iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** VII **Month of publication:** July 2024

DOI: https://doi.org/10.22214/ijraset.2024.63532

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VII July 2024- Available at www.ijraset.com

Use of Waste Tyre Rubber Powder and Waste Plastic in Bituminous Road Construction

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Abstract: Many roads agencies have been experiencing problem of premature failure of pavements like potholes, roughness, cracks and etc. which leads to poor performance of roads and its life. On the other hand, plastics, rubbers, etc. are increasing day by day. Waste like plastic bottles, polymers, cups, waste tyre's can be re-used by powdering or blending it with crusher's and can be coated over aggregate and bitumen by any heating process. In this study we have used polymer and crumbed rubber as a binder with respect to aggregate and bitumen. In bituminous roads, we use materials like aggregate (of various sizes), grit and bitumen. The various tests are conducted during this study on aggregates such as crushing value, impact value, abrasion value, and specific gravity and also on bitumen penetration value, ductility, softening point. The results are discussed in this paper.

The escalating environmental challenges posed by increasing volumes of waste plastic and waste rubber necessitate innovative solutions for their sustainable management. This M.Tech mini project focuses on exploring the feasibility and efficacy of incorporating waste plastic and waste rubber into road construction materials, specifically in aggregates and bitumen. The research encompasses a comprehensive investigation into the physical, chemical, and mechanical properties of these waste materials, assessing their compatibility with traditional road construction requirements.

The project unfolds through systematic phases, commencing with a thorough literature review to contextualize the current state of research on utilizing waste plastic and waste rubber in road materials. Following this, samples of waste plastic and waste rubber are collected and characterized, ensuring a nuanced understanding of their material properties. Laboratory experiments are then conducted to modify road aggregates and bitumen with varying proportions of these waste materials.

The anticipated outcome of this mini project is a holistic understanding of the viability and benefits of incorporating waste plastic and waste rubber in road construction materials. The findings are expected to contribute to sustainable road infrastructure development, providing a foundation for future research and practical implementation in the realm of civil engineering. This research aligns with the broader goal of promoting environmentally conscious practices and mitigating the impact of waste materials on our ecosystems.

I. INTRODUCTION

A. General

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.

B. Research Objectives

The use of waste tire rubber powder and waste plastic in bituminous road construction serves several objectives, offering both environmental and economic benefits. Here are some key objectives:-

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1) *Waste Utilization*
a) *Tire Rubber Powder:* Recycling waste tire rubber powder helps in reducing the environmental impact of tire disposal. It utilizes a significant amount of discarded tires that would otherwise contribute to landfills or illegal dumping.
b) *Waste Plastic:* Incorporating waste plastic in road construction provides an avenue for recycling and reusing plastic waste, preventing it from polluting the environment.

2) *Improved Asphalt Performance*
a) *Tire Rubber Powder:* Adding rubber to bituminous mixtures enhances the properties of asphalt. Rubber-modified asphalt tends to have improved elasticity, durability, and resistance to cracking and rutting.
b) *Waste Plastic:* The addition of waste plastic can enhance the properties of asphalt by improving its strength, flexibility, and resistance to deformation.

- *Durability and Longevity:* The use of waste tire rubber powder and waste plastic can contribute to the durability and longevity of bituminous road surfaces. This is particularly beneficial in high-traffic areas and regions with extreme weather conditions.
- *Reduced Maintenance Costs:* Roads constructed with rubber-modified asphalt tend to require less maintenance over time, as they exhibit greater resistance to wear, cracking, and other forms of distress.
- *Environmentally Friendly:* The use of waste materials in road construction reduces the demand for virgin resources, helping to conserve natural materials and energy. It also minimizes the environmental impact associated with the disposal of waste tires and plastic.
- *Energy Savings:* Incorporating waste materials in road construction can lead to energy savings compared to traditional road construction methods. The processing of waste tire rubber and plastic for use in asphalt typically requires less energy than the production of equivalent virgin materials.
- *Noise Reduction:* Rubberized asphalt has been shown to reduce road noise, providing a potential solution for noise pollution in urban and residential areas.
- *Economic Benefits:* Utilizing waste materials in road construction can result in cost savings for both the public and private sectors. It may also create opportunities for businesses involved in waste recycling and processing.

C. Significance of Study Methodology

The use of waste tire rubber powder and waste plastic in bituminous road construction holds significant importance due to various environmental, economic, and engineering advantages. Here are key aspects of their significance:

1) *Waste Reduction and Recycling:* Incorporating waste tire rubber powder and waste plastic into bituminous road construction provides a sustainable solution to the disposal of these materials. Recycling waste products minimizes the environmental impact associated with land filling or burning, helping to address the global issue of waste management.
2) *Resource Conservation:* The use of waste materials in road construction reduces the demand for virgin resources such as aggregates and bitumen. This conservation of natural resources aligns with sustainable development principles and helps in preserving ecosystems and landscapes.
3) *Improved Asphalt Properties:* Rubber-modified asphalt from waste tire rubber powder enhances the performance of roads. It improves the elasticity, flexibility, and durability of the asphalt, leading to reduced cracking, rutting, and other forms of distress. This, in turn, contributes to longer-lasting and more resilient road surfaces.
4) *Durability and Longevity:* Roads constructed with waste tire rubber powder and waste plastic tend to exhibit increased durability and longevity. This is especially significant in regions with harsh weather conditions, heavy traffic loads, or areas prone to frequent freeze-thaw cycles.
5) *Reduced Maintenance Costs:* The incorporation of waste materials in road construction can result in lower maintenance costs over the life of the road. Rubber-modified asphalt, for example, requires less frequent repairs and resurfacing, leading to potential cost savings for government agencies and taxpayers.
6) *Environmental Pollution Mitigation:* By utilizing waste tire rubber powder and waste plastic in road construction, the potential for environmental pollution is reduced. It helps mitigate the negative impacts of improper disposal of these materials, including soil and water contamination and air pollution from burning.
7) *Energy Efficiency:* The production of waste tire rubber powder and waste plastic for road construction typically requires less energy compared to the production of equivalent virgin materials. This contributes to overall energy efficiency and reduces the carbon footprint associated with road construction.

8) *Noise Reduction:* Rubber-modified asphalt has noise-dampening properties, which can contribute to reduced road noise in urban and residential areas. This is particularly valuable for enhancing the quality of life for nearby residents and improving the overall environmental impact of road infrastructure.
9) *Economic Opportunities:* The use of waste materials in road construction can create economic opportunities in the recycling industry. It encourages the development of technologies and processes for converting waste into valuable construction materials, potentially leading to new businesses and job opportunities.

D. Methodology

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.
The four basic process undergoes are as follows:-

1) Segregation Stage

Plastics are typically arranged by their compound structure of the polymer's spine and side chains. 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.
a) PET, Polyethylene Terephthalate
b) HDPE, High-Density Polyethylene
c) PVC, Polyvinyl Chloride
d) LDPE, Low-Density Polyethylene
e) PP, Polypropylene
f) PS, Polystyrene

The major components of crumb rubber modifier (CRM) are 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) Segregation 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:
a) *Wet Grinding:* The cleaned plastic bottles are shredded to 1 cm flakes.
b) *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.
c) *Separating:* Using a fresh batch of water, the flakes are separated in a fraction that floats (PP and PE) and a fraction that sinks.
d) *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.

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.

a) Agglomerater

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.

b) 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

4) Blending Stage

a) 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:- 1.4.4(i) (a) 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

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. 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:- 1.4.4(i) (b) Bitumen Sample.

b) 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:- 1.4.4(ii) (a) Coarse Aggregate Sample.

E. Processes used in the Construction of Rubber and Plastic Roads

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.

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.

F. Materials and Methods

Coarse and fine aggregates are used in the preparation of bituminous mix samples. The gradation of aggregates has been prepared according to IRC: 107–2015 (Table 1.6.2). Specific gravity, water absorption, impact value, crushing value and Los angles abrasion value of aggregates are tested according to the Indian standards (Table 1.6.3). The specific gravities of coarse and fine aggregates were found to be 2.7 and 2.64, respectively. The specific gravities of the stone dust were found to be 2.5.

Table 1.6.1

Sr. No.	Plastic replacement with bitumen (%)	Rubber replacement with aggregate (%)	Stone Dust (%)	Optimum waste materials
1	2-10	-	-	5.2%
2	1-5	-	-	4.1%
3	2-10	0-5	-	9% plastic and 6% rubber
4	4-8	2-12	-	10% plastic and 11% rubber
5	6-14	-	-	11%
6	5-11	-	-	10%
7	-	1-9	-	4%
8	-	-	0-100 used as a filler	Stability increases

Table 1.6.2

Sieve Size	Passing %	Select passing	% Quality of aggregate
26.5 mm	100	100	
19 mm	85–100	91	9
13.2 mm	63–82	73	18
9.5 mm	52–74	67	6
4.75 mm	39–54	41	26
2.36 mm	28–43	39	2
600 µm	15–27	22	17
300 µm	7–21	19	3
150 µm	5–15	13	6
75 µm	2–8	3	10
Filler 2.36 µm	0–2	3	3

Table 1.6.3

Property	Test Result	Test Method	Specification
Water absorption (%)	0.68%	IS:2386(part-III)	2
Los Angeles test (%)	19.86%	IS:2386(part-IV)	30
Impact test (%)	23.71%	IS:2386(part-IV)	24
Crushing test (%)	22.69%	IS:2386(part-IV)	30

1) Bitumen

VG30 grade bitumen has been used as bitumen for preparation of bituminous mixes. The physical properties of bitumen like penetration grade, softening point, and ductility test have been done (Table 4). And also waste plastic and waste rubber Replacement by Bitumen. The Crushed waste plastic according to the size required (4.75 mm–2.36 mm) and waste rubber according to the size required (1 mm–75 µm). And the specific gravity of waste plastic powder and waste rubber powder were found to be 0.47 and 0.509.

2) Methodology

The mix design has been considered Stability, Flexibility, Resistant to permanent deformation, Resistant to low- temperature cracking, Durability, Sufficient air voids to prevent bleeding, Workability and economy.
1200gm aggregate, 2% filler by weight of aggregate and various percentages of bitumen with various waste materials by weight of bitumen were selected to find out the optimum percentage of bitumen with waste.

Table 1.6.4

Property	Test method	Test result
Ductility test	IS:1208–1978	75 cm
Penetration test (25°C)	IS:1203–1978	67.666
Softening point test	IS:1205–1978	55.5°C
Specific gravity	IS:1202–1978	1.06

3) Preparation of Mix Specimens

For the preparation of bituminous mixes require quantities of coarse aggregate, fine aggregate, fly ash and stone dust have been taken in an iron pan and kept in an oven at 140°C –175°C for 2hour (IRC-MORTH). And the bitumen also heated 150°C -177°C (IRC-MORTH). Then the waste plastic and waste rubber added to the aggregate and mixed for few minutes. Then Bitumen is added to the mix. And mix process should be continued 12–15 minutes for proper mix; the temperature of mixing should be 120°C –160°C (IRC-MORTH). Prepared mix transferred to a casting mould and compacted at by Marshal Hammer, 75 no. of blows given on each side of the sample then these samples with moulds are kept separately and marked.
In this experimental work the preparation of samples have been done in 7 steps.

a) *Step 1:* According to literature review and objective the preparation of specimens has been started from 12% waste, and has been done 12% waste with different percentage of bitumen (4% to 8% increment 1%).
b) *Step 2:* Select the 10% waste with various percentage of bitumen without 4% bitumen because the result of 4% bitumen was not acceptable.
c) *Step 3:* In observed that the optimum percentage of bitumen with waste materials will be between 4.5% to 6% bitumen. And 14% waste with 6%, 5% with increment 0.5% bitumen have been selected.
d) *Step 4:* The results of step 3 came acceptable but on 5.5% bitumen had more stability, and it decided to do 5.5% of bitumen with various percentage of waste (12%, 10% and 8%) and also 5% bitumen with 8% waste also has been done.
e) *Step 5:* In this stage according to the cost and opti- mum percentage, the preparation of specimens has been done for 4.5% bitumen with various percentage of waste (12%, 10% and 8%) and the results were satisfied.
f) *Step 6:* With consideration of environmental solution by utilization of waste materials, it decided to do 16% of waste with 5.5% and 5% bitumen. But the results were not acceptable.
g) *Step 7:* In this stage preparation of specimens has been done for 4.5%, 5% and 5.5% bitumen as conventional mix to compare with use of waste on bituminous mixes

And also the physical properties of every specimen like unit weight, bulk specific gravity, theoretical Specific gravity and volume of specimen were found.

4) Marshall Stability Test

Marshall Stability test is very important, significant and standard laboratory test accepted all over world for assessment of bituminous mixes. It has been done to find the marshal properties like stability and flow value for various percentage of bitumen and waste materials. The Marshall Stability (ASTM-D, 1559)20 has been used for testing of bituminous mixes specimens.

Table 1.6.5

% Bitumen	% Waste rubber	% Waste plastic	% Course aggregate	% Fine aggregate	% Stone dust	% Flyash	Volume of specimen (cm³)	Theoretical specific gravity (Gmm)	Unit weight (gr/cm³)	Bulk specific gravity(Gmb)
4	6	6	51.796	42.204	1	1	480.467	2.484	2.395	2.310
4.5	0	0	51.520	41.980	2	0	491.144	2.500	2.395	2.517
	4	4	51.520	41.980	1	1	531.183	2.475	2.352	2.307
	5	5	51.520	41.980	1	1	515.168	2.469	2.335	2.410
	6	6	51.520	41.980	1	1	512.498	2.463	2.253	2.239
5	0	0	51.245	41.755	2	0	491.144	2.482	2.496	2.385
	4	4	51.245	41.755	1	1	515.168	2.455	2.539	2.491
	5	5	51.245	41.755	1	1	512.498	2.448	2.493	2.398
	6	6	51.245	41.755	1	1	469.790	2.442	2.419	2.578
	7	7	51.245	41.755	1	1	493.813	2.435	2.429	2.241
	8	8	51.245	41.755	1	1	499.152	2.429	2.306	2.239
5.5	0	0	50.969	41.531	2	0	477.798	2.465	2.462	1.892
	4	4	50.969	41.531	1	1	507.160	2.435	2.468	2.274
	5	5	50.969	41.531	1	1	493.813	2.428	2.439	2.351
	6	6	50.969	41.531	1	1	493.813	2.421	2.305	2.363
	7	7	50.969	41.531	1	1	507.160	2.414	2.302	1.960
	8	8	50.969	41.531	1	1	517.837	2.407	2.239	1.907
6	5	5	50.694	41.306	1	1	496.483	2.408	2.314	2.006
	6	6	50.694	41.306	1	1	491.144	2.401	2.246	1.901
	7	7	50.694	41.306	1	1	464.452	2.393	2.429	2.021
7	5	5	50.143	40.857	1	1	485.806	2.370	2.306	1.903
	6	6	50.143	40.857	1	1	416.405	2.361	2.379	2.299
8	5	5	49.592	40.408	1	1	493.813	2.332	2.405	2.350
	6	6	49.592	40.408	1	1	485.806	2.323	2.399	2.400

II. LITERATURE REVIEW

A. *Plastic – Properties & Behavior*

Plastic is a broad term used to describe a range of synthetic or semi-synthetic materials that have diverse properties and behaviors, making them highly versatile and widely used in various applications. Here are some key properties and behaviors of plastics:

1) Properties of Plastics

a) *Lightweight:* Most plastics are significantly lighter than metals, ceramics, and glass. This property makes them ideal for applications where weight is a critical factor, such as in automotive and aerospace industries.

b) Durability: Plastics are generally resistant to corrosion and degradation, which makes them suitable for long-term use in various environmental conditions.
c) Flexibility and Malleability: Plastics can be easily molded into different shapes and forms when heated. This property allows for the creation of complex shapes and intricate designs.
d) Chemical Resistance: Many plastics are resistant to chemicals, including acids, bases, and solvents, making them ideal for use in containers and piping that need to withstand harsh chemical environments.
e) Electrical Insulation: Plastics are excellent insulators and are widely used in electrical and electronic applications to provide insulation for wiring and components.
f) Thermal Insulation: Some plastics have good thermal insulating properties, which make them useful in applications requiring temperature control, such as in building insulation and thermal containers.
g) Transparency: Certain plastics, like acrylic and polycarbonate, can be made transparent, offering an alternative to glass for many applications, including windows, lenses, and screens.

2) Behavior of Plastics
a) Reactivity to Heat: Plastics vary in their response to heat. Thermoplastics soften and become moldable when heated, while thermosetting plastics harden and become brittle when exposed to high temperatures.
b) Environmental Impact: Plastics are known for their persistence in the environment, leading to pollution and waste management challenges. Biodegradable plastics and recycling initiatives are being developed to mitigate these issues.
c) Aging and Degradation: Over time, plastics can degrade due to exposure to UV light, oxygen, and other environmental factors. Additives such as stabilizers and UV inhibitors are often used to enhance the longevity of plastic products.
d) Mechanical Properties: The mechanical properties of plastics, such as tensile strength, impact resistance, and hardness, can vary widely depending on the type of plastic and the additives used. This allows for customization based on specific application needs.

B. Classification of Plastics

Plastics can be classified in various ways based on their chemical composition and physical properties. Here are some common classifications:
1) Organic Polymers: These are polymers that contain carbon atoms in their backbone. Most of the commonly used plastics are organic polymers. Examples include polyethylene, polypropylene, polystyrene, and polyvinyl chloride (PVC).
2) Inorganic Polymers: These polymers do not have carbon atoms in their backbone structure. They often contain elements like silicon, phosphorus, and boron. Examples include polysiloxanes (silicones) and polyphosphazenes.
3) Thermoplastics: Thermoplastics can be melted and re-molded multiple times without undergoing any significant chemical change. They become soft when heated and hard when cooled. Examples include polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), and polystyrene (PS).These are of 80% of waste plastics and some thermoplastic waste materials are recommended in these guidelines for addition in bituminous mixes in dry process.
4) Thermoset: Thermosetting plastics, once cured (hardened), cannot be remelted and remolded. They undergo a chemical change during the curing process, which makes them rigid and heat-resistant and hence thermosetting waste plastic materials shall not be used for dry process addition in bituminous mixes. Examples include epoxy resins, phenolic resins, and melamine formaldehyde. These are of 20% of waste plastics.

C. Benefits of Plastics

The Considerable growth in plastic use is due to the beneficial properties of plastics and some of them are as follows:-
1) .Light weight than competing materials, reducing fuel consumption during transportation.
2) Durability.
3) Extreme versatility and ability to be tailored to meet very specific technical needs.
4) Resistance to chemicals, water and impact.
5) Good safety & hygiene properties for food packaging.
6) Excellent thermal and electrical insulation properties.
7) Relatively inexpensive to produce.

D. Sources of Generation of waste Plastics

The production and consumption of the plastics is increasing all over the world due to its benefits and the generation of waste plastics is also increasing at the same rate which is causing a major problem to the world. There are various types of sources which are producing the waste plastics. These sources are classified as below:-

Table 2.4.1

Sources	Waste Plastics Generated
Household	• Carry bags • Plastic Bottles • Containers • Trash bags
Health and Medicare	• Disposable syringes • Glucose bottles • Blood and euro bags • Intravenous tubes
Hotel & Catering	• Packing Items • Mineral water bottles • Plastic plates, glasses, spoons etc.
Air/Rail Travel	• Mineral water bottles • Plastic plates, glasses, spoons etc. • Plastic bags

E. Methods of Reducing the Waste Plastic

There are two ways by which we can reduce the amount of waste plastics to a great extent are as follows:-

- Recycling of plastics
- Use of waste plastics in road construction

1) Recycling of Plastics

Recycling of plastics is the process of converting the waste plastics into value-added fuel products.

a) Plastics for Recycling

Not all plastics are recyclable. There are 4 types of plastic which are commonly recycled:

- Polyethylene (PE) - both high density and low density polyethylene.
- Polypropylene (PP)
- Polystyrene (PS)
- Polyvinyl chloride (PVC)

A common problem with the recycling plastics is that plastics are often made up of more than one kind of polymer or there may be some sort of fibre added to plastic to give added strength. This can make recovery difficult.

There are basically 4 different ways of recycling of plastics (Zadgaonkar, 1904). These are:

- Primary Recycling- Conversion of waste plastics into products having performance level comparable to that of original products made from virgin plastics.
- Secondary Recycling- Conversion of waste plastics into products having less demanding performance than the original material.
- Tertiary Recycling- The process of producing chemicals/fuels / similar products from waste plastics.
- Quaternary Recycling- The process of recovering energy from waste plastics by inciration.

Zadgaonkar's invention deals with the Tertiary Recycling. Her work involved- use of post- consumer waste of plastics and other polymeric materials to produce fuel at a cheaper cost.

The process consists of two steps:

(1) Random De-polymerization.

- Loading of waste plastics into the reactor along with the catalyst system.
- Random de-polymerization of the waste plastics.

(2) Fractional Distillation

- Separation of various liquid fuels by virtue of the difference in their boiling points

2) Reuse of waste plastics in road construction

a) Plastic- as binder and modifier

Waste plastics on heating soften around 130-140 degree C. A study using thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130°C - 180°C. Moreover the softened plastics have a binding property. Hence, the molten plastic materials can be used as a binder and or they can be mixed with binder like bitumen to enhance their binding property. This may be a good modifier for the bitumen, used for road construction.

b) Process of Road Laying using Polymer-aggregate-Bituminous Mix

The study of using plastic wastes in road construction was performed by Central Pollution Control Board. The plastic waste (bags, cups, Thermocole) made out of PE, PP &PS were separated, cleaned if needed and shredded to small pieces. The aggregate was heated to 170 degree C in the mini hot Mix Plant and the shredded plastic waste was added, it got softened and coated over the aggregate. Immediately the hot bitumen (160°C) was added and mixed well. As the polymer and the bitumen were in the molten state, they get mixed and the blend is formed at the surface of the aggregate. It was observed that addition of plastics waste up to 10-15% by weight of bitumen resulted into higher values of softening point and lower values of penetration, which are appreciable improvements in the properties of the binder. The mixture was transferred to the road and the road was laid. Then this technique was extended to Central Mixing Plant too.

3) List of Roads Laid using Waste Plastics

Table 2.5.3.1

	Process	Blend Composition	Date
TCE	Polymer Blending with Bitumen	5% PE	23rd March-02
Kovilpatti	Polymer Blending with Metal and the Mixing with Bitumen	10% PE	4th October-02
Maduari	Polymer Blending with Metal and the Mixing with Bitumen	15% PE	5th October-02
Salem	Polymer Blending with Metal and the Mixing with Bitumen	10% PE	15th October-02
Komarapalayam	Polymer Blending with Metal and the Mixing with Bitumen	10% Mixture	15th October-02
Chennai	Polymer Blending with Metal and the Mixing with Bitumen	12% Mixture	22nd Novemeber-02
Trichy	Polymer Blending with Metal and the Mixing with Bitumen	10% Mixture	10th January-03
Salem	Polymer Blending with Metal and the Mixing with Bitumen	10% Mixture	17th April-03
Erode	Polymer Blending with Metal and the Mixing with Bitumen	10% Mixture	7th May-03
Theni	Polymer Blending with Metal and the Mixing with Bitumen	10% Mixture	10th May-03
Nagarcoil	Polymer Blending with Metal and the Mixing with Bitumen	10% Mixture	16th May-03

F. Waste Tyre Rubber – Properties & Behavior

Tyre rubber, primarily composed of natural and synthetic rubber compounds, is engineered to meet specific performance criteria. Here's an overview of its properties and behavior:

1) *Properties of Tyre Rubber*
a) *Elasticity and Flexibility:* Rubber exhibits high elasticity, allowing it to return to its original shape after deformation. This is critical for absorbing shocks and providing a smooth ride.
b) *Durability:* Tyre rubber is engineered for long-lasting performance, withstanding harsh conditions and extensive wear.
c) *Traction:* The tread pattern and rubber compound provide grip on various surfaces, crucial for safety and performance.
d) *Thermal Stability:* Designed to endure temperature fluctuations, maintaining performance in both cold and hot conditions.
e) *Chemical Resistance:* Resistant to oils, fuels, and other chemicals typically encountered by tyres.
f) *Abrasion Resistance:* Tyre rubber is highly resistant to abrasion, extending the life of the tyre..

2) *Behavior of Tyre Rubber*
a) *Load Bearing:* Tyres support the vehicle's weight, with the rubber's elasticity allowing it to compress and absorb impacts while maintaining structural integrity.
b) *Temperature Effects*
- *High Temperatures:* Can lead to softening of the rubber, reducing its lifespan and performance. Heat build-up during driving can also cause thermal degradation**.**
- *Low Temperatures:* Can cause hardening, leading to reduced grip and increased brittlenes**s.**

c) *Aging and Weathering:* Exposure to UV light, ozone, and other environmental factors can lead to the degradation of rubber, causing cracks and loss of elasticity.
d) *Deformation and Recovery:* Under load, tyres deform to provide a larger contact area with the road, improving grip. Once the load is removed, they recover their shape.
e) *Dynamic Performance:* Tyres must balance multiple dynamic factors, including rolling resistance (affecting fuel efficiency), cornering stability, and braking performance.

G. Classification of Tyre Rubber

Tyre rubber can be classified based on various criteria such as the type of rubber used, application, construction, and performance characteristics.

Here's a detailed classification:

1) *Based on Type of Rubber*
a) *Natural Rubber (NR) Tyres*
- Made primarily from natural rubber derived from latex.
- Excellent elasticity, tensile strength, and resistance to wear and tear.

b) *Synthetic Rubber Tyres*
- Styrene-Butadiene Rubber (SBR): Commonly used in tyre manufacturing for its good abrasion resistance and aging stability.
- Butadiene Rubber (BR): Known for its high resilience and resistance to low temperatures.
- Polybutadiene Rubber (PBR): Offers good wear resistance and low rolling resistance.
- Ethylene Propylene Diene Monomer (EPDM): Used for its excellent heat, ozone, and weather resistance.

c) *Blended Rubber Tyres*
- A mix of natural and synthetic rubbers to combine the beneficial properties of both types.

2) *Based on Application*
a) *Passenger Car Tyres (PCT)*
- Designed for standard passenger vehicles.
- Emphasizes comfort, fuel efficiency, and quiet operation.

b) *Light Truck Tyres (LT)*
- For light trucks and SUVs.
- Provides better load-carrying capacity and durability.

c) *Heavy-Duty Truck Tyres (HDT)*
- Used in commercial trucks and buses.
- Focuses on high mileage, durability, and resistance to cuts and punctures.

d) *Off-the-Road Tyres (OTR)*
- For construction, mining, and agricultural vehicles.
- Designed to handle rough terrains and heavy loads.

e) *Racing Tyres*
- Used in motorsports.
- Offers maximum grip and performance at high speeds.

3) *Based on Construction*

a) *Radial Tyres*
- Features cords arranged radially from the center.
- Provides better fuel efficiency, smoother ride, and longer tread life.

b) *Bias Tyres*
- Has cords that run diagonally across the tyre.
- Offers stronger sidewalls and better resistance to cuts.

c) *Tubeless Tyres*
- No inner tube, air is retained by the tyre and rim.
- Reduces the risk of sudden deflation and improves safety.

d) *Tube-Type Tyres*
- Contains an inner tube to hold air.
- Common in older vehicles and some specific applications.

4) *Based on Performance Characteristics*

a) *All-Season Tyres*
- Designed to perform well in various weather conditions.
- Balances performance in dry, wet, and light winter conditions.

b) *Winter Tyres*
- Optimized for cold weather and snowy or icy conditions.
- Made from softer rubber compounds to maintain flexibility in low temperatures.

c) *Summer Tyres*
- For warm weather conditions.
- Provides excellent dry and wet traction but not suitable for freezing temperatures.

d) *All-Terrain Tyres*
- Designed for both on-road and off-road driving.
- Offers enhanced traction on various surfaces.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VII July 2024- Available at www.ijraset.com

e) Performance Tyres
- Optimized for high-speed handling and cornering.
- Provides superior grip and responsiveness.

f) Eco Tyres
- Focuses on reducing rolling resistance to enhance fuel efficiency.
- Often uses advanced materials and tread designs.

5) Based on Special Features
a) Run-Flat Tyres
- Can be driven for a short distance after a puncture.
- Enhances safety by allowing the vehicle to reach a safe location for repair.

b) Noise-Reducing Tyres
- Designed with special tread patterns and materials to minimize road noise.
- Improves driving comfort.

c) Self-Sealing Tyres
- Contains a sealing layer that can automatically seal small punctures.
- Provides convenience and safety.

These classifications help manufacturers and consumers choose the right type of tyre rubber based on their specific needs and driving conditions.

III. CHARACTERISTICS OF PLASTIC & RUBBER COATED AGGREGATE

A. Moisture Absorption and Void Measurement
Hot stone aggregate (150ºc) is mixed with hot bitumen (170 ºc). The aggregate is chosen on the basis of its strength, porosity and moisture absorption capacity as per IS coding. The bitumen is chosen on the basis of its binding Property, Penetration value and visco-elastic property. The aggregate, when coated with plastics and rubber improved its quality with respect to voids, moisture absorption and soundness. The coating of plastic and rubber decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement. It is to be noted here that stones with < 2% porosity only allowed by the specification.

B. Soundness Test
Soundness test is intended to study the resistance of aggregate to weathering action. The weight loss is attributed to the poor quality of the aggregate. The plastic and rubber coated aggregate, did not show any weight loss, thus conforming the improvement in the quality of the aggregate.

C. Aggregate Impact Value
A study on the effect of plastic and rubber coating was extended to study on the aggregate impact value. Aggregate was coated with 1% & 2% plastics and rubber by weight (splitted in 0.5% & 1%) and then was submitted to Aggregate Impact Value test and the values were compared with values for non-coated aggregate. For each % of waste, the tests were conducted twice to get the better results.

Table 3.3.1

Percentage of Plastics (%)	Percentage of Rubber (%)	Aggregate Impact Value (%)	Conventional Value (%)
0.5	0.5	9.23	12.63
0.5	0.5	8.73	12.16
1	1	8.73	12.14
1	1	8.10	12.63

It is clearly observed that the coating of plastics & rubbers improves Aggregate Impact Value. Coating of plastics & rubber over the stone aggregate improves the quality of the aggregate. Moreover a poor quality of aggregate can be made useful by coating with polymers & rubbers. This in turn helps to improve the quality of flexible pavement.

D. *Aggregate Crushing Value*

A study on the effect of plastic and rubber coating was extended to study on the aggregate crushing value. Aggregate was coated with 1% & 2% plastics and rubber by weight (split in 0.5% & 1%) and then was submitted to aggregate crushing Value test and the values were compared with values for non-coated aggregate. For each % of waste, the tests were conducted twice to get the better result.

Table 3.4.1

Percentage of Plastics (%)	Percentage of Rubber (%)	Aggregate Impact Value (%)	Conventional Value (%)
0.5	0.5	11.41	23.66
0.5	0.5	12.27	22.37
1	1	11.30	23.70
1	1	11.32	23.86

E. *Los Angel's Abrasion Test*

The repeated movement of the vehicle with iron wheeled or rubber tire will produce some wear and tear over the surface of the pavement. This wear and tear percentage of an aggregate is determined with the help of los Angeles abrasion study. Under this study the percentage of wear and tear values of the 1% & 2% plastic & rubber coated aggregate is found to be in decreasing order with respect to the conventional values. This wear and tear percentage of an aggregate is determined with the help of Los Angeles abrasion study.

Table 3.5.1

Percentage of Plastics (%)	Percentage of Rubber (%)	Aggregate Impact Value (%)	Conventional Value (%)
0.5	0.5	14.64	17.51
0.5	0.5	14.72	17.42
1	1	13.77	17.46
1	1	13.85	17.43

When the Los Angeles abrasion value of plain aggregate value is compared with the Plastic and rubber coated aggregate the values are less for conventional aggregates as compared to polymer and rubber coated aggregates.

IV. OVERVIEW OF CONSTRUCTION INDUSTRY

A. *Construction Industry*

The Road construction industry's adoption of waste tyre rubber powder and waste plastic in bituminous road construction has gained momentum due to the numerous benefits associated with this sustainable practice. More than 1000kms length of Plastic tar road was laid by Tamil Nadu government during 2004-2006. Test road were laid at Mumbai, Pondicherry and Trivandrum. These roads are functioning well without pothole, raveling and rutting. The process requires only 30 seconds for mixing 10% of plastics and rubber. The plastic available in the nearby area can be used.

B. *Overview of Construction Industries in 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.

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.
The use of waste tyre rubber powder and waste plastic in bituminous road construction is an innovative and sustainable approach within the construction industry. This practice contributes to addressing environmental concerns associated with the disposal of these waste materials while enhancing the performance and longevity of road infrastructure. Here's an overview of the key aspects:

1) Environmental Sustainability

Waste Tyre Rubber Powder: Incorporating rubber powder from waste tyres reduces the environmental impact of tire disposal, which is a significant concern due to the non-biodegradable nature of tyres.
Waste Plastic: Utilizing waste plastic in road construction helps in recycling and reducing the accumulation of plastic waste, contributing to the global effort to manage plastic pollution.

2) Benefits of Using Waste Tyre Rubber Powder

Improved Flexibility and Durability: Rubber-modified bitumen enhances the flexibility and durability of the road surface, leading to reduced cracking and rutting.
Noise Reduction: The addition of rubber powder can contribute to noise reduction, making roads quieter, especially in urban areas.

3) Benefits of Using Waste Plastic

Enhanced Strength: The inclusion of waste plastic in bituminous mixtures can enhance the strength and resistance to wear and tear of the road surface.
Reduced Oxidation and Aging: Plastic-modified bitumen is known to reduce oxidation and aging of the road, resulting in a longer lifespan.

4) Bituminous Road Construction Process

Mix Design: The bituminous mix design needs to be adjusted to incorporate the waste materials effectively. This involves determining the optimal proportion of waste rubber powder and plastic to achieve the desired properties.
Production of Modified Bitumen: The waste materials are added to the bitumen during the mixing process, creating a modified bitumen that is then used in the construction of the road.

5) Challenges

Quality Control: Ensuring consistent quality and performance can be challenging, and rigorous quality control measures are necessary during the manufacturing and construction phases.
Regulatory Approvals: Obtaining regulatory approvals for using recycled materials in road construction may require thorough testing and validation.

6) Economic Considerations

Cost-effectiveness: While initial costs may vary, the long-term benefits in terms of reduced maintenance and increased road lifespan can make the use of waste materials economically viable.

7) Global Examples

India: Several road projects in India have successfully incorporated waste materials, showcasing the feasibility and benefits of this approach.
Other Countries: Various countries are exploring and implementing similar practices to promote sustainability in road construction.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VII July 2024- Available at www.ijraset.com

V. RESEARCH METHODOLGY

A. 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 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:- 5.1(a) Paving Road using waste tyres.

VI. RESEARCH CONCLUSION

A. Results

For each trial, were prepared 3 specimens. And the aver- age of 3 specimen results has been reported. The optimum bitumen content criterion was selected to have maximum stability, acceptance flow value, maximum unit weight and acceptance percentage of air voids. And also considered anther criteria according to IS-MORTH for selected optimum bitumen content like Voids filled with bitumen percentage (VFB), water absorbed percentage. And also has been considered the correction factors for Marshall Stability values. And also the all Marshall properties were found.

Table 6.1.1

% Bitumen	% Waste plastic	% Waste rubber	Stability (kN)	flow value (mm)	% Airvoids (AV)	% Volume of bitumen	%VMA	%VFB	%Water absorbed
4	6	6	7.913	2.866	9.894	3.753	13.648	27.501	0.690
4.5	0	0	17.773	2.333	3.997	4.441	8.438	52.628	0.743
	4	4	14.538	2.800	22.941	5.141	28.081	18.306	14.194
	5	5	18.089	2.767	2.371	4.746	7.117	66.686	1.887
	6	6	16.196	3.000	22.810	4.933	27.743	17.781	13.106
	0	0	17.424	2.833	3.346	5.813	9.160	63.466	–0.661
	4	4	15.144	3.233	19.311	5.036	24.346	20.683	14.537

5	5	5	16.091	2.833	2.061	5.232	7.293	71.740	1.020
	6	6	15.018	3.200	6.394	4.523	10.917	41.432	0.972
	7	7	11.922	2.367	22.295	5.339	27.634	19.321	6.729
	8	8	14.328	2.900	21.633	5.185	26.817	19.334	13.561
5.5	0	0	15.825	3.033	3.098	5.369	8.467	63.413	–1.261
	4	4	13.562	3.400	19.925	6.049	25.974	23.289	13.667
	5	5	15.934	3.233	3.175	5.711	8.885	64.268	2.090
	6	6	13.756	3.233	2.399	5.584	7.983	69.948	1.916
	7	7	8.312	2.533	7.264	4.926	12.189	40.410	9.536
	8	8	9.886	2.900	16.042	5.330	21.372	24.939	11.464
6	5	5	11.484	2.600	–0.088	5.182	5.094	101.736	–6.753
	6	6	13.412	3.567	3.912	5.295	9.207	57.508	0.533
	7	7	10.387	1.667	6.379	5.328	11.707	45.511	9.007
7	5	5	9.858	2.733	–5.112	5.762	0.650	885.902	–7.133
	6	6	12.469	3.833	2.640	6.944	9.584	72.458	0.217
8	5	5	7.336	4.933	–2.278	6.774	4.495	150.684	–3.836
	6	6	12.151	3.233	0.520	6.838	7.358	92.931	0.000

In this experimental work has been done various percentage bitumen with various percentage of waste plastic and waste rubber to find the optimum percentage of waste material on bituminous mixes. But according to the cost and acceptance results of 4.5% to 5.5% with 0.5% increment bitumen.

The Marshall Properties graphs have been plotted on 4.5%, 5% and 5.5% of bitumen with 0%, 8%, 10% and 12% of waste plastic and waste rubber. And also 50% of fly ash as a filler considered.

B. Advantages

Rubber & waste plastic granules used in asphalt come from used tyres, making the product more environmentally friendly. Rubber recovered from used tyres is sufficient to resurface four thousand kilometers of two-lane roads every year, according to estimates. It has been said that rubber asphalt roads automatically de-ice themselves in the winter. The patent holder asserts that projecting rubber granules distort the pavement to the point where de-icing happens. The ice layer breaks up as a result of this. Then, the wind from the cars melts the ice and makes the road safe to drive on again.

1) Reportedly reducing noise by as much as 10 decibels (dB) compared to the noise levels of traditional pavement surfaces.
2) It has been said that the pavement's better skid resistance in dry, wet, and icy conditions is due to the surface texture and protruding rubber granules. The average stopping distance on ice roads was found to decrease by 25%, according to the measurements.
3) This product is said to be effective against hydroplaning and water spray because of its high coarse aggregate concentration, which creates a coarse surface texture with adequate surface drainage.
4) The demand for sanding and salting would be substantially reduced if surfaces were more skid-resistant and had better deicing properties. Costs associated with repairs and corrosion damage to automobiles could be reduced in this way.
5) Improves a road's ability to drain water.
6) Due to the constant influx of traffic, compression does not occur.
7) Increased vibration dampening properties are expected.
8) Helps keep the price of road paving down over time.

C. Study 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) .

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.

D. Recommendation of the Future Research

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’.

For usage of waste materials in bituminous mixes should consider the following parameters:

1) Check physical and chemical properties of all road materials especially waste materials mixed with bitumen.
2) Use of waste plastic and waste rubber together with partial replacement of bitumen as a binder.
3) Stability comparison of modified and conventional bituminous mixes.
4) Predication the Marshall parameters Using Artificial Intelligence Techniques.

VII. ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my Supervisor (Chitranajn Kumar) for giving me the opportunity to work in this area. It would never be possible for me to take this Thesis to this level without his/her innovative ideas and his/her relentless support and encouragement.

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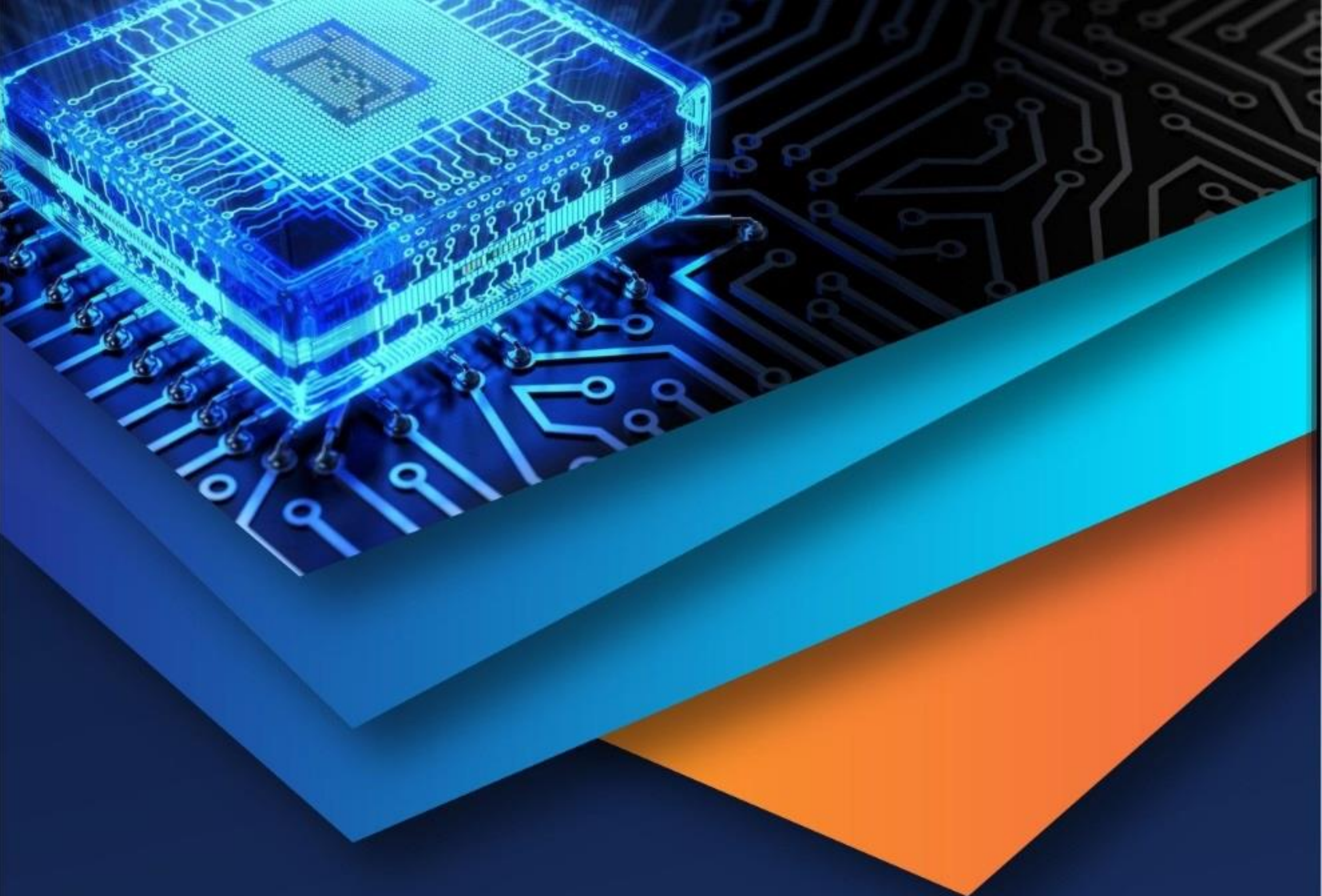

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