bituminous mixtures, it has been demonstrated that the mixture's qualities are enhanced and that some of the disposal issues are partially resolved. Using a shredding machine, the cleaned plastic trash is

reduced in size till it fits through a 2.36 mm sieve. When the aggregate mixture is heated, the plastic coats the aggregates efficiently. To manufacture the job mix formula, the plastic waste-coated aggregates are combined with hot bitumen. The current study examines the use of used plastic in semi-dense bituminous concrete as a modifier. it has been found that the Marshall stability value is maximum when 12% plastic waste is added to the mix. The other Marshall parameters are also improved with the addition of plastic waste into the bituminous mix[11].

Due to changes in lifestyle and population growth, there is a growing amount of plastic garbage in municipal solid waste. As a result of plastics' inability to biodegrade, disposing of waste plastic is dangerous and has turned into a major problem on a global scale. Since plastic roads outperform conventional roads, they are increasingly used in road construction. Plastic trash disposal has grown to be a significant issue, and burning plastic waste to dispose of it pollutes the environment. Utilizing waste plastic bituminous mixtures has shown that they improve the mix's qualities while also resolving disposal issues[12].

A solid waste management system's primary goal is to successfully protect the health, safety, and welfare of the general public. Both the construction and plastics recycling industries value the development of new building materials made of recycled plastics. A significant amount of study examined the use of resins based on recycled PET plastic waste to create polyester concrete, which is a high performance composite material (PC). It may be possible to create high-quality PC at a lower source cost by employing resins made from recycled PET. A significant benefit in recycling applications is the long-term disposal of PET waste made possible by PC products[13].

The advancements in the use of plastic waste as a component of building materials are outlined in this study. It has been thoroughly examined if plastic waste may be used in place of cement and sand for making bricks, tiles, concrete, and roads as a binder, aggregate, fine aggregate, modifier, or replacement. Additionally, the impact of adding plastic waste has been thoroughly discussed with regard to tensile qualities, water absorption, durability, etc. Based on whether they discussed the use of plastic waste for bricks, tiles, or concrete for road building, the research studies taken into consideration for this evaluation have been divided into two categories[14].

3. Methods

3.1. Selecting and collecting the right plastic

It is important to only select the correct and unique type of plastic. This is because different types of plastic melt and burn at different temperatures and have different physical properties as mentioned in the literature review[15]. The process will describe here works well with PETE Water bags. It is important that other types of plastics are not added in the process unless they have the same physical and chemical properties. Time and technology in the country limits the ability to study these properties but to use literatures and other studies. So for the research, same types of products without any other impurities/different kind plastics will be use. Therefore PETE water bags would be used for the whole process. These plastic wastes are collected from office wastes, dump sites by plastic collectors and also bought from the market.

3.2. Shredding

The plastic bags will then cut into smaller pieces using scissors and cutters. In the developed countries this cutting process is made using a machine made to cut and grind the plastic in to more simplified and fine pieces. But for this research cutting are made manually by scissors and cutters in to small pieces for easy melting process.

3.3. Washing

The plastic chunks will then washed to remove glue, paper labels, dirt and any remnants of the product they once contained.

3.4. Drying

This process is for both the washed plastic and sand. An average sand is filled with humidity which makes it impossible to bond with [16]. For the sand, oven drying system or sun drying can be used. For this research, sun drying will be used for 24 plus hours for both materials.

3.5. Making of the mold

For this research, to give the molten plastic and sand mix its final shape of the tile, a mold will be prepared. This is to have the same size (15cm*15cm) as our comparison specimens of concrete tiles. This was manufactured by welding Mild Steel (MS) plates together.

3.6. Manufacturing

In developed countries there are plastic shredding, mixing and melting machineries available. But for this research purpose melting and production will be made traditionally by burning wood, and then mixing and melting using iron bowl or plate.

3.7. Melting

This will be done by gradually adding shredded plastic pieces in the melting plate. The source of heat is fire wood. As the plastic reached glass transition temperature, more plastic will be added. When it gains some significant amount of plastic body formation, will start adding sand to the molten plastic that plays the role of a binder.

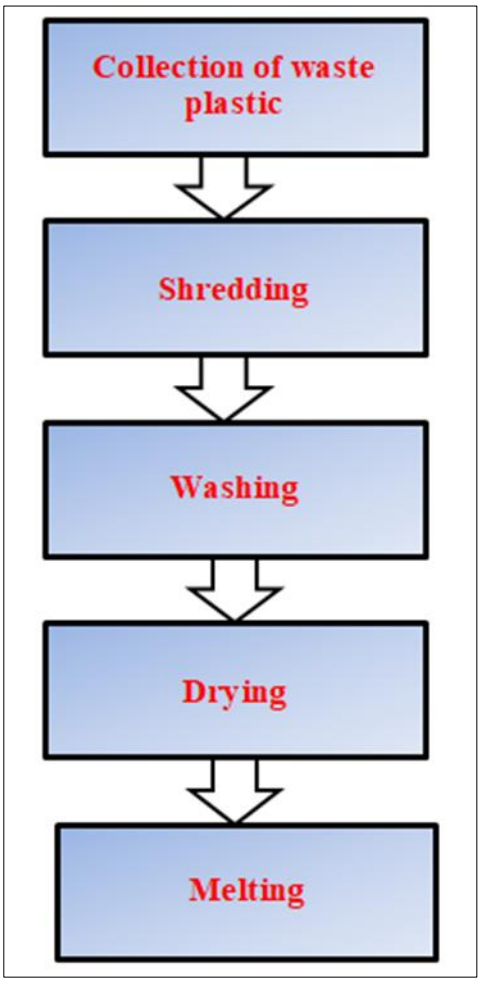

Figure 1 Schematic diagram for preparing composites based on waste plastics

3.8. Analytical techniques

3.8.1. Compression test

Compression test was conducted as per the ASTM D 695-2015 (Standard test method for compressive properties for rigid plastics). For this, the standard specimen size is 15 x 15 x 25.4mm. The specimen is placed between compressive plates parallel to the surface. The specimen is then compressed at a uniform rate. The maximum load is recorded along with stress-strain data.

3.8.2. Water Absorption test

In this test, tiles were weighed in dry condition and soaked in fresh water for 24 hours. After 24 hours of immersion, specimens were taken out from water and wiped out with clean dry cloth. Then, tiles were weighed in wet condition. The difference between weights is the water absorbed by tiles. The percentage of water absorption is then calculated. The less water absorbed by tiles the greater its quality. Good quality tiles don't absorb more than 3% water of its own weight.

3.8.3. Flexural Tensile Strength Test

Flexural strength testing was done according ASTM C67-0. The loading scheme was modified from third-point loading to center-point loading. A total of 5 samples were tested for each of the seven mix designs. A Universal Hydraulic UH Series Shimadzu universal testing machine with a maximum load capacity of 1000 KN was used. The machine was set up with a Linear Variable Differential Transformer (LVDT) displacement sensor to record mid-span deflection.

$$S = 3WL/2bd^2 \quad (1)$$

where:

- S = Modulus of rupture of the block at the plane of failure, PSI (Pound per Square Inch) (MPa);
- W = Maximum load indicated by the testing machine, lbs (N);
- L = Span length, in (mm);
- b = Average width of the block at the plane of failure, in (mm);
- d = Average depth of the block at the plane of failure, in (mm).

4. Conclusion

This paper reviewed the perfect use of waste plastics for construction application like road, building etc.The purpose of this study was to assess waste plastic material and its management practice as a reuse for construction Material and its optimization with respect to its impacts in the construction management fields. The study identified the major impacts of the plastic floor finish material and its application in the construction industry in reducing the main problems of the sector.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors whose names are listed in this study that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or nonfinancial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

References

[1] N. Shebek, V. Timokhin, Y. Tretiak, I. Kolmakov, and O. Olkhovets, "Sustainable development and harmonization of the architectural environment of cities," 2020.

[2] N. Pešić, S. Živanović, R. Garcia, and P. Papastergiou, "Mechanical properties of concrete reinforced with recycled HDPE plastic fibres," Construction and building materials, vol. 115, pp. 362-370, 2016.

[3] A. Bohra, A. K. Nema, and P. Ahluwalia, "Global warming potential of waste management options: case study of Delhi," International Journal of Environmental Technology and Management, vol. 15, pp. 346-362, 2012.

[4] V. Upadhyay, M. R. Prasad, A. Srivastav, and K. Singh, "Eco tools for urban waste management in India," Journal of Human Ecology, vol. 18, pp. 253-269, 2005.

[5] M. Shahnawaz, M. K. Sangale, and A. B. Ade, "Plastic waste disposal and reuse of plastic waste," in Bioremediation technology for plastic waste, ed: Springer, 2019, pp. 21-30.

[6] R. Manju, S. Sathya, and K. Sheema, "Use of plastic waste in bituminous pavement," Int J ChemTech Res, vol. 10, pp. 804-811, 2017.

[7] A. Trimbakwala, "Plastic Roads Use of Waste Plastic in Road Construction," International Journal of Scientific and Research Publications, vol. 7, pp. 137-139, 2017.

[8] M. A. J. Chavan, "Use of plastic waste in flexible pavements," International Journal of Application or Innovation in Engineering and Management, vol. 2, pp. 540-552, 2013.

[9] A. Gawande, G. Zamare, V. Renge, S. Tayde, and G. Bharsakale, "An overview on waste plastic utilization in asphalting of roads," Journal of Engineering Research and Studies, vol. 3, pp. 1-5, 2012.

[10] A. H. Mir, "Use of plastic waste in pavement construction: an example of creative waste management," IOSR Journal of Engineering (IOSRJEN), vol. 5, pp. 57-67, 2015.

[11] P. S. Rajput and R. Yadav, "Use of plastic waste in bituminous road construction," International Journal of Science and Technology & Engineering, vol. 2, pp. 509-513, 2016.

[12] V. Patel, S. Popli, and D. Bhatt, "Utilization of plastic waste in construction of roads," International Journal of Scientific Research, vol. 3, pp. 161-163, 2014.

[13] K. Rebeiz and A. Craft, "Plastic waste management in construction: technological and institutional issues," Resources, conservation and recycling, vol. 15, pp. 245-257, 1995.

[14] P. Lamba, D. P. Kaur, S. Raj, and J. Sorout, "Recycling/reuse of plastic waste as construction material for sustainable development: a review," Environmental Science and Pollution Research, pp. 1-24, 2021.

[15] M. Sepe, "The strain rate effect: last month we briefly discussed the influence of time as the second important factor in the mechanical response of polymers. The flip side of time is strain rate," Plastics Technology, vol. 57, pp. 21-24, 2011.

[16] M. M. Al-Tayeb, H. Ismail, O. Dawoud, S. R. Wafi, and I. Al Daoor, "Ultimate failure resistance of concrete with partial replacements of sand by waste plastic of vehicles under impact load," International Journal of Sustainable Built Environment, vol. 6, pp. 610-616, 2017.