LABORATORY EVALUATION OF USAGE OF WASTE TYRE RUBBER IN BITUMINOUS CONCRETE

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ABSTRACT

India has a wide road network of more than 3 million km is one of the largest in the world. For the development of Indian infrastructure and industrial growth the fast transportation is necessary as well as wide road network is also necessary. Due to fast transportation the vehicles used for transportation is increased due to this use of vehicles the wear and tear of tyres is occurring. For high use of tyres it becomes useless and discarded. These useless tyres are disposed by burning or landfilling, due to these processes the burning causes the environmental pollution and landfill causes the valuable land wastages. To avoid or minimizes this pollution the new method is to be used to recycles this tyres and to overcome this problem. So the use of waste tyre rubber mixed with bitumen and enhances the properties of bitumen as well as achieving the economy in bitumen. 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.

INTRODUCTION

Emerging economies need a proper transportation system, of which roadways are a crucial fragment. The construction and maintenance of road pavements should be long enduring due to their extensive influence on the economy of a nation. The increase in overall traffic, poor material quality and climatic effects are Prime reasons of the damaged conditions of roads. Recycled tyre rubber constitutes Vulcanized natural and synthetic rubber which is highly valuable. Therefore, beyond the conventional components of the bituminous pavement layers, the use of crumb rubber recycled from used tires should be studied as a form of environmental stewardship and as a pavement performance enhancer. It will be substitute way of solid waste disposal.

Over the years, road structures have deteriorated more promptly due to increasing in service traffic density, axle loading, and poor maintenance services. To minimize the damage of pavement surface and increase the durability of flexible pavement, the conventional bitumen needs to be improved with regards to performance related properties, such as resistance to permanent deformation (rutting) and fatigue cracking.

The modification of bituminous binder has been explored over the past years in order to improve road pavement performance properties. There are many modification processes and additives that are currently used in bitumen modifications, such as styrene butadiene styrene (SBS), styrene-butadiene rubber (SBR), ethylene vinyl acetate (EVA) and crumb rubber modifier (CRM).

The use of commercial polymers, such as SBS and SBR in road and pavement construction will increase the construction cost as they are highly expensive materials. However, with the use of alternative materials, such as CRM, will definitely be environmentally beneficial, and not only it can improve the bitumen binder properties and durability, but it also has 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.

Objectives of Study

A planned disposal of waste tyre rubber is quite essential for attaining sustainability and economy.

1. To check the feasibility of the waste tire rubber blended with bitumen.
2. To study the properties of bitumen after blended with waste tyre rubber.
3. To check the safe disposal of waste tyre rubber.

Bitumen

Crude petroleum obtained from different places has quite a different composition. It varies place to place. Crude petroleum is not pure at the first place. Hence, the petroleum should be dehydrated first before carrying out the distillation. General types of distillation processes are a fractional distillation and destructive distillation. In fractional distillation, the various volatile constituents are separated at successively higher temperatures without substantial chemical change. The successive fractions obtained yield gasoline. Naphtha, kerosene, and lubricating oil; the residue would be petroleum bitumen.

Crumb rubber

The purpose of this Usage Guide is to provide the California Department of Transportation (Caltrans) state-of-the-practice information regarding product selection and use, design, production, construction, and quality control and assurance of asphalt rubber binder, paving materials and spray applications.

Asphalt Rubber

According to the ASTM definition, asphalt rubber (AR) is "a blend of asphalt cement, reclaimed tire rubber, and certain additives in which the rubber component is at least 15 percent by weight of the total blend and has reacted in the hot asphalt cement sufficiently to cause swelling of the rubber particles." By definition, asphalt rubber is prepared using the "wet process." Physical property requirements are listed in ASTM D 6114, "Standard Specification for Asphalt Rubber Binder," located in Vol. 4.03 of the Annual Book of ASTM Standards 2001, and in Caltrans Standard Special Provisions for Asphalt Rubber Binder. The asphalt rubber is produced at elevated temperatures (≥177°C), under high agitation to promote the physical interaction of the asphalt binder and rubber constituents, and to keep the rubber particles suspended in the blend. Various petroleum distillates or extender oil may be added to reduce viscosity, facilitate spray applications, and promote workability.

Recycled tire rubber is used for the reclaimed rubber and is called crumb rubber modifier (CRM). Tire rubber is a blend of synthetic rubber, natural rubber, carbon black, anti-oxidants, fillers, and extender type oils that is soluble in hot paving grade asphalt.

Asphalt rubber should not be confused with other rubberized asphalt products such as the "dry process" in which crumb rubber is substituted for a small proportion of the aggregate and is not reacted with the asphalt binder prior to mixing, or with "terminal blends." Terminal blends are made by the wet process, but historically have included no more than 10 percent ground tire rubber along with other additives.

Rubberized asphalt concrete (RAC) may be produced using a variety of rubber-modified binders, including asphalt rubber, rubberized terminal blends, RMB materials, or by the dry process

Asphalt

Asphalt is a mixture of a bituminous binder with mineral aggregate (stone), sand and filler, typically containing approximately 4-7% bitumen. Asphalt is primarily used for road construction, the properties being dependent upon the type, size and amount of aggregate used in the mixture, all of which are adjusted to provide the required properties for the desired application.

Marshall Stability test

This test covers the measurement of resistance to plastic flow of 102 mm cylindrical specimens of bituminous paving mixture loaded in a direction perpendicular to the cylindrical axis by means of the Marshall apparatus. This test is for use with dense graded bituminous mixtures prepared with asphalt cement (modified and unmodified), cutback asphalt, tar, and tar-rubber with maximum size aggregate up to 25 mm in size (passing 25 mm sieve).

Methodology:

General

Pavement consists of more than one layer of different material supported by a layer called sub grade. Generally pavement is two type flexible pavement and Rigid pavement. Flexible pavements are so named because the total pavement structure deflects, or flexes, under loading. A flexible pavement structure is typically composed of several layers of material. Each layer receives the loads from the above layer, spreads them out then passes on these loads to the next layer below. Typical flexible pavement structure consisting of:

- Surface course. This is the top layer and the layer that comes in contact with traffic. It may be composed of one or several different HMA sub layers. HMA is a mixture of coarse and fine aggregates and asphalt binder
- Base course. This is the layer directly below the HMA layer and generally consists of aggregate (either stabilized or un-stabilized).
- Sub-base course. This is the layer (or layers) under the base layer. A sub-base is not always needed.

Asphalt Concrete

Asphalt concrete is a composite material commonly used in construction projects such as road surfaces, airports and parking lots. It consists of asphalt (used as a binder) and mineral aggregate mixed together, then are laid down in layers and compacted. Mixing of asphalt and aggregate is accomplished in one of several ways:

Hot mix asphalt concrete (commonly abbreviated as HMAC or HMA) is produced by heating the asphalt binder to decrease its viscosity, and drying the aggregate to remove moisture from it prior to mixing. Mixing is generally performed with the aggregate at about 300 °F (roughly 150 °C) for virgin asphalt and 330 °F (166 °C) for polymer modified asphalt, and the asphalt cement at 200 °F (95 °C). Paving and compaction must be performed while the asphalt is sufficiently hot. In many countries paving is restricted to summer months because in winter the compacted base will cool the asphalt too much before it is packed to the optimal air content. HMAC is the form of asphalt concrete most commonly used on highly trafficked pavements such as those on major highways, racetracks and airfields.

Warm mix asphalt Concrete (commonly abbreviated as WMA) is produced by adding either zeo-lites waxes, asphalt emulsions, or sometimes even water to the asphalt binder prior to mixing. This allows significantly lower mixing and laying temperatures and results in lower consumption of fossil fuels, thus releasing less carbon dioxide, aerosols and vapors. Not only are working conditions improved, but the lower laying-temperature also leads to more rapid availability of the surface for use, which is important for construction sites with critical time schedules. The usage of these additives in hot mixed asphalt (above) may afford easier compaction and allow cold weather paving or longer hauls.

Cold mix asphalt concrete is produced by emulsifying the asphalt in water with (essentially) soap prior to mixing with the aggregate. While in its emulsified state the asphalt is less viscous and the mixture is easy to work and compact. The emulsion will break after enough water evaporates and the cold mix will, ideally, take on the properties of cold HMAC. Cold mix is commonly used as a patching material and on lesser trafficked service roads

Cut-back asphalt concrete is produced by dissolving the binder in kerosene or another lighter fraction of petroleum prior to mixing with the aggregate. While in its dissolved state the asphalt is less viscous and the mix is easy to work and compact. After the mix is laid down the lighter fraction evaporates. Because of concerns with pollution from the volatile organic compounds in the lighter fraction, cut-back asphalt has been largely replaced by asphalt emulsion.

Mastic asphalt concrete or sheet asphalt is produced by heating hard grade blown bitumen (oxidation) in a green cooker (mixer) until it has become a viscous liquid after which the aggregate mix is then added.

Then bitumen aggregate mixture is cooked (matured) for around 6-8 hours and once it is ready the mastic asphalt mixer is transported to the work site where experienced layers empty the mixer and either machine or hand lay the mastic asphalt contents (20-30 mm) for footpath and road applications and around ⅜of an inch (10 mm) for flooring or roof applications. In addition to the asphalt and aggregate, additives, such as polymers, and anti-stripping agents may be added to improve the properties of the final product.

Natural asphalt concrete can be produced from bituminous rock, found in some parts of the world, where porous sedimentary rock near the surface has been impregnated with upwelling bitumen.

HOT MIX ASPHALT

HMA is a mixture of coarse and fine aggregates and asphalt binder. HMA, as the name suggests, is mixed, placed and compacted at higher temperature.

HMA is typically applied in layers, with the lower layers supporting the top layer. They are Dense Graded Mixes (DGM), Stone Matrix asphalt (SMA) and various Open graded HMA. Figures below show various HMA surface and lab. Sample collected from website http://www.pavementinterective.org/article/hma-types/.

Dense-Graded Mixes

This type of bituminous concrete is a well-graded HMA has good proportion of all constituents are also called Dense bituminous macadam. When properly designed and constructed, a dense-graded mix is relatively impermeable. Dense-graded mixes are generally referred to by their nominal maximum aggregate size and can further be classified as either fine-graded or coarse-graded. Fine-graded mixes have more fine and sand sized particles than coarse-graded mixes. It is Suitable for all pavement layers and for all traffic conditions. It offers good compressive strength. Materials used are Well-graded aggregate, asphalt binder (with or without modifiers)

Stone Matrix Asphalt (SMA)

Stone matrix asphalt (SMA), sometimes called stone mastic asphalt, is a gap-graded HMA originally developed in Europe to maximize rutting resistance and durability in heavy traffic road. SMA has a high coarse aggregate content that interlocks to form a stone skeleton that resists permanent deformation. The stone skeleton is filled with a mastic of bitumen and filler to which fibers are added to provide adequate stability of bitumen and to prevent drainage of binder

PROPERTIES OF HOT MIX ASPHALT (HMA)

The bituminous mixture should posses following properties

- Resistance to Permanent Deformation
- Resistance to Fatigue and Reflective Cracking
- Resistance to Low Temperature (Thermal) Cracking
- Durability.
- Resistance to Moisture Damage (Stripping)
- Workability.
- Skid Resistance

Future Scope

Many properties of SMA and BC mixes such as Marshall properties, drain down characteristics, tensile strength characteristics have been studied in this investigation. Only 60/70 penetration grade bitumen and a modified natural fibre called sisal fibre have been tried in this investigation. However, some of the properties such as fatigue properties, moisture susceptibility characteristics, resistance to rutting and dynamic creep behaviour can further be investigated. Some other synthetic and natural fibres and other type of binder can also be tried in mixes and compared. Sisal fibre used in this study is a low cost material, therefore a cost-benefit analysis can be made to know its effect on cost of construction. Moreover, to ensure the success of this new material, experimental stretches may be constructed and periodic performances monitored.

After careful evaluation of the properties and taking various tests as per standards the results shown by 10% addition of rubber crumbs has best suitability for blending it with bitumen. This will help to dispose the waste tire rubber in a proper way and solve the problem of environmental concerns up to a certain extent.

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