Revisiting the Use of Rubberised Asphalt Mixtures

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MODIFIERS currently available in the market fall into various categories, such as naturally occurring materials, industrial by-products and waste materials as well as carefully engineered products. Some of the more common categories include reclaimed rubber products, fillers, fibres, catalysts, polymers (natural and synthetic) and extenders, to name a few [1]. Among these, a blend of asphalt and polymer is the most popular for improving the fundamental characteristics of asphalt, as its characteristics are related to the performance of asphalt mixtures.

Polymer-modified asphalts, commonly abbreviated to PMAs, have been used for many years in road construction. However, recently, waste or recycled PMA is used to reduce modification costs and energy consumption as well as solve environmental problems. Scrap tyres are an example of recycled materials available that can be compounded with asphalt mixtures.

Approximately 900 million tyres are scrapped every year worldwide [2]. In Malaysia, over 2.8 million scrap tyres (approximately 57,391 tonnes) are generated each year. Of these, over 60% are unused and stock piled [3]. Diverting scrap tyres to pavement use is therefore worth the on-going efforts to further ease landfill pressures. In road construction, scrap tyres are used in the form of crumbrubber. The crumbrubber is obtained by reducing scrap tyres or other rubber into uniform granules, while the inherent reinforcing materials such as steel and fibre are removed along with other types of inert contaminants such as dust, glass or rock. In general, the use of crumbrubber in asphalt mixtures has two distinct approaches. One is to dissolve scrap tyres in the asphalt as a binder modifier; the other is to replace a portion of the fine aggregates with ground rubber that is not fully reacted with the asphalt. These are referred to as the wet process and the dry process respectively. The modified binder from the wet process is termed asphalt-rubber; an asphalt mixture made by the dry process is called rubberised asphalt [4].

The use of rubberised asphalt can be traced back to the 1840s, when natural rubber was introduced into asphalt to increase its engineering performance [5]. Since the 1960s, researchers and engineers have used shredded car tyres in asphalt mixtures. In the United Kingdom, the first polymer used in the mid-1800s, was natural polymer latex rubber. It was not until the late 1980s that the use of rubberised asphalt became popular. By 2000, rubberised asphalt was used in more than 40 States worldwide. Malaysia, as a rubber-producing country, is also moving toward this technology in producing road surfacing bituminous materials with improved durability and stability.

Rubberised asphalt offers a beneficial solution to surmount these problems. For example, Clemson University in the United States of America (USA) conducted a study which showed that between 500 and 2,000 scrap tyres can be used in each lane mile (1 mile = 1.609 km) of pavement, depending on the application selected. This means that for a one-mile section of a four-lane highway, between 2,000 and 8,000 scrap tyres can be recycled to create a longer-lasting flexible pavement road. An example of the implementation of a rubberised binder overlay before and after 16 years of performance is shown in Figure 1 [6]. More than 40 years' practical experience in the USA has shown that rubberised asphalt significantly improves properties compared to conventional asphalt mixtures, including increased temperature modulus, viscosity and toughness,

Figure 1: (a) before and (b) after using rubberised binder overlay after 16 years of performance [6]

increased elasticity, reduced temperature susceptibility and less age hardening [7].

In Malaysia, the responsibility to study the effectiveness of using rubberised asphalt was jointly taken by the Malaysia Public Works Department (PWD) and the Rubber Research Institute of Malaysia (RRIM) via a development project titled "The use of crumbrubber as a bitumen additive". The research on rubber as an additive for flexible pavement roads began as early as the 1930s, when the RRIM conducted research into rubber components in roads. As a result, a highway from Kuala Lumpur to Klang, Selangor, was built in the 1930s using rubber as a component. It was not until the 1950s that this technology became interesting to researchers. Figure 2 shows the chronology of rubberised asphalt research trials on various flexible pavement roads in Malaysia.

In 2003, a full-scale road trial was successfully built on Route 2, Section Nos. 340–345, in Kuantan, Pahang. Harun and Razali [8] found that the presence of crumbrubber in the road surfacing dense material appears to impart an appreciable improvement to the resistance to reflective cracking in the relatively thin overlay with relatively fine aggregate gradation. However, similar improvements could not be ascertained in a thicker overlay with coarser aggregate gradation, as it was observed that the section with crumbrubber performed only slightly better than conventional asphalt mixtures after 52 months. Recently, a group of researchers from the Center for Transportation Research, University of Malaya, conducted a study on crumbrubber and inferred that the usage of rubberised asphalt can significantly enhance resistance to rutting and produce roads with better durability by minimising the distresses caused in flexible pavement. Hence, road users would be ensured safer and smoother roads. Furthermore, the problem of pollution will be reduced and, subsequently, our environment will be protected [9].

Despite real achievements in the formulation, characterisation and use of rubberised asphalt, many challenges and opportunities remain. One problem is storage stability. It is common in the asphalt industry for polymers such as crumbrubber to be blended with base asphalt and stored for weeks at a time. As a result, this

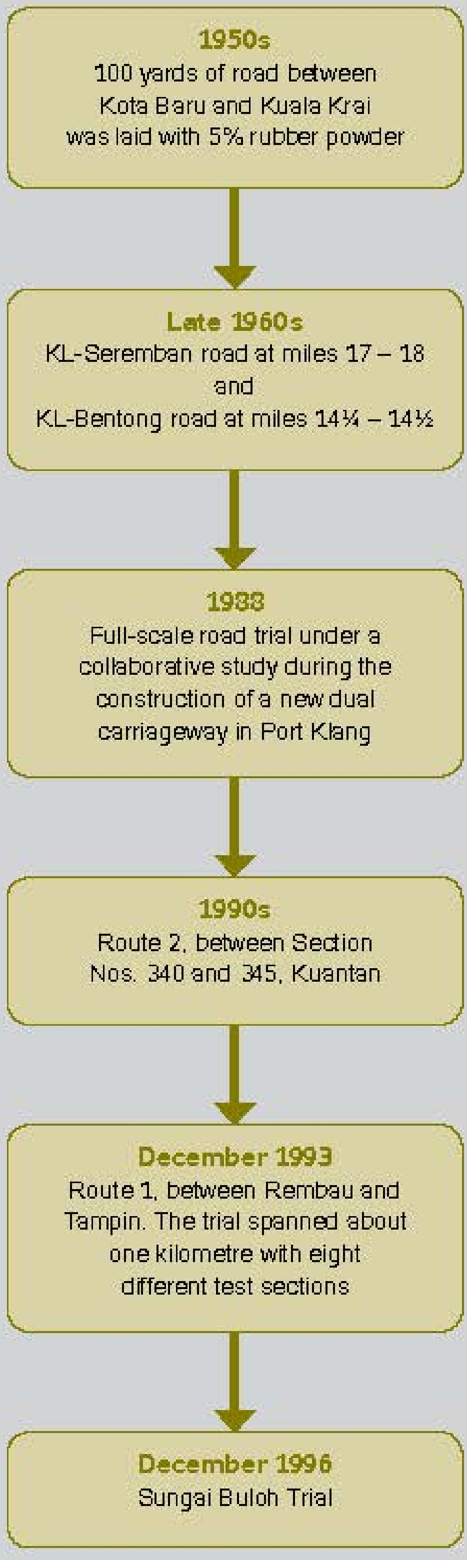

Figure 2: The chronology of rubberised road research trials in Malaysia

short-term ageing of the rubberised asphalt can affect the performance dramatically [10]. There is some polymer breakdown due to the thermal and mechanical action of the mixing process, but this effect is not critical (4-5%). The crumbrubbers are exposed to thermo-oxidative degradation when the modified binder is stored at temperatures exceeding 150°C, but storage conditions are generally milder. Therefore, the major concern is the lack of morphological (physical) stability during long storage. In addition, the mixing and compaction of rubberised asphalt will require a higher temperature compared to the conventional asphalt mixtures, which means it will consume more energy and produce more emissions.

However, at an international level, a continual improvement process is being conducted on the use of asphalt-rubber in road construction. This commitment can be seen vividly through the Asphalt Rubber Conference (ARC). Held every three years, it was first organised in Portugal (2000), followed by Brazil (2003), the USA (2006), China (2009) and, recently, Germany (2012). This conference provides a unique platform for asphalt-rubber experts from around the world to attend and present their studies covering all aspects of asphalt-rubber design, life cycle costs, binder design and construction methods, research, energy and environmental benefits, maintenance, tyre/pavement sound reduction and the production of asphalt-rubber as a binder or used in asphalt mixtures. This marks the beginning of a new era of road construction worldwide, as asphalt-rubber is more widely adopted. Therefore, the construction of roads using asphalt-rubber should be revisited and taken seriously by the Malaysian government to ensure better roads in the future. ■

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