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Use of waste tyres and plastics for road constructions

A Pirakasam *, V Harshidha, TM Mahalakshmy, K Arthi and R Aarthi

Department of Civil Engineering, E. G. S. Pillay Engineering College, Nagapattinam, Tamil Nādu, India.

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Abstract

The disposal of plastic waste and exhausted tyres of two wheeler, four wheeler vehicles is increasing day by day. Waste tyres and waste plastics in India are categorized as solid and hazardous waste. It is assessed that about 60% of disposed tyres and plastic wastes are through indefinite ways in the rural and urban zones. This leads to various environmental problems which include air pollution associated with open burning of tyres and plastics (particulates, odour, visual impacts and other harmful contaminants such as polycyclic aromatic hydrocarbon. Therefore, it is necessary to minimize the plastic and rubber wastes effectively in each field. To increase the mechanical characteristics of the conventional road by bitumen, bitumen was partly substituted with the waste materials of rubber and plastics. Then it is observed that the mechanical characteristics are improved for the road mix. Utilization of waste tyres and plastics to minimizes the use of conventional aggregate which is available in exhaustible quantity.

Keywords: Waste Plastics; Waste Tyres; Shredding; Blending; Crumb Rubber**.**

1 Introduction

Road network is the transportation which serves as the feeder system as it is nearest the people. So, the roads are to be maintained in the good condition. The quality of roads depends on materials used for constructions. Now-a-days, disposal of wastes produced from the different industries is a great problem. These materials pose environmental pollution in the nearby locality because many of them are non-biodegradable. Traditionally soil, stone aggregate, sand, bitumen, cement etc., are used for road constructions. Natural material being exhaustible in nature, its quantity is declining gradually. Also, cost of extracting good quality of natural material is increasing. Concerned about this, the scientists are looking for alternative materials for highway construction, by which the pollution and disposal problems may be partly reduced. Keeping this in mind the need for bulk use of these solid wastes in India, it was thought expedient to test these materials and to develop specifications to enhance the use of waste tyres and plastics in road making in which higher economic returns may be possible. The possible use of these materials should be developed for construction of low volume roads in different parts of our country. The necessary specification should be formulated and attempts are to be made to maximize the use of solid wastes in different layer of the road pavement.

Post construction pavement performance studies are to be done for these waste materials for construction of low volume roads with two major benefits [8].

- It will help clear valuable land of huge dumps of wastes.
- It will also help to reserve the natural reserves of aggregates, thus protecting the environment.

* Corresponding author: A Pirakasam
Department of Civil Engineering, E.G.S.Pillay Engineering College, Nagapattinam, Tamilnadu, India.

Rubber tyres and plastics are user friendly. But, not eco-friendly as they are non-bio degradable. The practice of disposing waste tyres under plastics in landfills and open burning is becoming unacceptable because of rapid depletion of available landfill sites and clear environment respectively.

The conventional bituminous mix includes stone aggregate and 3% to 5% bitumen by weight of the aggregate. The scrap type rubber and plastics can be incorporated into bitumen, often abbreviated as modified bitumen and granulated or ground rubber or crumb rubber and plastics can be used as portion of the fine stone aggregate. The use of waste in hot bituminous mixes enhances pavement performance, protect environment and provide low cost and quieter roads [1].

Waste plastic and tyres materials are shredded and blended with the bitumen. It builds the dissolving purpose of the bitumen and makes the street hold its adaptability amid winters bringing about its long life. Utilization of the destroyed plastics and rubber waste goes about a solid “Restricting specialist” for tar making the bitumen keep going long. By blending plastic and rubber with bitumen the capacity of the bitumen to withstand high temperature increments. The plastic waste and rubber waste are blended with bitumen in a specific proportion. The tests at the research level demonstrated that the bituminous blends arranged utilizing the treated bitumen fastener satisfied all the predefined Marshall Blend outline criteria for surface course of street asphalt. There was a significant increment 1n Marshall Stability estimation of the bituminous blend, of the request of a few times higher incentive in examination with the common bitumen. Another imperative perception was the bituminous blend arranged utilizing the treated fastener could withstand antagonistic drenching conditions submerged for longer term.

Figure 1 Plastic and Rubber waste

1.1 Waste Tyre and Plastic Roads

Figure 2 Plastic waste road — Bangalore

Plastic and Rubber roads are exactly what they sound like, they are roads made primarily of plastic and rubber. To be more specific, they are made of recycled waste plastics such as water bottles and straws, or in some designs with rubber taken from everyday items such as bike tyres. The reason for its development is relevant now more than ever, with our growing worldwide epidemic with the rise of excess overflowing in landfills both on a land and within the ocean. As a result, to counter issues like these, plastic and rubber roads were developed as a plausible answer to these modern day problems. Given how much plastics and rubbers are used during the production, and how reusable it presents itself to be during maintenance, they serve to be one of the potential leading products to fight against environmental pollution

[6]. As now plastic and rubber roads are seen to be one of the most efficient means of waste recycling presently, with the goal to reduce plastic and rubber buildup in landfills around the world. With little waste emission and consistent sources of materials always at hand, plastic and rubber roads are able to increase production routinely without the need to cut down on valuable resources that can be allocated better elsewhere.

1.2 Research Contribution

The plastic and rubber wastes could be utilized as a part of development of streets and the field tests withstood the anxiety and demonstrate that plastic and rubber squanders utilized after appropriate handling as an added substance would enhance the life of the streets and furthermore understand natural conditions. The present study highlights the advancements in utilizing plastic and rubber wastes to make plastic and rubber streets. The fast rate of urbanization and improvement has prompted expanding plastic waste era. Disposal of plastic and rubber wastes are difficult as plastic and rubber tyres are non-biodegradable in nature, it stays in condition for quite a while and arranging plastic and rubber squanders at landfill and dangerous since harmful chemicals filler out into the dirt, and under-ground water and dirty the water bodies [2]. Because of littering propensities, lacking waste administration framework/ foundation, plastic and rubber waste transfer keep on being a noteworthy issue for the city specialists, particularity in the urban regions. As expressed above, plastic and rubber transfer are one of the significant issues for creating nations like India, at a same time India needs a substantial system of streets for its smooth financial and social improvement. Shortage of bitumen needs a profound thought to guarantee quick development of roads.

Figure 3 Paving Road using Waste tyres

2 Methodology

2.1 Materials

The major materials include Bitumen, Fine aggregate, Coarse aggregate and Quarry dust, Plastic wastes (Like LDPE, HDPE, Polypropylene and Crumb rubber are used to prepare the Rubber Road Construction.

2.2 The four basic process undergoes are as follows

- Segregation stage
- Cleaning stage
- Shredding stage
- Blending stage

2.2.1 Segregation stage

Plastics are typically arranged by their compound structure of the polymer's spine and side ~~chain~~s. Some critical gatherings in these orders are the acrylics, poly-esters, silicones, polyurethanes, and halogenated plastics. Plastics can likewise be characterized by the concoction procedure utilized as a part of their amalgamation, for example, buildup, poly-expansion and cross- connecting. There are two sorts of plastics: thermoplastics and thermosetting polymers. Thermoplastics are the plastics that don't experience any concoction change in their structure when warmed and can be formed over and over. Illustrations incorporate polyethylene, polypropylene, polystyrene, polyvinyl chloride and poly tetra fluro ethylene (Pl'bE). In the thermosetting procedure, a synthetic response happens that is irreversible. The

vulcanization of elastic is a thermosetting procedure. Before warming with sulphur, the polyisoprene is a cheap, marginally runny material, yet after vulcanization the item is inflexible and non-crude. The properties of plastics are characterized primarily by the natural science of the polymer. For example, hardness, thickness, and imperviousness to warmth, natural solvents, oxidation and ionizing radiation.

- PET, Polyethylene Terephthalate
- HDPE, High-Density Polyethylene
- PVC, Polyvinyl Chloride
- LDPE, Low-Density Polyethylene
- PP, Polypropylene
- PS, Polystyrene

The major components of crumb rubber modifier (CRM) is scrap tyre rubber which is primarily natural and synthetic rubbers and carbon black. Automobile tyres have more synthetic rubber than truck tyres. Truck tyres contain a high percentage of nature rubber than automobile tyres. Advances in tyre manufacturing technology have decreased the difference in chemical composition between the types of tyre rubber. The typical bulk CRM produce in today's market is uniform in composition. The average car tyre contains 10 types of synthetic rubber, 4 types natural rubber, 4 types of carbon black, steel cord, bead wire and 40 kinds of chemicals, waxes, oils, pigments, etc.,

2.2.2 Cleaning Stage

Plastics are shredded and cleaned in our factory in Montfort, the Netherlands. By making smart adjustments to the 6000 ton/year industrial plastic washing/recycling line of Stiphout Plastics, we are able to clean plastics that are polluted with frying oils. The industrial plastic recycling line consists of four stages:

- Wet grinding: The cleaned plastic bottles are shredded to 1 cm flakes.
- Washing: Using waste water from the nearby waste site and our patent pending cleaner, the shredded plastics are cleaned in a specifically designed washing unit. Water, oil and cleaner are afterwards separated to limit waste of materials.
- Separating: Using a fresh batch of water, the flakes are separated in a fraction that floats (PP and PE) and a fraction that sinks.
- Drying: The fractions are fed to the rotation dryer, a large centrifuge. Clean and dry flakes are packed in big bags and shipped to be re-used in production processes. (https://www.tusti.nl/the-process/) [7].

2.2.3 Shredding stage

Shredding is the way toward cutting the plastic into little sizes between 2.36 mm to 4.75 mm with the assistance of the plastic destroying machine viz. Agglomerater and Scrap Grinder. In Agglomerater, thin movies of poly-ethylene and poly-propylene convey sacks are destroyed and in Scrap Grinder strong plastic materials are shredded i.e., plastic jugs, tricide lines, electric link lines and soon.

Agglomerator

For shredding of poly-ethylene "Agglomerater" is utilized. In this procedure, a thin waste plastic convey packs cut in little pieces with the assistance of settle and rotator. This entire procedure required 20 minutes to 25 minutes for shredding.

Preparation of waste rubber materials

These scrap tyres are delivered to a processing plant as a whole, cut, or shredded tyres or buffing waste. CRM is produced using one or more combination of the 4 processes.

- Cracker Mill

The most common method is the cracker mill process. The scrap tyres are pre-processed by shredding to remove steel cord and bead wire. Rotating corrugated steel drums are used to tear the scrap tyres into smaller ground CRM. The ground CRM has irregular torn shape with large surface areas and sizes ranging from 4.75 mm to 425 pm.

- Granulator

In the granulator process, steel cord and bead wire are removed and close tolerance revolving steel plates are used to cut the scrap tyres into granulated CRM. The granulated CRM is cubical, uniformly shaped with a low surface area with sizes ranging from 9.5 nun to 2.0 mm (3/8 inch to No.10 sieve).

- Wet Grinding

In the wet grinding process, ground or granulated CRM is mixed with water and forced between rotating discs to reduce the CRM to sizes fanning from 425 um to 75 um (No. 40 to No. 200 sieve). Before the material is processed in the wet grinding process, it must be reduced in size using another process.

- Cryogenic Process

In the cryogenic process, the pre-chipped scrap tyres are cooled with liquid nitrogen. The brittle tyre rubber is easily fractured with a hammer mill. The process uses a cooler to chill tile material, a grinder, approximate screen and conveyors and steel and fiber separation systems. Usually, the cryogenic process is used as a preliminarily step to other processes which will reduce the particle to the desire size.

2.2.4 Preparation of Rubber Blend

Crumb rubber is used to modify bitumen in an appropriate manner, so that its resistance to temperature, water etc., is better. This modified bitumen is one of the important construction materials for flexible road pavement. The rubber waste / crumb rubber modified bitumen show better properties for road construction.

Figure 4 Crumb Rubber Waste

The studies on the behavior and binding property promoted a study on the preparation of rubber waste — bitumen blend. Its bituminous properties are found. These properties are compared with normal bitumen. Then its suitability as a blend for road construction is investigated. Scrap tyre rubber can be incorporated into asphalt paving mixes using two different methods, which are referred to as the wet process and the dry process. In the wet process, crumb rubber acts as on asphalt cement modifier, while in the dry process, granulated or ground rubber or crumb rubber is used as a portion of the fine aggregate [4].

Figure 5 Fine Aggregate sample

Crumb Rubber Modified Bitumen is produced by the so-called wet process in which crumb rubber is added to hot bitumen of temperature around 150-160°C and the mixture is agitated mechanically until there is a “reaction” between the bitumen and crumb rubber [9].

The “reaction” is not a chemical process but rather a diffusion process that includes the physical absorption of aromatic oils from the bitumen into the polymer chain of the rubber. The rubber particles swell as they absorb oils, which cause the viscosity of the CRMB to increase during the first hour or so. After the “reaction” and associated swelling is over the viscosity of the blend levels off.

In preparing the modified binders, about 500 gm of the bitumen was heated to a fluid condition in a 1.5 litre capacity metal container. For the blending of crumb rubber with bitumen, it was heated to a temperature 160 °C and then crumb rubber was added. For each mixer sample 0%, 8%, 10%, 12% and 14% of crumb rubber by weight is used. The blend is mixed manually for about 3-4 minutes. The mixture is then heated to 160 °C and the whole mass was stirred using a mechanical stirrer for about 50 minutes. Carries taken to maintain the temperature between l60 °C to 170 °C. The contents are gradually stirred for about 55 minutes. The modified bitumen is cooled to room temperature and suitably stored for testing.

Figure 6 Bitumen sample

2.2.5 Preparation of Plastic blend

Polyethylene conveys sacks are cut into pieces utilizing a destroying machine. They are sieved and the plastic pieces going through 4.75 mm strainer and holding at 2.36 mm sieve gets gathered. These pieces are added gradually to the hot bitumen of temperature around 170 °C- 180 °C. The blend mixed well utilizing mechanical stirrer for around 20 minutes-30 minutes. Plastic waste-bitumen blends of various organizations can be arranged and utilized for completing different tests.

The aggregates are warmed to around 170 °C, the plastic waste destroyed to the size fluctuating in the vicinity of 2.36 mm and 4.75 mm. This destroyed plastic waste is included over hot aggregate with ceaseless blending to give a uniform dispersion. The plastic get mellowed and covered over the aggregates. The hot plastic covered totals are blender with hot bitumen having consistency review 40 (160 °C).

Figure 7 Coarse Aggregate sample

3 Two processes used in the Construction of Rubber and Plastic Roads

3.1 Wet Process

In this procedure, the plastic and rubber waste is specifically blended with hot bitumen at 160°C and this blend is then appropriately blended utilizing a mechanical stirrer. This blend likewise contains extra stabilizers and requires legitimate cooling. This strategy is very little famous in light of the fact that it needs colossal speculations.

3.2 Dry Process

To begin with the plastic and the rubber waste is gathered, isolated and put away. The isolation is done in light of the fact that a few sorts of plastic like poly- vinyl chloride (PVC) and flux sheets can't be utilized as street developments for well-being concerns. The following stride includes the cleaning of the rubber and plastic.

This is vital on the grounds that the vast majority of the rubber and plastic waste gathered has been utilized for bundling (55% in India) and subsequently is probably going to contain leftover substances, for examples, little bits of nourishment which must be expelled. After this the plastic and rubber experiences the way toward destroying which lessens it to the right thickness of 2mm- 4mm. The total is warmed to around 160 °C to 170 °C and afterward the plastic and rubber are include and following 30 seconds -40 seconds, a uniform covering is watched. This covering gives it a slick look. The bitumen is included at a temperature of around 155 °C-163 °C. This temperature is deliberately directed to ensure that the coupling is solid.

4 Advantages & Disadvantages of Rubber and Plastic Waste Road Construction

4.1 Advantages

- The construction of these pavements uses only the environmental hazard factors like waste tyres waste plastic materials. So, it is eco-friendly.
- Use higher percentage of plastic and rubber.
- Reduce the need of by around 10%.
- Delays oxidation of mixes thus enhanced pavement life and increase the strength and performance of the road.
- It doesn't increase cost of road construction and it reduces the cost to around Rs.5000/Km of single lane road.
- Better resistance towards rain water and cold weather.
- Burning of wastes could be avoided.

4.2 Disadvantages

- Heavy vehicles cannot travel in this road, only light vehicles can travel in it.

5 Conclusion

The expansion of plastic and rubber waste adjust the properties of bitumen. The utilization of plastic waste as in development of roads draws out a superior execution. Since, there is better authoritative bitumen with rubber and plastics. The recurrence of purge spaces is likewise diminished because of expanded holding and contact territory between plastic, rubber and aggregates or bitumen. This eventually helps in lessening the absorption of moisture and oxidation of bitumen by entangled air. Henceforth, the roads can hold up under substantial activity, in this way expanding their toughness. Softening point and specific gravity values expanded with the expansion in rate of rubber and plastic waste however subsequent to achieving the idea level, the quality began diminishing. So, it is fitting to utilize adjusted bitumen pavement development to limit.

Issues like, Rutting and spading of vehicles amid hot atmosphere conditions. By and large increment in softening point value demonstrates bring down temperature defenselessness and is predominantly favored in hot atmospheres. The adjustment in the softening fine qualities might be because of the chemical nature of plastic and rubber wastes included. The reason changes in particular gravity qualities are high surface thickness without any adjustments in its weight. Likewise, notwithstanding easing the natural issues of these substances, bitumen and different materials will be additionally devoured less (thickness of different layers can be lessened through expanding thickness of pavement) [9].

Thus the utilization of waste rubber and plastics for pavement is one of the best techniques for simple transfer of waste rubber and plastics. The usage of changed bitumen and altered total is superior to the utilization of ordinary bitumen

and typical totals in numerous angles. For example, if every one of the asphalts in India are changed over into plastic and rubber roads, all the rubber and plastic wastes accessible will be utilized as a part of the development of street and waste plastics and rubber transfer will never again be an issue [8].

Recommendations

Expanded activity conditions are decreasing the life expectancy of streets. Plastic and rubber roads are methods for avoidance and at last will be the cure. It will spare a great many dollars in future and diminish the measure of assets utilized for development of roads. It is expected that the utilization of industrial waste for construction of pavements will be an environmentally friendly step forward to help 'Swachh Bharat Mission', or 'Clean India Mission'.

Compliance with ethical standards

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