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EVALUATION OF THE PROPERTIES OF MODIFIED LOCAL ASPHALT BINDER BY USING STYRENE BUTADIENE RUBBER (SBR) OR LOW-DENSITY POLYETHYLENE (LDPE)

Key words: asphalt binder, polymers, SBR, LDPE, rheological properties

Introduction

Bitumen is one of the earliest engineering materials known to humanity (Whiteoak, Read & Hunter, 2003). Asphalt is a cementitious material that ranges from dark brown to black and is mostly composed of high molecular weight hydrocarbons, although asphalt is portrayed as a low--value byproduct, these heavy fractions of petroleum were among the first oil-derived compounds having applications in human history in various ways such as construction industry, medicine and jewellery adhesives. If one considers that asphalt is the most commonly used material for paving roadways, in addition to a joint sealant for waterproofing material and roofing applications, the significance of asphalt becomes evident (Hardin, 1995; Singh, Tarannum & Gupta, 2003; Speight, 2016). The present global bitumen consumption is over 102 million tonnes per year, with 85% of that used in various types of pavements (Mostafa, Tawhed & Elshahat, 2016). The quality of generated asphalt is intrinsically tied to refinery operations and crude oil sources. Some good bitumen qualities can be attained by selecting good petroleum or using correct refinery techniques. Due to limited petroleum for manufacturing high-

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-quality bitumen and an absence of efficient control actions through the refinery process, in addition to the economic benefits, industries have focused increasing attention on bitumen modification (Zhu, Birgisson & Kringos, 2014). Furthermore, the pavement and waterproofing industries have grown quickly around the world in recent decades, particularly in developing countries (Presti, 2013). Asphalt's rheologic qualities such as viscoelastic, adhesion and durability are significant when considering it as a paving material (Cao et al., 2018; Abduljabbar et al., 2022). Polymers-modified asphalt gained popularity in the second half of the twentieth century and are now essential in limiting the deterioration of road networks and intervention in modern waterproofing industries (Polacco, Filippi, Merusi & Stastna, 2015; Hameed, Al-Busaltan, Dulaimi, Kadhim & Al-Yasari, 2021). Due to increased traffic in Iraq because of the growing growth of uncontrolled vehicles and extreme weather conditions due to global climate change, many defects such as high-temperature rutting (permanent deformities) and low temperature cracking or fatigue cracking. It is obvious that most roads in Iraq suffer higher deformation at high ambient temperatures and when traffic is slow or stationary (Abed, Hamdou & Ahmed, 2011; Abbas, 2017; Chopra, Parida, Kwatra & Chopra, 2018). The bitumen is responsible for the visco-elastic behaviour characteristic of asphalt when mixing the polymer with bitumen and plays a prime role by increasing the elastic component of the bitumen thereby reducing the viscous component. It also influences a variety of features of road performance, including resistance to permanent deformation and cracking (Whiteoak et al., 2003). During the last four decades, an increasing number of studies have focused on polymer modification of asphalt, and a rapidly growing number of research papers have been published that investigated various polymer modifications to improve the quality and performance of asphalt pavement, such as thermoplastic elastomers, e.g.: styrene isoprene styrene (SIS), styrene butadiene styrene (SBS), and plastomers, e.g.: ethylene-butyl acrylate (EBA) and polypropylene (PP) polyethylene (PE) (Al-Hadidy & Yi-Qiu, 2009; Mazumder, Siddique, Ahmed, Lee & Lee, 2020; Alghrafy, El-Badawy & Abd Alla, 2021; Babagoli, 2021; Che et al., 2022). According to various research, the mixing temperature for a homogeneous blend should range from 150° to 230°C, with a typical range of 175–200°C, for a period of 30 min to 4 h. The temperature at which the blend becomes a homogeneous polymer with asphalt solution is directly related to the asphalt binder's polymer concentration and asphaltenes content (Ahmed & Al-Harbi, 2014; Babagoli, 2021). The modification of bitumen using thermoplastic elastomers, of the four major groups of thermoplastic elastomers–polyether-polyester copolymers, polyurethane, styrenic block copolymers, and olefinic copolymers is the styrenic block copolymers that have proved to present the greatest potential when blended with bitumen (McNally, 2011). Styrene butadiene rubber (SBR) is a representative of elastomers (Whiteoak et al., 2003). Increased elasticity, higher adhesion and cohesion qualities of the binders, and a lower rate of oxidation are all benefits of using SBR in mixes (Roque, Birgisson, Tia, Kim & Cui, 2004), this revealed why SBR has been widely used as an important asphalt modifier. Many studies show the addition of polymer (SBR) considered one of the asphalt improvement solutions techniques has been used in several countries (Sadhu & Bhowmick, 2004; Chakraborty et al., 2010; Zhang & Yu, 2010; Ameri, Vamegh, Rooholamini & Haddadi, 2018). These researchers discovered that SBR modified asphalt mixtures could produce exceptional pavement performance, including anti-rutting, anti-cracking, and moisture resistance, which was even better than SBS modified asphalt mixtures (Ren et al., 2018). Polyethylene (PE) is a representative of plastomer and it is the most often used non-rubber thermoplastic polymer in modified road binders. Thermoplastics are defined by their ability to soften when heated and rigid when cooled (Whiteoak et al., 2003; Polacco, Stastna, Biondi & Zanzotto, 2006). The penetration of these polymers is more important than the softening point, which is the reverse of thermoplastic elastomers. Several researches have already been completed on the compound modification of asphalt binder utilizing PE in road and roofing applications (Fang, Li, Zhang & Wang, 2008; Navarro, Partal, Martinez-Boza & Gallegos, 2010; Liang et al., 2021).

It was found that using 1.5 wt% of polypropylene fibres could importantly increase the impact resistance of lightweight concrete and improve the compressive and flexural strengths at the same time (Orouji, Zahrai & Najaf, 2021; Najaf, Abbasi & Zahrai, 2022). Recycled polypropylene fibre had a compressive and tensile strength of roughly 1.7 and 1.6 times in comparison to the reference samples (Najaf, Orouji & Zahrai, 2022).

Rheological criterion and morphology revealed that low-density polyethylene (LDPE) has the best compatibility with asphalt, whereas high-density polyethylene (HDPE) has the worst compatibility. More branched PE has lower density and crystalline, resulting in a more homogeneous dispersion in microscopy and better compatibility (Liang et al., 2021). Finally, bitumen is a low-cost thermoplastic material that is utilized in roofing, road, and pavement applications. A study was done on the characteristics of LDPE asphalt mixtures. As a result of the addition of LLDPE, rotational viscosity, softening point, elasticity, and penetration index increased, but permanent deformation and penetration were reduced (Nizamuddin, Jamal, Gravina & Giustozzi, 2020).

Currently, there is a rapid usage of different materials to enhance the performance of the asphalt binder. The major objective of this research is to examine the possibility of using low-density polyethylene (LDPE) and styrene butadiene rubber (SBR) as additives for conventional asphalt binder (unmodified asphalt binder). Given that increasing attention has been given to using SBR or LDPE to manufacture asphalt pavements, this paper will examine the feasibility of the use of SBR or LDPE as an additive to the asphalt binder. In addition, the performance of the asphalt binder containing SBR or LDPE has not been fully considered to date. Different percentages of SBR and LDPE (3, 5, 7 and 9%) were added to conventional asphalt for the preparation of modified asphalt. The properties of virgin and modified asphalt binder were considered, counting penetration, viscosity and ductility and effects of available additive polymer with the suitable amount, on the properties of asphalt binder and compared these properties with virgin unmodified asphalt binder.

Materials and test methods

Asphalt binder

The used asphalt binder is 40–50 penetration grade that is obtained from Al-Daurah refinery. The asphalt binder's physical parameters and tests are listed in Table 1. These experiments were carried out in the laboratory of the Al-Daurah refinery, which is located southwest of Baghdad.

TABLE 1. Physical properties of asphalt binder used in this study (Ministry of Oil, Midland refineries company, Al-Daurah refinery, 2021)

Performance index	Unit	Value
Penetration at 25°C (100 g, 5 s) (0.1 mm)	1/10 mm	49
Ductility at 25°C (5 cm·min^{-1})	cm	97
Softening point	°C	50
Specific gravity at 25°C	–	1.02
Flash point (Cleveland open cup)	°C	285

Styrene butadiene rubber (SBR) and low-density polyethylene (LDPE)

In this study, two types of polymers are used styrene butadiene rubber (SBR) and low-density polyethylene (LDPE). At all temperatures, SBR is a random copolymer of styrene and butadiene that has a considerable impact on the outcomes of ductility and elastic recovery tests (Johnston & King, 2008). It is obtained locally from tires factory in Al-Najaf governorate and has a name SBR1502. The LDPE is a plastomers polymer, a white granule that is utilized in the tires industry and other private manufacturers in Iraq to make plastic belts. Two asphalt binders (40–50; modified and unmodified binders) used in this study were prepared by a supplier from the same asphalt. The modified asphalt binder is prepared by adding four percentages of the polymer SBR (3, 5, 7 and 9%) and four percentages of the polymer LDPE (3, 5, 7 and 9%) by weight of the asphalt binder. The physical properties of polymer SBR and LDPE are in Tables 2 and 3. Figure 1 shows photos of the SBR and LDPE polymer samples.

TABLE 2. Physical properties and specification of styrene butadiene rubber SBR1502 (Company for Tire Industry, 2021)

Performance index	Unit	Value
Specific gravity	–	0.95
Tensile strength (σ_t)	MPa	23 min
Modulus at 300% ext.	MPa	1–23
Bound styrene	%	23.5 +1.0 max
Melting point	°C	200 ±10
Elongation at break	%	340 min
Viscosity ML (1 + 4) 100°C	M.U.	52 ±3
Organic acid	%	4.7–7.2

TABLE 3. Physical properties and specification of low-density polyethylene (State Company for Petrochemical Industry in Basrah City, 2008)

Performance index	Unit	Value
Specific gravity	–	0.922
Tensile strength at break	MPa	21
Tensile strength at yield	MPa	9
Melt index	g per 10 min	0.33
Elongation at break	%	310
Melting point	°C	170
1% secant modulus	MPa	175

a b

FIGURE 1. Styrene butadiene rubber SBR1502 (a) and low-density polyethylene (b)

Preparation of specimens

The modified asphalts were prepared by using a blending machine, SBR1502 and LDPE were blended with asphalt binder by using a wet process (Al-Bana'a, 2010). The asphalt binder was first heated in a container until it became fluid, and then when it reached 170–190°C the SBR1502 and LDPE were added. The mixing time was 60 min and the mixing speed was 4,000 rpm in the laboratory (Kim, Mazumder, Lee & Lee, 2018; Mazumder et al., 2020; Liang et al., 2021).

Physical properties test

The physical properties of asphalt binder, including (softening point test, penetration test and ductility test), were tested following designations AASHTO T 51-09, T 53-09 and T 49-15 specifications respectively (American Association of State Highway and Transportation Officials [AASHTO], 2013a, 2013b, 2015).

Softening point test apparatus

This apparatus measures the softening point of asphalt binder materials whose softening ranges between 30° and 200°C). The temperature at which the asphalt sample descends a distance of 2.54 cm, when heated at a speed of $5°C \cdot min^{-1}$, is known as the softening point.

Penetration test apparatus

Penetration is a measure of the hardness of asphalt binder, as this device measures the penetration of solid and semi-solid asphalt materials, the penetration of a typical needle through an asphalt binder sample under the following conditions: load of 100 g, temperature of 25°C (77 F) and time of 5 s.

Ductility test apparatus

This device measures the distance that asphalt binder materials can be stretched when exposed to the impact of clouds at a constant speed of 5 cm·min^{-1} until the asphalt sample is cut off, and the total distance of this device reaches 150 cm.

Results and discussion

The findings of the tests on the asphalt binder, comprising several quantities of styrene butadiene rubber (SBR) polymer and low-density polyethylene (LDPE) are reported in Table 4. Figures 2 and 3 show the impact of SBR and LDPE content on the softening point and penetration of the asphalt binder. Different contents of SBR and LDPE are selected to show the impacts on the softening point of asphalt under constant SBR or LDPE content. It can be seen that the softness point increases with increasing SBR or LDPE concentration. The softening point improved from 55° to 70°C when SBR increased from 3 to 9%. While the increase of LDPE from 3 to 9% results in an increase in the softening point from 53° to 60°C. This means that SBR has a better performance in comparison to the LDPE at the same content (9%). These results are consistent with Alghrafy et al. (2021) and Babagoli

TABLE 4. Physical properties of the original and modified asphalt binder with different percentages of styrene butadiene rubber (SBR) and low-density polyethylene (LDPE)

Test method	Neat	SBR content				LDPE content			
		3%	5%	7%	9%	3%	5%	7%	9%
Softening point [°C]	52	55	59	65	70	53	56	57	60
Penetration at 25°C [dmm]	49	44	41	34	36	40	34	31	26
Ductility [cm]	110	120	155	175	190	105	100	80	70
Penetration index (*PI*)	–1.0	–0.3	0.4	1.1	2	–1.0	–0.7	–0.6	–0.4

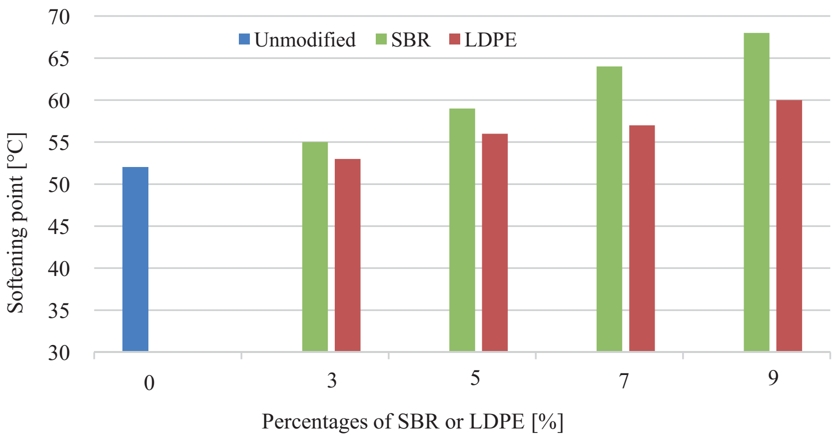

FIGURE 2. The softening point of asphalt with various styrene butadiene rubber (SBR) or low-density polyethylene (LDPE) contents

(2021). The penetration of the asphalt binder is decreasing with increasing the polymer percentage, where the optimum percentage of concentration is 7% SBR and 9% LDPE, but the penetration has a decreasing trend. It can be seen from Table 4 that the increase of SBR from 3 to 7% causes a reduction in the penetration from 44 to 34 dmm, while the penetration decreases from 40 to 26 dmm, when the LDPE increased from 3 to 9%. These results are in agreement with the findings of Babagoli (2021) and Che et al. (2022). Consequently, modified asphalt has a higher softening point and a lesser penetration than polymer-modified asphalt, showing that asphalt modification is more effective for improving the high temperature properties of asphalt binders.

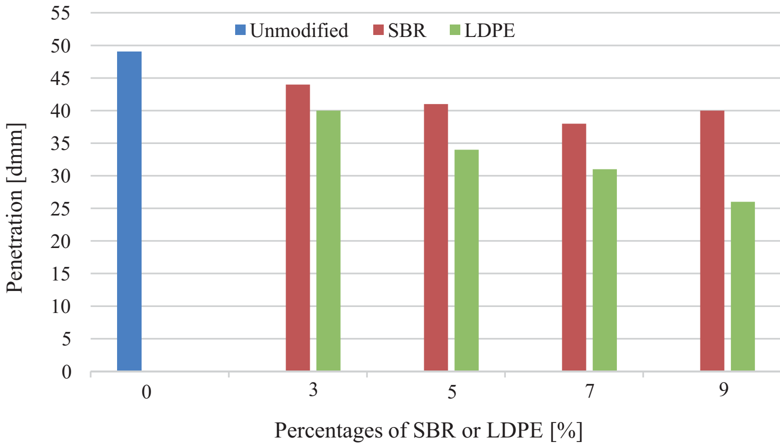

FIGURE 3. Penetration of asphalt with various styrene butadiene rubber (SBR) or low-density polyethylene (LDPE) contents

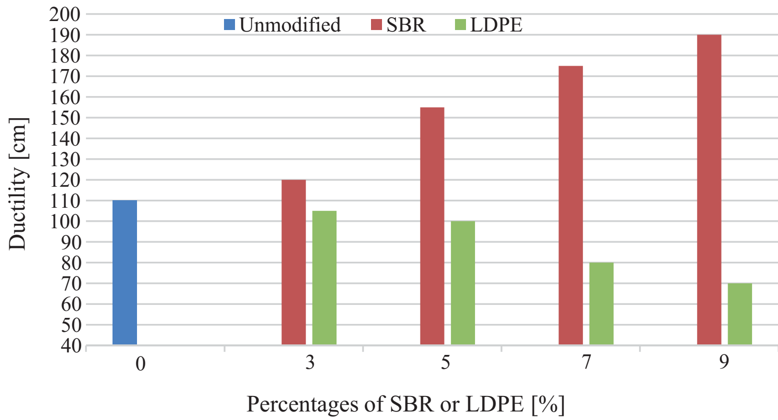

FIGURE 4. Ductility of asphalt with various styrene butadiene rubber (SBR) or low-density polyethylene (LDPE) contents

Regarding the ductility, it can be seen that when the concentration of LDPE increases from 3 to 9%, the ductility of the material decreases from 105 to 70 cm. It is worth noting that when a higher percentage of LDPE is used, the ductility drops rapidly; nevertheless, when the percentage of SBR increases, the ductility begins to rise. The ductility increased from 110 to 190 cm when the SBR increased from 3 to 9% (Fig. 4). This could be due to modifications in asphalt structures, which have made the asphalt more ductile. When the SBR concentration is raised, the rubber particles can form interconnections, making the asphalt less stiff and resulting in enhanced ductility; finally, the extra SBR introduces more elasticity, resulting in increased ductility.

The last row in Table 4 shows the penetration index (*PI*), and it is a developed relationship between the penetration and the softening point degree of the asphalt binder sample at 25°C. Through it, the sensitivity of the asphalt material and its impact on temperature are identified, and it can be calculated from the following mathematical relationship (Pfeiffer & Van Doormaal, 1936; Whiteoak et al., 2003).

$$\frac{20 - PI}{10 + PI} = 50\left[\frac{\log 800 - \log Pen.}{TRB - T}\right],$$

where:

PI – penetration index,
Pen. – penetration degree of the asphalt sample,
TRB – softening point is measured by the ring and ball method,
T – temperature at which penetration is measured is 25°C.

Increasing the *PI* of the asphalt binder remarkably enhances resistance to deformation of asphalt pavement, and the smaller the *PI* means the more sensitive the asphalt binder is to temperature variations. Asphalt binder specimens with standard specifications suitable for use in the field of paving (Tables 5 and 6) have *PI* values ranging from –2 to +2 (Hobson & Pohl, 1973). In this study, all the values of the *PI* are within the limits and range between +2 and –1. This indicates that meaning that the thermal stability of the product increases. The penetration index is illustrated in Figure 5.

TABLE 5. Rheological properties of asphalt binder (40–50) used in pavement according to the Iraqi specification SORB/R9 (State Commission of Roads and Bridges, 2003)

Property	Type 1	Type 2
	min	max
Softening point (R&B) [°C]	40	50
Penetration at 25°C [dmm]	51	62
Ductility [cm]	100	–

TABLE 6. Rheological properties of asphalt binder used in waterproofing and the field of flattening according to Iraqi specification IQS 1196 (Central Organization for Standardization and Quality Control [COSQC], 1988)

Property	Type 1		Type 2	
	min	max	min	max
Softening point (R&B) [°C]	57	66	70	80
Penetration at 25°C [dmm]	18	60	18	40
Ductility [cm]	100	–	30	–

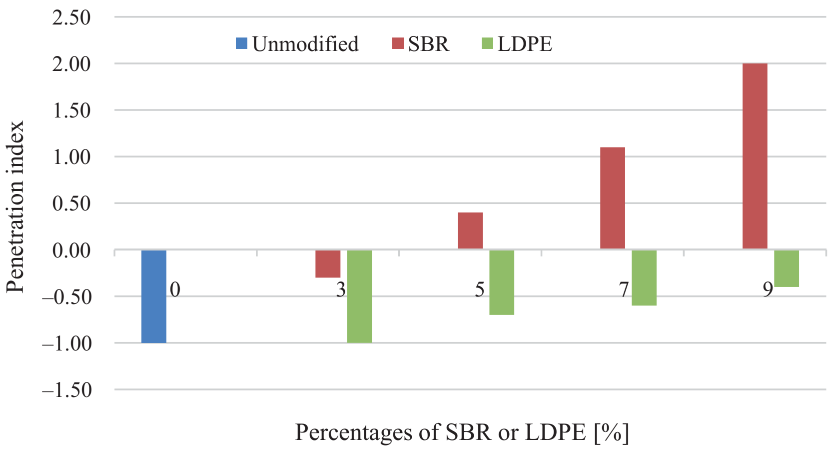

FIGURE 5. Penetration index of asphalt with various styrene butadiene rubber (SBR) or low-density polyethylene (LDPE) contents

Conclusions

1. The use of polymers such as SBR or LDPE affects the rheological property modification. Conventional asphalt binder testing results displayed that the addition of SBR or LDPE polymers increased the stiffness of the asphalt binder and reduced its temperature susceptibility. However, the degree of modification was more evident on asphalt binder residues, containing greater amounts of polymer SBR and depending on the valuable penetration index. The rheological properties of the asphalt modified with SBR or LDPE are mainly dependent on the SBR or LDPE content.
2. The polymers improved the rheological characteristics of the asphalt binder significantly and the improvement increased with polymer content but varied with polymer type. The modified local asphalt binder demonstrates that the effect of SBR or LDPE on the rheological properties of the asphalt at intermediate and high temperatures has been improved.
3. When SBR increased from 3 to 9%, the softening point improved by around 27%. While the increase in LDPE from 3 to 9% caused the softening point to rising from 53° to 60°C. This demonstrates that SBR performs better than LDPE at the same content (9%). Additionally, LDPE decreases the penetration of asphalt binder values of the emulsion residues considerably; although; their ductility properties begin to decrease slowly.
4. Both SBR and LDPE performs well in the improvement of the high-temperature performance of asphalt binders. Adding SBR or LDPE can improve the penetration index of asphalt binders leading to improve thermal stability. The behaviour of the two polymers showed that SBR had a higher penetration index,

this means the asphalt binder is less sensitive to temperature changes.

5. The penetration of asphalt is decreasing with increasing the polymer percentage, where the optimum percentage of concentration is 7% SBR and 9% LDPE, but the penetration has a decreasing trend. It can be seen from Table 4 that the increase of SBR from 3 to 7% causes a reduction in the penetration from 44 to 34 dmm, while the penetration decreases from 40 to 26 dmm when the LDPE increased from 3 to 9%.
6. The optimal percentage of concentration in terms of the penetration test is 7% SBR and 9% LDPE. The penetration of the asphalt binder decreases as the polymer percentage increases. The increase of SBR to 7% results in a reduction in penetration to 34 dmm, while increasing LDPE to 9% results in a decrease in penetration to 26 dmm.
7. One of the greatest methods to give solution to reduce the frequency of maintenance required at certain places is to employ a modified asphalt binder, which provides a substantially longer service life for maintenance treatments at problematic sites.

The next step for all sectors of the Iraqi industry is to collaborate to gain a deeper knowledge of the material's potential to produce better, more cost-effective roads for the benefit of both the industry and the community as a whole in various projects.

References

Abbas, A. S. (2017). Temperature zoning of Iraq for asphalt mix design. *Journal of Engineering and Sustainable Development*, *21* (5), 54–63.

Abduljabbar, N., Al-Busaltan, S., Dulaimi, A., Al-Yasari, R., Sadique, M. & Nageim, H. A. (2022). The effect of waste low-density polyethylene on the mechanical properties of thin asphalt overlay. *Construction and Building Materials*, *315*, 125722.

Abed, A., Hamdou, H. & Ahmed, N. (2011). Rheological properties of Iraqi asphalt binders measured using superpave system and shell software. *Journal of Engineering*, *17* (4), 783–799.

Ahmed, N. Y. & Al-Harbi, A. S. M. (2014). Effect of density of the polyethylene polymer on the asphalt mixtures. *Journal of University of Babylon*, *22* (4), 674–683.

Al-Bana'a, J. (2010). *Effect of polymer type on the performance of modified asphalt paving mixture* (doctoral dissertaton, MSc thesis). Babylon: University of Babylon, College of Engineering.

Alghrafy, Y. M., El-Badawy, S. M. & Abd Alla, E. S. M. (2021). Rheological and environmental evaluation of sulfur extended asphalt binders modified by high- and low-density polyethylene recycled waste. *Construction and Building Materials*, *307*, 125008.

Al-Hadidy, A. & Yi-Qiu, T. (2009). Mechanistic approach for polypropylene-modified flexible pavements. *Materials & Design*, *30* (4), 1133–1140.

American Association of State Highway and Transportation Officials [AASHTO] (2013a). *Standard method of test for ductility of asphalt materials* (T 51-09). Washington: The American Association of State Highway and Transportation Officials.

American Association of State Highway and Transportation Officials [AASHTO] (2013b). *Standard method of test for softening point of bitumen (Ring-and-Ball Apparatus)* (T 53--09). Washington: American Association of State Highway and Transportation Officials.

American Association of State Highway and Transportation Officials [AASHTO] (2015). *Standard method of test for penetration of bituminous materials* (T 49-15). Washington: American Association of State Highway and Transportation Officials.

Ameri, M., Vamegh, M., Rooholamini, H. & Haddadi, F. (2018). Investigating effects of nano/SBR polymer on rutting performance of binder and asphalt mixture. *Advances in Materials Science and Engineering*, *2018*, 5891963.

Babagoli, R. (2021). Laboratory investigation of the performance of binders and asphalt mixtures modified by carbon nano tube, poly phosphoric acid, and styrene butadiene rubber. *Construction and Building Materials*, *275*, 122178.

Cao, X., Wang, H., Cao, X., Sun, W., Zhu, H. & Tang, B. (2018). Investigation of rheological and chemical properties asphalt binder rejuvenated with waste vegetable oil. *Construction and Building Materials, 180*, 455–463.

Central Organization for Standardization and Quality Control [COSQC] (1988). *Bitumen used for flatness* (IQS 1196). Baghdad: Central Organization for Standardization and Quality Control.

Chakraborty, S., Kar, S., Dasgupta, S., Mukhopadhyay, R., Bandyopadhyay, S., Joshi, M. & Ameta, S. C. (2010). Study of the properties of in-situ sodium activated and organomodified bentonite clay–SBR rubber nanocomposites – Part I: Characterization and rheometric properties. *Polymer Testing*, *29* (2), 181–187.

Che, T., Pan, B., Li, Y., Ge, D., Jin, D. & You, Z. (2022). The effect of styrene-butadiene rubber modification on the properties of asphalt binders: aging and restoring. *Construction and Building Materials, 316*, 126034.

Chopra, T., Parida, M., Kwatra, N. & Chopra, P. (2018). Development of pavement distress deterioration prediction models for urban road network using genetic programming. *Advances in Civil Engineering*, *2018*, 1253108.

Company for Tire Industry (2021). *Physical properties and specification of SBR*.

Fang, C., Li, T., Zhang, Z. & Wang, X. (2008). Combined modification of asphalt by waste PE and rubber. *Polymer Composites*, *29* 10), 1183–1187.

Hameed, A., Al-Busaltan, S., Dulaimi, A., Kadhim, M. A. & Al-Yasari, R. (2021). Evaluating modified asphalt binder comprising waste paper fiber and recycled low-density polyethylene. *Journal of Physics: Conference Series*, *1973* (1), 012237.

Hardin, J. C. (1995). *Physical properties of asphalt cement binders*. Error! Hyperlink reference not valid. West Conshohocken: ASTM International.

Hobson, G. D. & Pohl, W. (1973). *Modern petroleum technology*. New York: John Wiley & Sons.

Johnston, J. B. & King, G. (2008). *Using polymer modified asphalt emulsions in surface treatments. A federal lands highway interim report.* Washington: Federal Highway Administration.

Kim, H. H., Mazumder, M., Lee, S. J. & Lee, M. S. (2018). Characterization of recycled crumb rubber modified binders containing wax warm additives. *Journal of Traffic and Transportation Engineering (English Edition)*, *5* (3), 197–206.

Liang, M., Xin, X., Fan, W., Zhang, J., Jiang, H. & Yao, Z. (2021). Comparison of rheological properties and compatibility of asphalt modified with various polyethylene. *International Journal of Pavement Engineering, 22* (1), 11–20.

McNally, T. (2011). *Polymer modified bitumen: properties and characterisation*. Philadelphia: Woodhead Publishing.

Mazumder, M., Siddique, A., Ahmed, R., Lee, S. J. & Lee, M. S. (2020). Rheological and morphological characterization of Styrene-Isoprene-Styrene (SIS) modified asphalt binder. *Advances in Civil Engineering*, *2020*, 8877371.

Ministry of Oil, Midland refineries company, Al-Daurah refinery (2021). *Physical properties of asphalt binder*. Baghdad.

Mostafa, A. E. A., Tawhed, W. M. F. & Elshahat, M. R. (2016). Performance assessment of asphalt pavement mix modified by nano-silica and nano-clay. *International Journal of Advanced Engineering and Nano Technology*, *3* (3), 7–11.

Najaf, E., Abbasi, H. & Zahrai, S. M. (2022). Effect of waste glass powder, microsilica and polypropylene fibers on ductility, flexural and impact strengths of lightweight concrete. *International Journal of Structural Integrity*, *13* (3), 511–533.

Najaf, E., Orouji, M. & Zahrai, S. M. (2022). Improving nonlinear behavior and tensile and compressive strengths of sustainable light

-weight concrete using waste glass powder, nanosilica, and recycled polypropylene fiber. *Nonlinear Engineering*, *11* (1), 58–70.

Navarro, F. J., Partal, P., Martinez-Boza, F. J. & Gallegos, C. (2010). Novel recycled polyethylene/ground tire rubber/bitumen blends for use in roofing applications: Thermo-mechanical properties. *Polymer Testing*, *29* (5), 588–595.

Nizamuddin, S., Jamal, M., Gravina, R. & Giustozzi, F. (2020). Recycled plastic as bitumen modifier: The role of recycled linear low-density polyethylene in the modification of physical, chemical and rheological properties of bitumen. *Journal of Cleaner Production*, *266*, 121988.

Orouji, M., Zahrai, S. M. & Najaf, E. (2021). Effect of glass powder & polypropylene fibers on compressive and flexural strengths, toughness and ductility of concrete: an environmental approach. *Structures*, *33*, 4616–4628.

Pfeiffer, J. P. & Van Doormaal, P. (1936). The rheological properties of asphaltic bitumens. *Journal of the Institute of Petroleum Technologists*, *22*, 414–440.

Polacco, G., Filippi, S., Merusi, F. & Stastna, G. (2015). A review of the fundamentals of polymer-modified asphalts: asphalt/polymer interactions and principles of compatibility. *Advances in Colloid and Interface Science*, *224*, 72–112.

Polacco, G., Stastna, J., Biondi, D. & Zanzotto, L. (2006). Relation between polymer architecture and nonlinear viscoelastic behavior of modified asphalts. *Current Opinion in Colloid & Interface Science*, *11* (4), 230–245.

Presti, D. L. (2013). Recycled tyre rubber modified bitumens for road asphalt mixtures: a literature review. *Construction and Building Materials*, *49*, 863–881.

Ren, S., Liang, M., Fan, W., Zhang, Y., Qian, C., He, Y. & Shi, J. (2018). Investigating the effects of SBR on the properties of gilsonite modified asphalt. *Construction and Building Materials*, *190*, 1103–1116.

Roque, R., Birgisson, B., Tia, M., Kim, B. & Cui, Z. (2004). *Guidelines for use of modifiers in superpave mixtures: executive summary and volume 1 of 3 volumes: evaluation of SBS modifier*. Retrieved from: https://trid.trb.org/view/697983 [accessed 03.08.2022].

Sadhu, S. & Bhowmick, A. K. (2004). Preparation and properties of styrene–butadiene rubber based nanocomposites: the influence of the structural and processing parameters. *Journal of Applied Polymer Science*, *92* (2), 698–709.

Singh, B., Tarannum, H. & Gupta, M. (2003). Use of isocyanate production waste in the preparation of improved waterproofing bitumen. *Journal of Applied Polymer Science*, *90* (5), 1365–1377.

Speight, J. G. (2016). *Asphalt Materials Science and Technology*. Boston: Butterworth-Heinemann.

State Commission of Roads and Bridges (2003). *General specification for roads and bridge. Hot-mix asphaltic concrete pavement* (SORB/R9). Baghdad: Ministry of Housing and Construction, Department of Planning and Studies.

State Company for Petrochemical Industry in Basrah City (2008). *Physical Properties and Specifications for HDPE and LDPE polymers*. Basrah: State Company for Petrochemical Industry in Basrah City.

Whiteoak, D., Read, J. & Hunter, R. N. (2003). *The Shell bitumen handbook* (5^{th} ed.). London: ICE Publishing.

Zhang, F. & Yu, J. (2010). The research for high-performance SBR compound modified asphalt. *Construction and Building Materials*, *24* (3), 410–418.

Zhu, J., Birgisson, B. & Kringos, N. (2014). Polymer modification of bitumen: advances and challenges. *European Polymer Journal*, *54*, 18–38.

Summary

Evaluation of the properties of modified local asphalt binder by using styrene butadiene rubber (SBR) or low-density polyethylene (LDPE). The influence of styrene butadiene rubber (SBR) or low-density polyethylene (LDPE) polymers on the characteristics of local asphalt binder was analyzed to characterize the rheological properties. The results indicated that the

SBR or LDPE increased the softening point. The softening point was enhanced by around 35% when 9% of SBR was used in comparison to the unmodified asphalt, while there was a 15% increment when LDPE was used. The results also indicated that the SBR or LDPE decreased the penetration rate. The penetration decreases by around 36% when 9% of SBR is used compared to the neat asphalt, while a significant increment was 89% when 9% of LDPE is used. Additionally, when 9% SBR was employed, the ductility of the asphalt binder rose by roughly 73%, but 64% less ductility was seen when 9% LDPE was utilized. Finally, the addition of the additive has improved the penetration index, thus reducing the temperature sensitivity. Due to said above, SBR and LDPE are practical and promising modifiers that will be useful in enhancing the performance of the asphalt binder straightforwardly and efficiently.