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Use of Waste Tyre Rubber Powder in Bituminous Road Construction

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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. The increasing consumption of waste tire has generated many problems such as increasing landfill space, environmental pollution and causing health hazards. Parallel to this is the increasing of roads construction as a result of heavy traffic on roads. This study reviews to the use of crumb rubber (waste tires in powder form) in bitumen using the wet process. The study focuses on the crumb rubber as a replacement to the total weight of bitumen. The design or life span for all highways and urban roads is 10 – 20 years. Unfortunately, damages or distresses on pavements are still occurring before reaching the maximum period of the designed road serviceability. Among the major influencing factor that is contributing to this distress is the repeated heavy traffic loading on the road surfaces. Moreover, the use of waste crumb rubber in road construction as a pavement surface has a better skid resistance, fatigue crack resistance and increased rut resistance. The review includes physical tests that are used to determine the physical properties of bitumen and modified crumb rubber mix. The physical tests involve penetration test, softening point test, and ductility test. The expectations from the study are to develop bitumen with waste crumb rubber that would minimize the costs of bitumen and providing better physical properties compared to the convention bitumen based on the tests that was conducted. In this study percentage of waste tyre powder was used in different rations like 2 to 14 percentages and carried out with different tests like ductility , softening and penetration . like these tests were carried out the experimental work and concluded that the how much percentage of waste tyre powder were used in bitumen mixes for execution purposes as follows in this experimental work.

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.

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.

Waste Tyre and Plastic Roads

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.

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.

In India, over 15 million waste tires are generated annually. Not only are these tire mounds eyesores, they are also environmental and health hazards. The little pools of water retained by whole waste tires create an ideal breeding ground for mosquitoes. Aside from the persistent annoyance, mosquitoes have been shown to spread various dangerous diseases. Equally hazardous are tire fires, which pollute the air with large quantities of carbon smoke, hydrocarbons, and residue. These fires are virtually impossible to extinguish once started. Currently, the only large-scale methods to use waste tires are through burning for electric power generation, production of cement in cement kilns, energy to run pulp and paper mills, and recycling at tires-to-energy facilities. In 1990, the Environmental Protection Agency (EPA) estimated that out of the 242 million waste tires generated that year, 78% of the tires were either stockpiled, a land filled, or illegally dumped. While some states burn waste tires this is only a temporary solution because of the tires, in many cases, tend to float back up to the surface. Land filling waste tires has also become more and more expensive as landfill space has decreased. Asphalt acting as a binder for aggregates is a very important ingredient affecting the life cycle and travel comfort on roads. So, an attempt to use this waste tire rubber for improving the properties of bitumen by blending it with crumb rubber and ultimately a new method to be introduced to reduce pollution problems and protect our environment. However, with the use of waste tire rubber in bitumen, it will definitely be environmentally beneficial, it can improve the bitumen binder properties and durability, and it will also have a potential to be cost effective. Conventional bituminous materials have been used satisfactorily in most highway pavement Environmental factors such as temperature, air, and water can have a profound effect on durability of these pavements. The ideal bitumen should be strong enough, at optimum temperatures, to withstand rutting or permanent deformation, and soft enough to avoid excessive thermal stresses, at low pavement temperatures, and fatigue, at moderate temperatures. After adding the waste tire rubber in bitumen, the properties of the bitumen will be checked. As disposal of waste tires has become a worldwide problem and has caused worry to administrators, researchers and environmentalists. This paper is intended to study the feasibility of the waste tire rubber as a blending material in bitumen, which is used for road construction. The Waste tire rubber appears to possess the potential to be partially added in bitumen, providing a recycling opportunity. If Waste or used tire rubber can be added in bitumen for improving the properties, and disposing off the tires, thus the environmental gains can be achieved.

Hazards of Tyre Waste

- This waste tyres are produced carbon by burning process.
- This amount of tyres is very large manner so it becomes dangerous as well as uncomfortable to placing, because of Land problems to our country.
- Potentially harmful substances were found exposed to highly acidic solutions.
- Aside from the persistent annoyance, mosquitoes have been shown to spread various dangerous diseases.
- Equally hazardous are tyre fires, which pollute the air with large quantities of carbon smoke, hydrocarbons, and residue.
- Not only are this tyre mounds eyesores, they are also environmental and health hazards. The little pools of water retained by whole waste tyres create an ideal breeding ground for mosquitoes.
- These fires are virtually impossible to extinguish once started.

There is huge usage and production of bitumen is being carried out every year. Nearly 85% of petroleum bitumen are used as a binder in several types of asphalt laying: airports, highways, sidewalks etc. When we are using bitumen for asphalt mixture production then every time it is not possible to create a material that would fully satisfy the consumers with their performance properties. Now-a-days disposal of different wastes produced from different Industries is a great problem. These materials pose environmental pollution in the nearby locality because many of themare non-biodegradable. Traditionally soil, stone aggregate, sand, bitumen, cement etc. are used forroad construction. 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 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 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 specifications should be formulated and attempts are to be made to maximize the use of solid wastes in different layers 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. It will help clear valuable land of huge dumps of waste.

Bituminous roads can be defned as roads that are built using bitumen as a binder. It consists of aggregate and bitumen in addition to some fllers, where the quantity and quality of the fller is used to improve the durability and quality of the road . Many fllers can be used in the bituminous mixture, such as lime, cement, and granite powder, but the problem is that such materials can be used for other purposes which are more important and of higher added value; in addition to that, they are expensive and are extracted from natural sources, which results in more damage to the environment. On the other hand, many waste materials are available and can be used as fllers, which helps to get rid of them and at the same time preserve the environment. Therefore, many recent conducted studies analyzed the efect of using waste materials as fllers in bituminous mixtures on the quality and durability of bituminous mixtures. There are many wastes that can be used as fllers, such as waste vegetable oil, oil shale waste ash, olive waste ash, medical waste ash, and olive husk ash. The use of waste tire rubber in asphalt pavements has attracted the interest of researchers around the world, as an alternative additive of the raw materials extracted from natural resources to be used in asphalt concrete mixtures, and as use is an efective way for waste tires' rubber disposal. Using waste tire rubber in the asphalt mixture led to reduce the temperature sensitivity, improve the resistant against permanent deformation and rutting, improve the durability, and reduce fatigue cracking . Compared to limestone, waste tire rubber has a higher value of accumulated stress when added to asphalt mixtures. Tire rubber crumb-modifed asphalt is a general type of modifed asphalt mixture that contains the rubber of waste tires. There are many terms that are used for this mixture, such as asphalt rubber, rubber-modifed asphalt concrete, and rubberized asphalt . There are two methods for making the rubber asphalt mixture, the dry process and wet process, and the diference in terms used to describe the mixture is usually related to the use of one of these methods. The rubber crumbs are mixed with the binder at a high temperature in the wet process, while in the dry process, a part of the aggregate, about 1–3% of the total weight, is replaced by the rubber crumbs and then mixed with the binder. It was found that the dry process is more efective as it can recycle larger amounts of tires and be more cost-efective. However, the dry process has lost its efectiveness due to many unresolved problems including the difculty in achieving consistent performance in relation to the swelling efect after compaction. Gawel et al. found that the reaction of rubber with bitumen can infate rubber particles from three to fve times of their original size and may resist compaction efort. The swelling efect can lead to premature failure, such as raveling and cracking due to non-achievement of target density. The term "interaction" refers to rubber particles' swelling due to the difusion of the lighter bitumen in the rubber. In addition, the reaction of rubber with bitumen leads to maintaining high stifness at high temperatures and giving greater fexibility at low temperatures due to the increase in the viscosity of bitumen resulting from the reaction. Several studies reported that the interaction between asphalt and added rubber takes place during the mixing and transportation stages, which needs from 2 to 3 h. Also, it has been reported that the long-term performance of the modifed asphalt mixture with tire rubber using dry proses needs further study. Due to the growth of the world's population and the increasing demand on vehicles, the amounts of generated waste tires have increased considerably, which imposes an environmental challenge that needs to be addressed. One way of managing this type of waste is to use the waste tire rubber in asphalt mix for road pavement. The proposed solution is well aligned with the transition from linear economy to circular economy where in this case we reuse the waste tire as a secondary raw material for road pavement.

Waste Tire Rubber Material Characterization

The global population and industrial growth in recent decades have led to a tremendous growth in the automobile industry, which has increased the growth of rubber tire industry; which ended up in generating a huge stockpile of used tires. This created a big challenge to manage this waste and led many researchers to conduct various intensive research to fnd a proper solution and explore the possibility of using waste rubber tires in various applications to protect the environment of this waste in the best possible efective way.

Physical Characterization

The properties of waste tire rubber powder, where rubber powder was produced from the tires of three diferent cars in a mechanical way under room temperature. In addition, the steel was removed through magnetic separation, and the textile fbers were densely removed. The steel was removed from the sample permanently, but about 2% of the textile fbers remained. A microscopic examination was conducted to fnd the dimensions of the rubber powder, where it was found that it ranged between 0.08 and 1.6 mm. The density of the obtained rubber powder was 0.83 using a helium pycnometer. The rubber powder is characterized by its low water absorption rate of 3%; Table 1 surmises the physical properties of the waste tire rubber. Figures 1 and 2 shows scanning electron microscopy (SEM) photo for crumb tire rubber and rubberized asphalt, respectively.

Chemical Properties

Tires consist mainly of rubber. Its composition differs slightly between car tires and heavy truck tires. Rubber consists of a complex mixture of elastomers, polyisoprene, polybutadiene, and styrene. Citric acid, zinc oxide, extender oil, and carbon black are also important compounds in the formation of tires, chemical properties of rubber. The chemical interaction between aggregate and rubber asphalt was analysed , Where the researchers found that the mineral composition of the aggregates significantly affects the interfacial behaviour with rubber asphalt. Also, calcite aggregates have the lowest adhesion energy, followed by dolomites, and the highest adhesion energy with quartz aggregates.

2. LITERATURE REVIEW

Prof. Justo et al (2002)(1), at the Centre for Transportation Engineering of Bangalore University compare the properties of the modified bitumen with ordinary bitumen. It was observed that the penetration and ductility values of the modified bitumen decreased with the increase in proportion of the plastic additive, up to 12 percent by weight. Therefore, the life of the pavement surfacing using the modified bitumen is also expected to increase substantially in comparison to the use of ordinary bitumen. Shankar et al (2009), crumb rubber modified bitumen (CRMB 55) was blended at specified temperatures. Marshall's mix design was carried out by changing the modified bitumen content at constant optimum rubber content and subsequent tests have been performed to determine the different mix design characteristics and for conventional bitumen (60/70) also. This has resulted in much improved characteristics when compared with straight run bitumen and that too at reduced optimum modified binder content (5.67 %). Mohd. Imtiyaz (2002) concluded that the mix prepared with modifiers shows: - Higher resistance to permanent deformation at higher temperature.

Nabin Rana Magar, (2014) (2) investigates the performance of crumb rubber modified bitumen by varying the sizes of crumb rubber. The test results of common laboratory test on plain bitumen and crumb rubber modified bitumen shows that the penetration values and softening points of plain bitumen can be improved significantly by modifying it with the addition of crumb rubber which is a major environmental pollutant. The best size to be used for crumb rubber modification is suggested as (0.3-0.15mm) size for commercial production of CRMB. Siddharth Rokade, (2012) The Crumb Rubber was added to 60/70 grade bitumen in varying percentage. The mix was prepared with 5 % bitumen and the varying percentages of Crumb Rubber. The bitumen, when mixed with Crumb Rubber, is termed as Crumb Rubber Modified Bitumen (CRMB). The results observed that the Marshal Stability Value is increased from 4% to 12% Crumb Rubber and then it is decreased 15% of Crumb Rubber of the weight of bitumen is the optimum dose for getting enhanced strength characteristics of the mix.

Nuha S.Mashaan, (2012) (3) In their study presented the application of crumb rubber modifier in the asphalt modification of flexible pavement. From the results of the previous study, it aspires to consider crumb rubber modifier in hot mix asphalt to improve resistance to rutting and produce pavement with better durability by minimizing the distresses caused in hot mix asphalt pavement. Hence, road user would be ensured of safer and smoother roads. 2.4 Mashaan et al, (2011a) The penetration is a measure of hardness or softness of bitumen binder which shows an effect by adding crumb rubber to bitumen binder; it decreases as rubber content is increased. The penetration shows lower values as rubber content increases at different mix conditions of rubberized bitumen binder, indicating that the binder becomes stiff and more vicious The softening point refers to the temperature at which the bitumen attains a particular degree of softening. The use of crumb rubber in bitumen modification leads to an increase in the softening point and viscosity as rubber crumb content increases.

Becker et al, (2001) (4) claimed that blend properties will be influenced by the amount of crumb rubber added to the bitumen. Higher amounts indicated significant changes in the blend properties. As rubber content generally increases, it leads to increased viscosity, increased resilience, increased softening point and decreases penetration at 25°C.

Abedlrahman and Carpenter, (1999) (5) From the study he determines that the various properties of CRMB vary with blending temperature and blending time. The optimum blending temperature and blending time found out 175ºC and 45 minutes respectively for preparing high-quality CRMB.

Mohammad A. T. Alsheyab (6) This research paper aims at providing a comprehensive analysis of the efect of the addition of waste tire rubber to asphalt mix and its properties. Having reviewed several published research papers, it is concluded that the addition of waste tire rubber to asphalt mix increases the softening point, viscosity, fow, void mineral aggregate (VMA), and Marshall stability. On the other hand, it reduces the penetration, ductility, specifc gravity, fash point, and retained stability. It is stated also that the addition of waste tire rubber to asphalt mix is a safe way of managing huge amounts of waste tires generated around the world in a high-value reuse.

3.EXPERIMENTAL INVESTIGATION

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.

The four basic process undergoes are as follows

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

Waste rubber tyres were collected from roads sides, dumpsites and waste-buyers. The collected waste tyres were sorted as per the required sizes for the aggregate. The waste tyres were cut in the form of aggregate of sizes ranging from 22.4 mm to 6.00 (as per IRC-SP20) in the tyre cutting machine. The waste rubber tyres can be managed as a whole tyre, as slit tyre, as shredded or chopped tyre, as ground rubber or as a crumb rubber product. The rubber of tyre usually employed inbituminous mix, in the form of rubber particles are subjected to a dual cycle of magnetic separation, then screened and recovered in various sizes and can be called as Rubber aggregate. It was cleaned byde-dusting or washing if required. Basic properties of VG-30 grade bitumen are compared with the addition of 0-4% rubber waste of 2mm size. Marshall Stability test are conducted to get the optimum bitumen content (OBC). By adding 0-4% of 2mm rubber waste Marshall stability test were conducted and similarly by replacing rubber waste of 22.4mm passing and 5.6mm retaining with aggregate mix. The rubber pieces (rubber aggregate) were sieved through 22.4 mm sieve and retained at 5.6 mm sieve as per the specification of mix design and these were added in bituminous mix, 10 to 20 percent by weight of the stone aggregate. These rubber aggregate were mixed with stone aggregate and bitumen at temperature between 1600 c to 1700 c for proper mixing of bituminous mix. As the waste rubber tyres are thermodynamically set, they are not supposed to melt in the bitumen, at the time of mixing of rubber aggregate, stone aggregate and bitumen in hot mix plant.

3.2 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.

- 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.,

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.

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.

Process Of Making Rubberised Bitumen

This terminology is related to the system of producing RTR-MB with the original wet process proposed by Charles McDonald in the1960s. The McDonald blend is a Bitumen Rubber blend produced in a blending tank by blending Crumb Rubber and bitumen. This modified binder is then passed to a holding tank, provided with augers to ensure circulation, to allow the reaction of the blend for a sufficient period (generally 45–60 min). The reacted binder is then used for mix production. Continuous Blending-reaction Systems: This system is similar to the McDonald process of blending; the difference is that CRM and bitumen are continuously blended during the mix production or prepared by hand and then stored in storage tanks for later use. Therefore, it consists of a unique unit with agitators, in which the reaction occurs during the blending.

Materials And Mix Design

This chapter provides a background on the materials used in crumb rubber modified bitumen and the

specifications for those materials. Specific topics will include a discussion of the production and properties of CRM, the shipping and handling of CRM, the properties of the asphalt cement as they relate to asphalt rubber.

Bitumen

Bitumen is a black, highly viscous and very sticky liquid or semi-solid, found in some natural deposits. It is also the by-product of the fractional distillation of crude petroleum. Generally in India bitumen used in road construction of flexible pavement is of grades 60/70 or 80/100 penetration grade.

Crumb Rubber

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

I. Cracker Mill

The most common method is the cracker mill process. The scrap tires are pre-processed by shredding to remove steel cord and bead wire. Rotating corrugated steel drums are used to tear the scrap tires into smaller ground CRM. The ground CRM has irregular torn shapes with large surface areas and sizes ranging from 4.75 mm to 425 μm (No. 4 to No. 40 sieve)

II. Granulator

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

III. 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 ranging from 425 μm to 75 μm (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.

IV. Cryogenic Process

In the cryogenic process, the pre-chipped scrap tires are cooled with liquid nitrogen. The brittle tire rubber is easily fractured with a hammer mill. The process uses a cooler to chill tile material, a grinder, appropriate screens and conveyors and steel and fiber separation systems. Usually, the cryogenic process is used as a preliminary step to the other processes which will reduce the particles to the desired size.

Crumb Rubber Modified Bitumen (CRMB)

Crumb rubber is also 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.

Preparations to make Crumb Rubber Modified Bitumen blend The studies on the behavior and binding property promoted a study on the preparation of rubber wastebitumen blend. It's bituminous properties are found. These properties are compared with Normal Bitumen. Then its suitability as a blend for road construction is investigated. Scrap tire 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 an asphalt cement modifier, while in the dry process, granulated or ground rubber and/or crumb rubber is used as a portion of the fine aggregate.

CRMB is produced by the so-called wet process in which crumb rubber is added to hot bitumen of temperature around 150 -160 degree 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.

4.RESULTS AND DISCUSSIONS

Mixing of Crumb Rubber with Plain Bitumen

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 of 160 °C and then crumb rubber was added. For each mixture 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. Care is taken to maintain the temperature between 160 °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.

Physical Properties of Crumb rubber

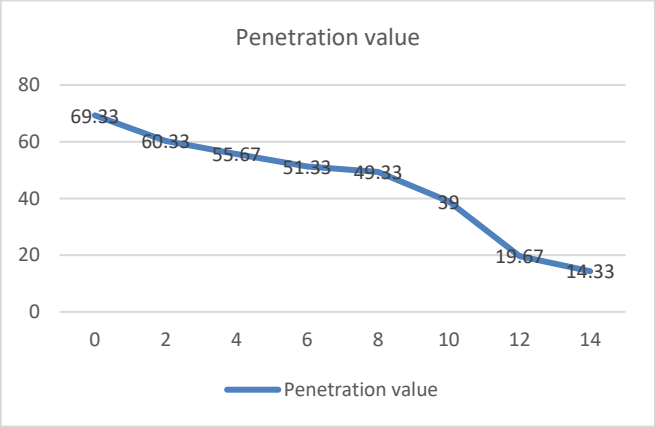
S.No.	Properties of Crumb rubber	Results
1	Specific gravity	1.01
2	Moisture content	2

Penetration Test on Bitumen

The use of different grade of bitumen depends on climatic conditions and type of construction. Commonly used grades are 30/40, 60/70 and 80/100. For bituminous macadam and penetration macadam, IRC suggests bitumen grades 30/40, 60/70, 80/100. Generally, in warmer regions, lowerpenetration grades are preferred to avoid softening and in colder regions bitumen with higher penetration grades like 180/200 are used to prevent the occurrence of excessive brittleness. The test is not intended to estimate consistency of softer materials like cut back which are usually graded by viscosity test. High penetration grade is used in spray application works. The penetration value of bitumen is measured by distance in tenths of mm that a standard needle would penetrate vertically into bitumen sample under standard conditions of test. By this test we can determine the hardness or softness value of bitumen.

Penetration test result

% of CRMB	TRAIL						AVG.
	1		2		3		
	Initial	Final	Initial	Final	Initial	Final	
0	0	64	0	69	0	75	69.33
2	0	58	0	59	0	64	60.33
4	0	51	0	57	0	59	55.67
6	0	47	0	49	0	58	51.33
8	0	44	0	48	0	56	49.33
10	0	33	0	37	0	47	39.00
12	0	19	0	20	0	20	19.67
14	0	14	0	14	0	15	14.33



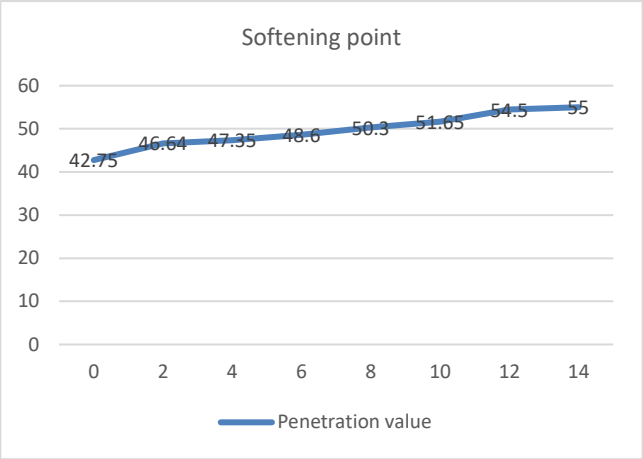
Penetration test result

Softening Point Test

Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the specifications of test. The test is conducted by using Ring and Ball apparatus. A brass ring containing test sample of bitumen is suspended in liquid like water or glycerin at a given temperature. A steel ball is placed upon the bitumen sample and the liquid medium is heated at a rate of 5oC per minute. Temperature is noted when the softened bitumen touches the metal plate which is at a specified distance below. Generally, higher softening point indicates lower temperature susceptibility and is preferred in hot climates. Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the specifications of test. The test is conducted in accordance with IS:1205-1978.

Softening point test values

% of CRMB	TRAIL		AVG.
	1	2	
0	42.4	43.1	42.75
2	45.2	48.1	46.64
4	46.1	48.6	47.35
6	47.8	49.4	48.60
8	49.1	51.5	50.3
10	51.4	51.9	51.65
12	54.1	54.9	54.5
14	54.2	55.8	55



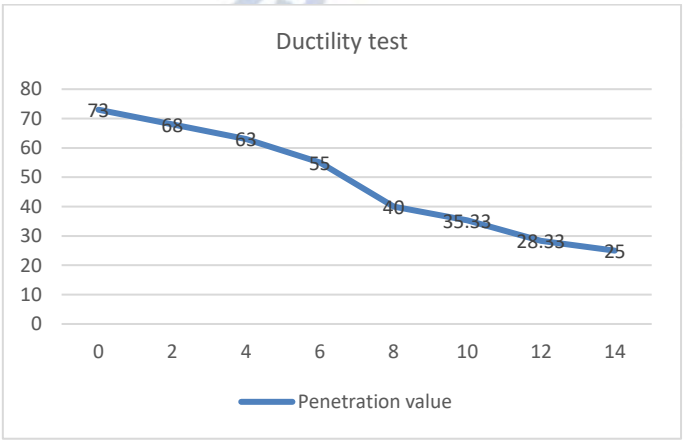
Softening point test values

Ductility Test

Ductility is the property of bitumen that permits it to undergo great deformation or elongation. Ductility is defined as the distance in cm, to which a standard sample or briquette of the material will be elongated without breaking. Ductility is the property of bitumen that permits it to undergo great deformation or elongation. This test was carried out in accordance with IS:208-1978.

Ductility Test

% of CRMB	TRAIL			AVG.
	1	2	3	
0	71	73	75	73
2	65	68	71	68
4	59	62	68	63
6	47	54	65	55
8	39	40	41	40
10	34	36	36	35.33
12	27	28	30	28.33
14	24	25	26	25



Ductility test

5. CONCLUSIONS

- Penetration value test result shows that Penetration value decreased ith the increased amount of the rubber waste added. Lower penetration value making a harder grade of asphalt, giving additional strength to the road and reduces water damage. Lower Penetration thereby making a harder grade of asphalt, giving additional strength to the road and reduces water damage.
- Softening point test shows that Softening Point increased with the increased amount of the rubber waste added. This showed that the bitumen becomes less susceptible to temperature changes as the content of rubber waste increased. Increase of Softening Point, thereby giving it protection against hot climatic conditions.
- Ductility test result shows that the rubber waste added will harden the bitumen. The bitumen becomes more viscous and harden, which would be useful to obtain stiffer bitumen asphalt.
- The biggest advantage of using rubberized bitumen is that the road life increases in comparison to the normal bitumen whereas the cost increase on the road. Improved adhesion aggregates and binder thereby giving better strength, stability and longer life.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Al-Qadi, I. L., Brandon, T. L., Smith, T., and Lacina, B. A., "How Do Geosynthetics Improve Pavement's Performance," Proceedings of Material Engineering Conference, San Diego, CA. 1996, pp. 606-616.

[2] Appea, A. K., Al-Qadi, I. L., Bhutta, S. A., and Coree, B. J., "Quantitative Assessment of Transmission Layer in Flexible Pavements," 77th Transportation Research Board, Paper No. 980994, Washington, DC, 1998.

[3] Barksdale, R. D., Brown, S. F., and Francis, C., "Potential Benefits of Geosynthetics in Flexible Pavement Systems," National Cooperative Highway Research Program, Report No. 315, Transportation Research Board, Washington, D. C. 1989.

[4] Battiato, G., and Verga, C., "The AGIP Visco elastic Method For Asphalt Pavement Design," Proceedings Of The Fifth International Conference On The Structural Design Of Asphalt Pavements, Ba Arnhem; Netherlands, August 23-26 1982, pp. 59-66.

[5] Hak-SeoKim, Andras Geiger, Serji N. Amirkhanian, Tae-Soon Park, Kwang-Woo Kim done "EFFECTS OF ASPHALT RATIOS

ON PROPERTIES OF CRUMB RUBBER MODIFIED ASPHALTS" 6th ICPT, Sapporo, Japan, July 2008.
[6] IRC, "Guidelines for the Design of flexible pavements",
[7] IRC: 37 -1970, Indian Roads Con IRC: SP: 53, 'Tentative Guidelines on the use of polymer and Rubber modified Bitumen in Road construction', Indian Road Congress (IRC), 2002.
[8] IRC SP-53:2010, "Guidelines on use of modified bitumen in road construction" ISI, "Indian Standards Specifications for Roads Tar", IS: 215, Indian standard Institution.
[9] Niraj D. Baraiya" Use of Waste Rubber Tyres in Construction of Bituminous Road-An Overview "International Journal of Application or Innovation in Engineering & Management (IJAIEM) Volume 2, Issue 7, July 2013 ISSN 2319-4847.
[10] Nuha S. Mashaan*, Asim Hassan Ali, Mohamed RehanKarim and MahrezAbdelaziz "An overview of crumb rubber modified asphalt".International journal of the physical sciences vol. 7(2), pp. 166 - 170, 9 January, 2012.
[11] Nuha S. Mashaan, Asim Hassan Ali, Mohamed RehanKarim and MahrezAbdelaziz. "Effect of blending time and crumb rubber content on compacting-properties of crumb rubber modified asphalt binder" international journal of the physical sciences doi: vol. 6(9), pp. 2189-2193, 4 may, 2011.
[12] Shankar (2009) "Use of Waste Rubber Tyre in Flexible Pavement", International Journal of Application or Innovation in Engineering and Management.
[13] Vasudevan, R et.al," Utilization of crumb rubber for flexible pavement and easy disposal of crumb rubber" International conference on sustainable solid waste management,5-7september2007, Chennai,india.pp.105- 111
[14] Biswanath Prusty(108CE036), "Use of waste polythene in bituminous mixes" (Ph.D. Thesis) Under the guidance of Prof. Mahabir Panda, Odisha: NIT-Rourkela; May 2012.
[15] Dr. Dinesh Chand and Dr.S.K.Singh, "Waste Plastics Use for Road Development: A Review", International Journal for Innovative Research in Multidisciplinary Field, pp.100-109, 6(8), 2020.
[16] Sasane Neha B. et. al. "Application of Waste Plastic as an Effective Construction Material in Flexible Pavement", IRJET, 1943-48, 2(3), 2015.
[17] NLaj D. Braraiya, " Use of waste rubber tyres in construction of bituminous roads- An overview", International Journal of Application or Innovation in Engineering & Management (IJAIEM), 2(7), 2013.
[18] Shukla R.S. and Jain, P.K., Improvement of waxy bitumen by the addition of synthetic rubbers, polymers and resins. Highway Res.Bull., 1984, 38, 17:28 (Indian Roads Congress, Dehli).
[19] Amit Gawande, et. al.,"An Overview on Waste Plastic Utilization in Asphalting of Roads". Journal of Eng. Research and Studies, pp 01-05, 3(2), 2012.
[20] TUSTI high tech recycling (Internet); TUSTI high tech recycling (cited 2022), Available (https://www.tusti.nl/the-process/)
[21] R. Manju Anand and S. Sathya, "Use of Plastic Waste in Bituminous Pavement". International Journal of ChemTech Research, pp 804-811, 10(8), 2017.
[22] S. Shankar and C.S.R.K. Prasad, "Evaluation of Rutting Potential for Crumb Rubber Modified Bitumen in Asphalt Mixes", Emirates Journal for Engineering Research, pp.91-95, 14(2), 2009