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Use of waste tyres in road construction

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Abstract - *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 them are non-biodegradable. The modified bitumen and granulated or ground rubber or crumb rubber can be used as a portion of the fine stone aggregate. A mixture of hot bitumen and crumb rubber derived from post-consumer waste or scrap tyres. It is a material that can be used to seal cracks and joints, be applied as a chip seal coat and added to hot mineral aggregate to make a unique asphalt paving material.*

***Key Words*: crumb rubber, chip seal coat.**

1. INTRODUCTION

The American Society of Testing and Materials (ASTM D8) defines rubberised bitumen as "a blend of asphalt cement [bitumen], reclaimed tyre rubber and certain additives, in which the rubber component is at least 15% by weight of the total blend and has reacted in the hot asphalt cement [bitumen] sufficiently to cause swelling of the rubber particles," [AST05] This definition was developed in the late 1990's. 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.

1.1 HISTORY

Rubberized Bitumen is being used in USA from 1960 Currently Arizona, Florida, Texas and California using 2 million tons of Rubberized Bitumen. Rubberized Bitumen is very popular in Australia for chip sealing wearing course sand structural layers. Use of Rubberized Bitumen being increase in developing countries of Latin America. In 1960s scrap tyres were processed and used as a secondary material in the pavement industry. One application was introduced by two Swedish companies which produced a surface asphalt mixture with the addition of a small quantity of ground rubber from discarded tyres as a substitute for a part of the mineral aggregate in the mixture, in order to obtain asphalt mixture with improved resistance to studded tyres as well as to snow chains, via a process known as "dry process". In the same period Charles McDonalds, a materials engineer of the city of Phoenix in Arizona (USA), was the first to find that after thoroughly mixing crumbs of RTR with bitumen (CRM) and allowing it to react for a period of 45 min to an hour, this material captured beneficial engineering characteristics of both base ingredients. He called it Asphalt Rubber and the technology is well known as the "wet process".

By 1975, Crumb Rubber was successfully incorporated into asphalt mixtures and in 1988 a definition for rubberised bitumen was included in the American Society for Testing and Materials (ASTM) D8 and later specified in ASTM D6114- 97. In 1992 the patent of the McDonald's process expired and the material is now considered a part of the public domain. Furthermore, in 1991, the United States federal law named "Intermodal Surface Transportation Efficiency Act" (then rescinded), mandated its widespread use, the Asphalt-Rubber technology concept started to make a "quiet come back". Since then, considerable research has been done worldwide to validate and improve technologies related to rubberised asphalt pavements. Nowadays, these rubberised bitumen materials, obtained through the wet process, have spread worldwide as solutions for different quality problems (asphalt binders, pavements, stress absorbing lays and inlayers, roofing materials, etc.) with much different evidence of success demonstrated by roads built in the last 30 years.

2. 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.

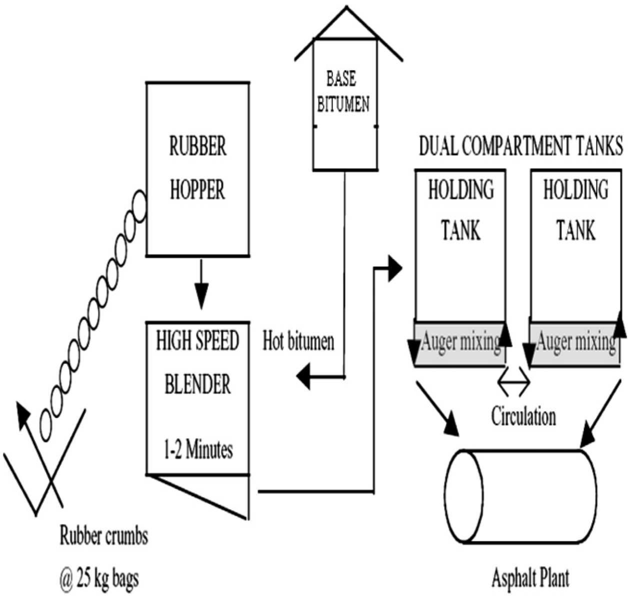

Fig -1: Schematic diagram of McDonald process

Fig -2: Rubberised bitumen applied as a slurry seal

3. USES OF RUBBERISED BITUMEN

3.1 Rubberised Bitumen as a Slurry Material:

Recognizing that fatigue cracking generally occurred in larger areas that small patches couldn't handle, the concept was extended to full pavement sections by spreading the rubberised bitumen with slurry seal equipment, Figure 2, followed by aggregate application with standard chip spreaders [MCD81]. This process had two distinct construction problems. First, in order to achieve the desired reaction of the bitumen and crumb rubber in the limited time available in the slurry equipment, it was necessary to employ bitumen temperatures of 4500 F (2320 C) and higher. Second, the thickness of the membrane varied directly with the irregularity of the pavement surface. This resulted in excessive materials in areas such as wheel ruts and insufficient membrane thickness.

3.2 Rubberised Bitumen as a Chip Seal Application:

In 1971, technology had developed to the point that standard bitumen distributor Lorries were employed to apply a uniform thickness of binder to the pavement, Figure 3. Although problems with distribution and segregation of materials were encountered on the early projects, these were recognized as primarily equipment limitations. Within the next few years equipment was developed with pumping, metering and agitation capabilities needed to handle the highly viscous rubberised bitumen materials. As noted earlier, the Arizona Department of Transportation (ADOT) monitored the development of AR and placed a Band-Aid type maintenance application of AR in 1964. In 1968, experience from trial and error and the burning of a couple of distributor boot lorries led to improvements in mixing to a satisfactory degree that AR could be safely and consistently placed with a distributor lorry by using a diluent (kerosene). From 1968 - 1972, ADOT placed AR on six projects that were slated for reconstruction. The cracking on these projects was generally typical of a failed pavement needing at least a six inch overlay or complete reconstruction.

For these seal coat type application projects a boot truck distributor was used to apply the AR. In these early applications the ground tyre rubber was introduced into the top of the boot lorry and mixed by rocking the lorry forward and backward. Even with this rather primitive early technology it was possible to construct the first full scale ADOT field experiment in 1972 using AR as a seal coat or Stress Absorbing Membrane (SAM), as well as an interlayer under a hot mix asphalt (HMA) surfacing. The interlayer application is typically referred to as a Stress Absorbing Membrane Interlayer (SAMI).

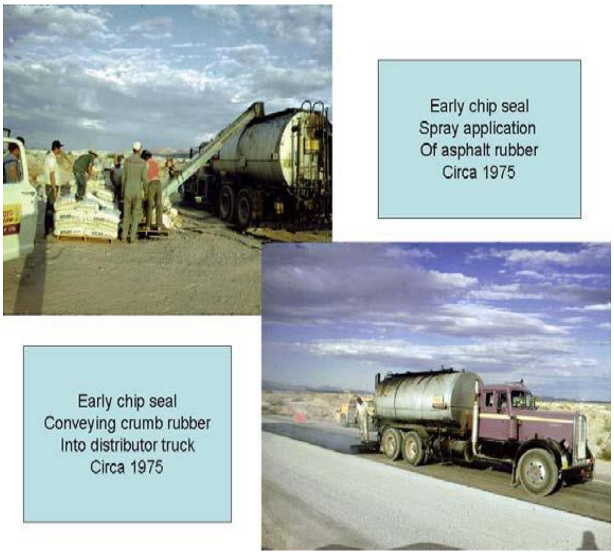

Fig -3: Crumb rubber chip seal

Fig -4: Rubberised bitumen chip seal applied to badly cracked pavement

4. Rubberised Bitumen Mix Construction:

Construction of an AR pavement involves first mixing and fully reacting the crumb rubber with the hot bitumen as required by specification. Typically 20 percent ground tyre rubber that meets the gradation shown in Table 1 and is added to the hot base bitumen. The bitumen needs to have a temperature of about 177^{0}C (about 350^{0}F) before being put into the blending unit, that heats the bitumen to 191^{0}C to 218^{0}C (375^{0}F to 425^{0}F) just prior to adding the rubber particles. The rubber and bitumen are mixed for at least one hour. After reaction, the rubberised bitumen mixture is kept at a temperature of between 163^{0}C and 191^{0}C (325°F and 375^{0}F) until it is introduced into the mixing plant Samples of the rubber, base bitumen, and AR mixture are taken and tested accordingly. The ARFC, which typically has one percent lime added to the mix, is placed with a conventional laydown machine and immediately rolled with a steel wheel roller.

Table -1: Ground Tyre Rubber Gradation

Sieve	Percent Passing
2 mm, #10	100
1.18 mm, #16	65-100
600 µm, #30	20-100
300 µm, #50	0-45
75 µm, #200	0-5

Fig -5: Crumb rubber

Fig -6: Rubberised bitumen construction

5. Why is Rubberised Bitumen a Best Practice?

1. It is a less expensive application when used as a thin top course over failed pavement that would otherwise need replacement (California & Arizona studies);
2. It is less expensive to maintain per lane-kilometer (lane-mile) in years 6 through 15 of pavement life over conventional pavements, and the same in years 1 through 5 (Arizona & California studies);
3. It significantly reduces noise as opposed to concrete pavements, and also is quieter than bituminous pavements; rubber bitumen makes urban environments more habitable (Arizona DOT studies);
4. It significantly improves wet surface traffic safety (Texas DOT studies);
5. It creates less of a "heat island" effect than with concrete pavement at surface (Arizona State University studies);
6. It provides better surface road drainage when used in an Open Grade Friction Course (Texas & Arizona studies); and
7. It is a hugely beneficial use for post-consumer waste tyre materials, using about 1,000 waste passenger tyres per lane-mile (about 621 waste passenger tyres per lane-kilometer).

6. CONCLUSION

This section deals with rubberised bitumen, a binder in hot mix asphalt and chip seal applications that results from the proper addition of crumb rubber to hot bitumen and then left in a heated state to react.

Rubberised bitumen is used extensively in California, Arizona and Texas in the USA, in several countries of Western Europe, and in South Africa. It is also used to a lesser extent in parts of Canada and in a dozen more states in the USA.

The benefits are many, including reduced long-term road maintenance and expense, significant noise reductions, improved traction and reduced accident rates in wet road conditions.

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