Section A-Research paper

USE OF WASTE TYRE IN ROAD CONSTRUCTION

Mrs Meenu Kalra, Piyush Kumar Lodhi, Shobhit Agrahari, Shubham Yadav, Swatantra Gupta, Vipin Kumar Maurya

Galgotias College of Engineering and Technology

Greater Noida, Uttar Pradesh, 201310, India

Email id -

yadavshubham2052000@gmail.com lodhipiyushkumar4@gmail.com vipinmaurya5677@gmail.com agrahari.shobhit05@gmail.com swatantragupta577@gmail.com

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ABSTRACT

The importance of effective waste management has grown as technology has permeated every sector of the economy. Tyres from discarded cars, trucks, tractors, construction equipment, and off-road vehicles can be found in every state. When tyres are burned in the open, they release noxious substances such polycyclic aromatic hydrocarbons, dioxins, furans, and oxides of nitrogen, all of which contribute to air pollution. The nonbiodegradability of waste tyre rubber has made it a problem in recent years. The use of recycled tyre rubber in bitumen is explored in this paper to determine its potential. This is accomplished by layering aggregate and scrap tyre rubber and then applying varying concentrations of bitumen (5, 10, and 15 percent) to the topmost layer. In light of these findings, the research estimates the potential improvement in road pavement strength and economic success from switching to rubber from conventional asphalt.This not only lessens the environmental impact of old tyres, but it also lessens the need for traditional aggregate, a resource with finite availability. The problem of where to put all the trash that modern industry creates is now pressing. Many of these materials are not biodegradable, which might have negative effects on the environment. Besides natural sand and gravel, you can also use modified bitumen or granulated, crushed, or crumb rubber as fine stone aggregate. Crumb rubber from recycled tyres mixed with hot bitumen. It serves multiple purposes, including crack and joint sealing, chip seal coating, and asphalt pavement production when combined with heated mineral aggregate.

INTRODUCTION

Based on the based on the yankee Society for testing and materials (ASTM) D8 definition, rubberized bitumen is "a mix of asphalt cement [bitumen], reclaimed tyre rubber, and sure components, in which the rubber the usa, issue is at the least 15% by way of weight of the overall combination and has reacted inside the hot asphalt cement [bitumen] sufficiently to cause swelling of the rubber particles." [ASTOS] This unique definition emerged inside the past due 1990s. The Centre for Transportation Engineering at Bangalore college analysed the modified bitumen and compared its performance to that of conventional bitumen. Penetration and ductility were found to be diminished by up to 12 percent by weight of the plastic component in the modified bitumen. The longevity advantages of modified bitumen over conventional bitumen suggest that it should be used on a larger number of roads. New and replacement tyres have become increasingly important as the number of cars in India has increased over the past few years. All newly made tyres are designed for the waste stream for disposal, recycling, or reclamation after being re-treaded, therefore there will be a significant increase in the quantity of used tyres going to landfills. Prompt action regarding recycling of used tyres is vital to solve the problem of disposal of used tyres because of the rising cost of raw materials, resource restrictions, and environmental concern (including fire and health hazard related with stockpiles of the used tyres). The global annual production of rubbish tyres is approximately 1.5 billion. Those in need in underdeveloped regions of Asia, Latin America, Southeast Asia, Africa, and Europe. Radial tyres are standard on all newly manufactured vehicles in India. It is estimated that 0.6 MMT of scrap tyres are produced annually in the country. It is often accepted in the tyre industry that each person discards of one tyre every year. As there is currently no industry body, industry, or government agency that tracks tyre disposal in the country, the best estimates are based on tyre manufacture. The growing number of automobiles in India guarantees the continued success of the scrap tyre industry. The required scrapping of end-of-life vehicles is likely to promote organised players and produce a substantial supply of scrap tyre in strategic sites by 2010-11 in metro areas and across India by 2012-13. As one of several forms of hazardous wastes that present specific issues for local governments, scrap tyre management has become increasingly difficult in recent years. Tyres, especially when still whole, have a nasty habit of rising to the top of landfills. These heaps not only pose a fire hazard, but also a health danger, an environmental issue, and a waste of energy and resources. Rubber, the basic component of tyres, has several use beyond just making tyres. The rising number of automobiles also boosts the industry's need for tyres.

HISTORY

In the United States, rubberized bitumen has been used since the 1960s. Currently, the states of Arizona, Florida, Texas, and California use 2 million metric tonnes of rubberized bitumen annually. In the coarse sand structural layers common in Australia, chip sealing with rubberized bitumen is commonly utilised. In the poorer countries of Latin America, the use of rubberized bitumen has increased. Recycled tyres have been used in the paving industry since the 1960s. Two Swedish companies have devised a process for making asphalt surface mixtures that involves replacing some of the mineral aggregate with crushed rubber from used tyres. The asphalt mixture produced using the "dry process" is more resistant to damage from studded tyres and snow chains than conventional asphalt. Simultaneously, a materials engineer from Phoenix, Arizona (USA) named Charles McDonalds found that when RTR crumbs were mixed with bitumen (CRM) and allowed to react for 45 minutes to an hour, the resulting material contained the desirable engineering qualities of both components. The "wet process" and "Asphalt Rubber" are also names he gave to this technique.

By 1975, Crumb Rubber was being successfully included into asphalt mixtures, prompting the American Society for Testing and Materials (ASTM) to first add a name for rubberised bitumen in D8 and then standardise it in D6114- 97. McDonald's patent on its process expired in 1992, therefore the technique is now free for anybody to use. As a result of the "Intermodal Surface Transportation Efficiency Act" (now repealed) in the United States, asphalt-rubber technology has been making a "quiet comeback" since 1991. Many people from different parts of the world have since laboured to ensure the effectiveness of rubberized asphalt road technology. Modern rubberized bitumen compounds, created by a wet process, have shown different degrees of success on roads built in the last 30 years. Asphalt binders, pavements, stress-absorbing lays and inlayers, roofing materials, etc. all make use of these substances to improve their respective quality profiles.

CHARACTERIZATION OF MATERIALS USED

A) SOIL SPECIMEN

When conducting experiments involving soil, it is common practice to specify the source of the soil and its properties. In your case, you mentioned that the soil used in the experiments was obtained from the Tugalpur, Grater Noida.The soil was described as clayey in nature.

To determine the optimum moisture content (OMC) and maximum dry density (MDD) of the plain soil without crumb rubber, the IS (Indian Standard) heavy compaction method was employed. The actual values of OMC and MDD would be listed in the table you mentioned, but since you haven't provided the specific values, I cannot include them in this response.

Sr No	Parameters(%)	Value
1	OMC	14.1
2	MDD(gm/cc)	1.672
3	Liquid Limit	30
4	Plastic Limit	22
5	Plasticity Limit	7
6	Soil classification as per ISCS	C L

Table 1.1 Properties of plain soil

B)SCRAP RUBBER TYRE CRUMBS

According to the information you shared, the waste rubber tire crumbs were collected from a local rubber tyre recycling workshop near the dumpsite called MRF Tyre in Tugalpur, Greater Noida. These tyre crumbs are the ground or grinded part of worn-out tyre treads and do not contain any steel or fluff.

The size of the rubber tyre crumbs varies, ranging from 4.75 mm to less than 0.075 mm, as reported by Oikonomou and Mavridou in 2009.

The specific gravity of the scrap tyre crumbs was determined according to ASTM C127 (2007) guidelines and was found to be 1.15. Specific gravity is a measure of the density of a material relative to the density of water.

The size distribution of the waste rubber tyre crumbs was analyzed using the sieve analysis method, following the guidelines of ASTM D422-63 (1998). Unfortunately, the specific results of the sieve analysis, including the particle size distribution, cannot be provided.

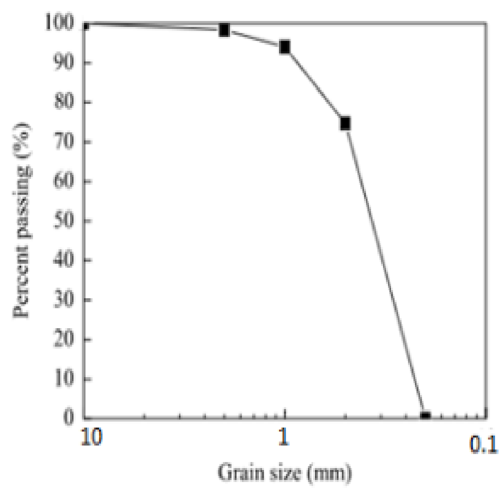


Fig-1: Particle-size distribution of waste rubber tire crumbs

RUBBERIZED BITUMEN MANUFACTURING METHODS

The term originates from Charles McDonald's idea of a wet way of producing RTR-MB in the 1960s, from which this jargon derives. The McDonald blend, sometimes known as Bitumen Rubber, is created by mixing Crumb Rubber and bitumen in a blending tank. The modified binder is then moved to a storage tank equipped with augers to enhance circulation, where the reaction of the blend can take place for an appropriate amount of time (usually 45-60 minutes). The resulting mixture makes good use of the binder's reactive character.

Methods of Constant Mixing and Response Systems: This system allows for continuous blending throughout mix manufacturing, as opposed to the McDonald blending technique, which only allows for mixing CRM and bitumen once during mix production or by hand and then storing in tanks. Therefore, the reaction occurs in a one-of-a-kind unit fitted with agitators for the duration of the blending process.

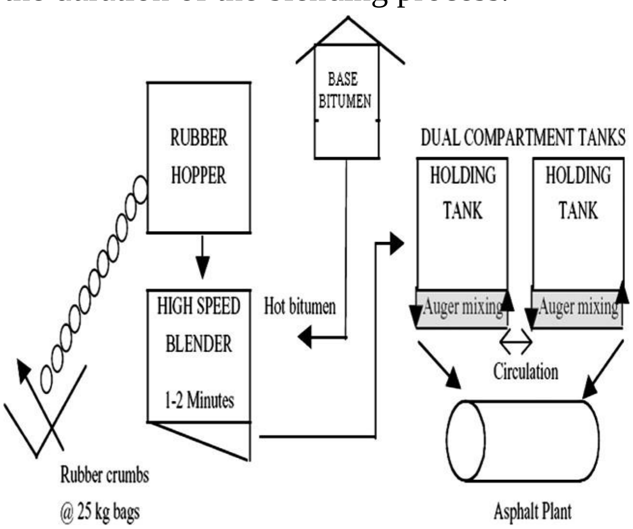


Fig -2: McDonald's Production Flowchart

TEST PERFORMED

A) MODIFIED PROCTOR TEST

The Modified Proctor Test, following the codal provisions of IS: 2720(Part 8)-1983, was conducted to investigate the compaction properties of both soil alone and soil mixed with rubber tyre particles of greater size in various percentages.

The test determines the Optimum Moisture Content (OMC) i.e moisture content at which the dry density is maximum as well as the Maximum Dry Density (γd).

In your experiment, the same test procedure was followed for both the soil alone and the mixtures containing different percentages of tyre crumbs. The proportions of tyre crumbs used in the mixtures were 4%, 6%, 8%, 12%, and 16%.

By performing the Modified Proctor Test, you were able to determine the OMC and MDD values for each combination of soil and tyre crumbs. These values provide insights into the compaction characteristics and the effect of the tyre crumbs on the engineering characteristics of the soil.

B) CALIFORNIA BEARING RATIO TEST

The California Bearing Ratio (CBR) test is widely used in transportation engineering to assess the strength and suitability of subgrade materials for road pavement construction. It was initially developed by O. J. Porter of the California Highway Department in the 1920s.

In this case, the CBR test was conducted according to the codal provisions outlined in the Indian Standard code IS: 2720(Part 16)-1987. This standard provides guidelines and procedures for performing the CBR test in India.

The CBR test, as you described, involves measuring the pressure needed to penetrate a soil sample using a plunger with a standardized area. The measured pressure is then divided by the pressure required to achieve the same penetration on a standard crushed rock material.

The same test procedure was repeated for soil samples mixed with different percentages of tyre crumbs, specifically at 4%, 8%, 12%, and 16% proportions. By conducting the CBR test on these mixtures, you aimed to evaluate the effect of the tyre crumbs on the subgrade material's strength and determine the corresponding CBR values.

The CBR values obtained from these tests can be used to assess the required thickness of subgrade material for road pavement construction. Higher CBR values generally indicate better strength and suitability for supporting the load from the pavement structure.

The CBR value serves as an important parameter in evaluating the strength and load-bearing capacity of soils, especially in the context of pavement design and construction. It helps engineers and designers determine the thickness of subgrade materials needed for road pavement construction, considering the soil's ability to support the load from the pavement structure.

Fig-3 : California Bearing Ratio test

C) UNCONFINED COMPRESSIVE STRENGTH TEST

The unconfined compressive electricity (qu) check is carried out to decide the energy of clayey soil beneath unconfined conditions. This take a look at is essential for calculating the unconsolidated undrained (UU) shear strength of the clay. The unconfined compressive energy (qu) represents the compressive pressure at which an unconfined cylindrical soil specimen fails in a simple compression test, as described via ASTM standards.

In your study, the test procedure and sample preparation follow the guidelines provided in the IS: 2720(Part 10)-1991 Indian Standard code. Soil samples that pass through a 2 mm I.S. sieve and rubber tyre crumbs that also pass through a 2 mm I.S. sieve are taken. The rubber tyre crumbs used are of medium grain size, regardless of their different densities.

The soil and rubber tyre crumbs are mixed in different proportions of 2%, 4%, 6%, 8%, and 10%. The objective is to observe any changes in the unconfined compressive strength (UCS) values resulting from the addition of tyre crumbs to the soil. By analyzing the UCS values at various mixture proportions, you can assess the impact of rubber tyre crumbs on the strength characteristics of the soil.

RESULTS AND DISCUSSION

A)MOISTURE CONTENT AND DRY DENSITY OF PLAIN SOIL

To determine the OMC, the IS (Indian Standard) heavy compaction test is used in your study. The test involves adding varying amounts of water to the soil, typically expressed as a certain percentage of the soil's weight. The compaction test is repeated multiple times, adjusting the moisture content each time, until a pattern is observed in the weight of the mold.

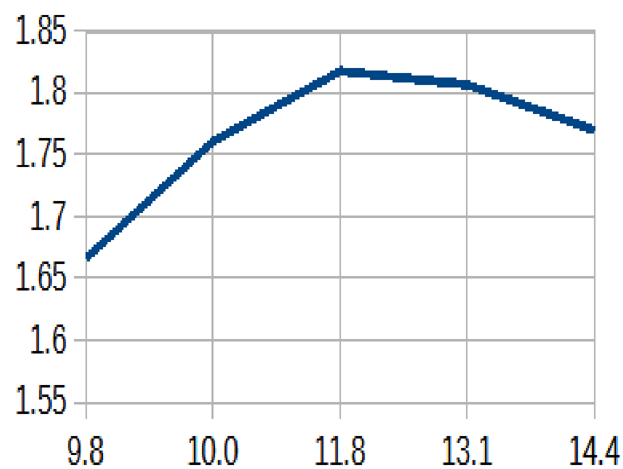
Initially, as the moisture content increases, the soil becomes more workable and compactable, resulting in an increase in the weight of the mold. However, at a certain point, the addition of more water starts to have a negative effect on the compaction process, causing the weight of the mold to decrease.

The moisture content at which the weight of the mold is maximum and starts to decrease is identified as the OMC. At this moisture content, the soil achieves its highest dry density, indicating the optimal conditions for compaction.

It is worth noting that the specific percentages of water by weight and the corresponding OMC values are not provided in your description, as they would depend on the specific testing parameters of your study.

Moisture Content(%)	Dry Density(gm/cc)
9.8	1.666
10.0	1.761
11.8	1.818
13.1	1.807
14.4	1.770

Table-2 : Moisture Content and Dry Density of Plain Soil



Graph -1: Compaction Curve for Soil (without tyre)

B)VARIATION OF CBR ON VARYING THE % OF TYRE CRUMB CONTENT

The CBR (California Bearing Ratio) price of the soil mixed with rubber tyre crumbs accelerated up to the addition of eight% crumb rubber powder. After reaching this threshold, the CBR fee began to ecrease. This lower is probably attributed to the higher percentage of rubber cloth, which provides to the compressibility of the mixture.

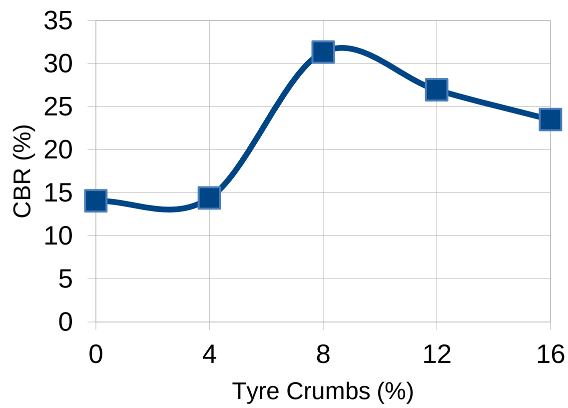
The addition of rubber tyre crumbs to the soil led to an improvement inside the CBR price in comparison to the soil with none tyre content. The CBR price confirmed a modern increase with the addition of four% to eight% tyre crumb content. At eight% tyre crumb content material, the CBR fee reached its most. extensively, there has been a significant increase of 122.6% inside the un- soaked CBR value at eight% tyre crumb content material.

The improved CBR cost is adantageous because it permits for a reduction inside the standard pavement thickness, thereby decreasing the overall value of road production. This finding may be relevant now not handiest to avenue production however additionally to the construction of parking plenty that enjoy heavy vehicular masses.

It's important to note that the specific CBR values and other details of the study are not provided in your description, but the general trend indicates the potential benefits of incorporating tyre crumbs in soil for pavement construction.

Tyre Crumbs(%)	CBR(%)
0	14.05
4	14.38
8	31.32
12	26.93
16	23.48

Table-3: CBR values at different content of tyre crumb in the soil



Graph-2: Tyre crumb content in the soil vs CBR

APPLICATIONS OF RUBBISH-IN-BITUMEN

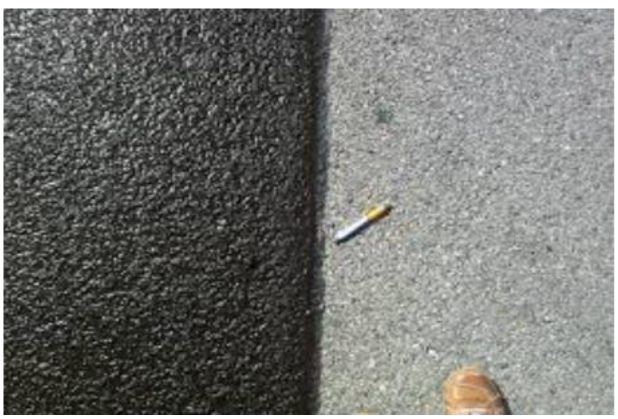
A) RUBBERIZED BITUMEN AS A SLURRY MATERIAL:

The idea was developed further to cover entire pavement sections by spreading the rubberized bitumen with slurry seal equipment, as shown in Figure 2, and then applying the aggregate with standard chip spreaders [MCD81]. This is because fatigue cracking typically affects larger areas than can be repaired using small patches. There were two distinct building problems during this process. First, with the intention to gain the proper reaction between the bitumen and crumb rubber within the constrained length allowed with the aid of the slurry equipment, bitumen temperatures of 4500 F (2320 C) or higher have been required. second, the membrane's thickness varied in direct relation to the unevenness of the road.. The consequence was an excess of materials in areas such as wheel ruts and an insufficient thickness of the membrane in other area

Fig -4: Rubberised bitumen applied as a slurry seal

B) RUBBERIZED BITUMEN AS A CHIP SEAL APPLICATION

Bitumen was first widely distributed in



1971. A uniform coating of binder was applied to the roadway through lorries (Figure 3).Material distribution and separation problems plagued early experiments, although it was subsequently established that they were caused primarily by equipment constraints. In the years that followed, manufacturers began to sell tools capable of pumping, measuring, and stirring rubberized bitumen. As indicated before, in 1964 the Arizona Department of Transportation (ADOT) monitored the development of AR and applied it as a Band-Aid for preventative maintenance. By adding a diluent (kerosene) in 1968, mixing had been refined to the point where AR could be regularly deployed with a distributor lorry. It took some trial and error and the destruction of a few distributor boot automobiles to get here. Six separate ADOT reconstruction projects utilised AR technology between 1968 and 1972. Cracking of the type seen in these projects is indicative of a failed pavement that requires either a six-inch overlay or a total redo.

For these seal coat-like applications, a boot truck distributor was used to disperse the AR. Ground tyre rubber was originally loaded into the open back of the vehicle and rocked forward and backward to blend the components. The first large-scale ADOT field experiment using AR as a seal coat or Stress Absorbing Membrane (SAM) and as an interlayer under a hot mix asphalt (HMA) pavement was built in 1972, when the technology was still rather basic. The acronym "SAMI" refers to a Stress Absorbing Membrane Interlayer. The first step in constructing an AR pavement is mixing the specified amounts of crumb rubber and hot bitumen and then waiting for the mixture to fully react. Ground tyre rubber that meets the gradation requirements in Table 1 is typically added to hot base bitumen at a rate of 20%. Before rubber particles can be added, bitumen must be heated to between 1910C and 218OC (375F and 425F) in the blending unit, and the ideal temperature for adding rubber is 177OC (about 350F). The mixing of the rubber and bitumen takes at least an hour. After the reaction, the rubberized bitumen mixture is kept in storage at 163OC 191OC (325°F 375OF) before being delivered into the mixing facility. Various samples are collected for testing, including rubber, bitumen, and AR. The ARFC, which typically has 1% lime in the mix, is laid out on a regular laydown machine and rolled using a steel wheel roller.

Fig-5: Rubberised bitumen chip seal applied to badly cracked pavement.

C)RUBBER CHIPS MADE FROM OLD TYRES

The purpose of this research was to examine the viability of employing tyre shreds, specifically large rubber chunks, as aggregates in coldmixes for road building. A cationic emulsion, shredded tyre rubber chunks and local aggregate were studied to generate a chunk rubber asphalt concrete mix design for low-volume road building. Different mixtures were tried out with varying amounts of chunk rubber, emulsion, and fly ash.

Results from Marshall stability tests on mixtures containing 10% Type C flyash indicated that for 2, 4, and 6% rubber, the optimal emulsion concentrations were 6.8, 7.3, and 7.8%, respectively. Values for Marshall stability dropped as rubber content increased. At 43 degrees Celsius, the desired Marshall stability value of an appropriate cold mix was set at 2225 N. Marshallstability tests conducted on a mixture consisting of 10% Type C fly ash, 2% rubber, and 7% emulsion yielded an average value of 1600 N. It appeared that some of these mixtures, based on the Marshall stability data, may function as binder courses or stabilised drainable bases for low volume roads. It is estimated that 3,350 tyres could be used to construct a one km long, 7.3 metre wide, low-volume road with a 100 mm thick base using this mixture. The application can help reduce the scrap tyre trash in rural areas.

Fig-6: Rubber Chips Made From Old Tyre

Reusing Old Tyres and Plastic Bottles Using recycled materials in road building is becoming increasingly popular as a means to lessen the industry's negative environmental impact and meet the growing demand for sustainable building practises around the world. Numerous novel materials and technologies have been developed for use in highway infrastructure to evaluate their potential in road design, building, and maintenance. Materials like plastics and rubbers are examples. Taking an ecological perspective into account, there is significant environmental damage caused by the widespread use of polythenes in commercial activities.Use of disposable plastic items like shopping bags, glasses, and cutlery continues to rise. Since polythenes are not biodegradable, there is an urgent need to find productive uses for polythene waste.The primary objective of this research is to make efficient and cost-effective use of the readily available waste/recycled plastic materials and waste rubber tyres. Incorporating plastic into the sub-base course of the pavement is not only cost-effective, but also environmentally responsible.

D)RUBBERIZED PAVEMENT CONTAINING INDUSTRIAL DEBRIS

Each of the test pits is 3m in length, 1.5m in width, and 0.8m in depth on average. A sub-grade layer of 0.5 m, a sub-base layer of 0.15 m, and a base-course layer of 0.15 m are all included in this total. Ten layers of sand soil mixed with water at OMC, compacted to a thickness of 0.05 m, are deposited in the prepared test pit for a total subgrade thickness of 0.5 m. Two layers of subbasematerial composed of murrum and flyash, with water content at OMC and compacted to a total thickness of 0.15 m on the prepared sand sub-grade. Reinforcing elements including recycled plastic and tyre rubber were evenly distributed throughout the subbase (at the optimal % determined by laboratory CBR testing).

ADVANTAGES

Rubber granules used in rubber asphalt come from used tyres, making the product more environmentally friendly. Rubber recovered from used tyres is sufficient to resurface four thousand kilometres 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 deicing 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.

Fig-7: Asphalt Modified with Rubber Powder

- ✓ Reportedly reducing noise by as much as 10 decibels (dB) compared to the noise levels of traditional pavement surfaces.
- ✓ 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.
- ✓ 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.
- ✓ 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.
- ✓ Improves a road's ability to drain water.
- ✓ Due to the constant influx of traffic, compression does not occur.
- ✓ Increased vibration dampening properties are expected.
- ✓ helps keep the price of road paving down over time.

CONCLUSION

Here, we'll talk about rubberized bitumen, a binder used in hot mix asphalt and chip seal applications that's made by combining crumb rubber with hot bitumen and letting the mixture sit at a high temperature to react.

Rubberized bitumen is widely used in South Africa, a number of Western European countries, and the American states of California, Arizona, and Texas. It is also utilised on a smaller scale in a dozen additional US states and several areas of Canada.

In addition to saving money in the long run on repairs and maintenance, the roads will be quieter, safer, and have better traction when wet. Rubber aggregate with scrap tyres added changes the surface layer's pliability. Hot temperature regions have less persistent deformation and thermal cracking. Rubber's primary function is to absorb sound, making it an effective solution to the problem of traffic noise. It's possible to reduce the amount of conventional stone aggregate needed. Used tyres have been shown to increase both the durability and ride comfort of roads. Rubber from used tyres is combined with aggregate in varying thicknesses, with bitumen added to the top surface layer at varying percentages (5%, 10%, 15%) to improve the bitumen's and aggregate's properties while reducing pollution caused by tyre disposal. Bitumen can be used in place of rubber to boost durability.

1.In adding of waste tires to rubber aggregate enhances the flexibility of the surface layer, potentially improving its performance and durability.

2.Waste tire rubber can help reduce permanent deformation especially in regions with hot temperatures. The rubber particles contribute to the overall elasticity and resistance to deformation.

3.Rubber has sound-absorbing properties, which can help reduce noise pollution from heavy traffic on roads. Incorporating waste tire rubber into road construction can contribute to quieter road surfaces.

4.By utilizing waste tire rubber in road construction, the need for conventional stone aggregate can be reduced to some extent, leading to resource conservation.

5.The use of waste tyre rubber in road construction can improve the overall quality and performance of the road. The rubber particles enhance certain properties of both the bitumen and the aggregate, resulting in a better road surface.

6.Waste tire rubber can be used in different layers of pavement construction, including mixing it with bitumen in the top surface layer. By replacing a certain percentage (5%, 10%, 15%) of bitumen with rubber, the properties of both the bitumen and the aggregate are enhanced. This approach helps minimize pollution from waste tires and also proves to be cost-effective compared to other materials.

7.The incorporation of rubber in bitumen can increase the strength of the road material. The rubber particles contribute to improved elasticity and resilience, enhancing the overall structural integrity of the pavement.

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