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ORIGINAL ARTICLE

Obtaining of modified bitumen with optimum quality through mixing of natural bitumen (gilsonite), bitumen and thinner oil

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Abstract In this research the modified bitumen was obtained from natural bitumen (gilsonite), B160/220 and B50/70 bitumen and thinner oil in different adding amount by weight. Some engineering properties of these materials were investigated and testing results were compared with each other and standards. It was found that standard penetration was reduced, viscosity and complex modulus were increased and there was no noticeable change on softening point and on phase angle by the addition of natural bitumen. The test results on the Marshall specimens showed that retained Marshall stability, indirect tensile strength ratio, stiffness modulus at temperatures of 15, 25 and 35 °C and fatigue life were significantly increased by the addition of natural bitumen (gilsonite) to normal bitumen. Furthermore, Şırnak (Silopi) asphaltites of 2, 4 and 8 % by weight in ratio were added into B160/220 bitumen. The mechanical properties of original bitumen and modified bitumen additives with additive asphaltite were studied and the optimum content of 4 % asphaltite and good results were found.

Keywords Modified bitumen · Asphalt · Asphaltite · Gilsonite · Bitumen

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1 Introduction

Asphalt is a material obtained from the mixing of sand, limestone, etc. component of the aggregates and petroleum derivatives or modified bitumen. There are two types of bitumen: natural bitumen (gilsonite) and oil bitumen. Natural bitumen (gilsonite) is a petroleum residuum that is end of the evaporation of volatile components of petroleum in the rocks. Petroleum bitumen is obtained from the distillation of crude oil. It has been widely used instead of natural bitumen in highways coating. The desired characteristics and amounts of aggregate and heated bitumen are mixed in a homogeneous in the mixer; prepared hot mix is moved without disturbing the flow feature and is used in construction places.

According to various climatic conditions in Turkey, provision of bitumen with appropriate performance grade (PG) is important and essential (The Asphalt Institute 1981; Mahmoud et al. 2011; Aflaki and Tabatabaee 2009). At present, due to the lack of various asphalt binder types, two types of asphalt binders with PG58-22 and PG64-22 are generally used in the pavement construction (AASHTO M 320-10 2010; Curtis 1992). The lack of thermal compatibility of the mentioned asphalt binders for arid areas, which require use of PG76-10 or PG70-10 asphalt binders, not only causes decrease in the service life of pavements, but also brings about some other problems such as premature failure, increased repair and maintenance costs, downgrading of driving quality in roads and finally reduced

safety. Nowadays, a great amount of mineral, organic, natural and industrial additives are used for improvement and modification of some properties of asphalt binders such as resistance to thermal and shrinkage cracking, reduction in permanent deformation.

Coating formation in highway, used as asphalt, is occurred 95 % aggregates and 5 % bituminous binder. The most important factor that determines the quality of the flexible pavements is a feature of the bituminous binder and aggregate materials which are occurring the coating of highway. In recent years, it is seen some common problems caused by the lack of adhesion in the top highway structure, rut formation, deformations such as cracks and peelings. Depending on the consistency of bitumen temperature changes, due to being sensitive to heat. Therefore, high temperatures of the bitumen to be rigid enough, it is not brittle at low temperatures than requested. Dried and heated to extremely high temperatures of hot asphalt and graded aggregate mixed as appropriate is called hot asphalt concrete mixture. Modified bitumen is obtained from 50 to 70 penetration bitumen with adding 3–7 % contribution by participating for increasing of road bearing capacity. Modified asphalt is produced with mixing modified bitumen, depending on the additives types, and aggregate in asphalt plant. Modified bitumen is a type prevention of occurring deformations such as forming a permanent deformation rutting in roads, thermal cracking and avoid distortions of aggregate bindings.

Today, in our country, the expanded usages particularly in the manufacturing of top-end construction projects have started to be used by adding the terms of the contract. Natural bitumen (gilsonite) for mixtures of modified bitumen is used as a performance-enhancing agent. In part to the use of natural asphalt in mixtures, while penetration, strength, softening temperature and shear resistance increases, deformation decreases and also can be processed easily in the low-temperature. In recent years, the lack of adhesion, caused by deformations such as cracks and peelings in the top of coating formation, are common problems. Depending on the consistency of bitumen temperature changes, due to being sensitive to heat. Therefore, high temperatures of the bitumen to be rigid enough, it is not brittle at low temperatures than requested. Dried and heated to extremely high temperatures of hot asphalt and graded aggregate mixed with hot asphalt concrete mixture referred to as appropriate (King et al. 1999).

Conducted research works is to determine the properties of modified bitumen which obtained from the mixing of natural bitumen (gilsonite), bitumen and thinner oil. The test results of modified bitumen were compared with conventional bitumen properties. The results of modified bitumen can be used as a weight percentage of bitumen binder in asphalt mixtures. Due to its physical and chemical properties, bitumen binder has a significant effect on the optimal performance, durability and stability of asphalt mixtures, and any type of bitumen binder performance will finally influence the performance of asphalt mixture (Scott 1978; Bulevicius et al. 2013; Tunç 2004). Physical and mechanical properties of modified bitumen have a significant impact on a condition of fitted pavement, its stability and reliability during the entire period of its operation. A number of researchers were studied about modified bitumen additives such as asphaltite, mineral, organic, natural and industrial additives (Kök et al. 2012; Gönenç 1990; Oruç and Eren 2008).

2 Engineering properties of samples

For obtaining of modified bitumen, natural bitumen (gilsonite), bitumen and thinner oil were mixed and four different bitumen samples were prepared in Petroleum and Natural Gas Engineering laboratory of Mustafa Kemal University (Table 1; Fig. 1). Used natural bitumen (gilsonite), bitumen and thinner oil properties were given in Table 2. The use of natural bitumen is a very important for the

Table 1 The mixing ratio (formula) of modified bitumen samples

Samples type	Bitumen (%)	Natural bitumen (%)	Thinner (%)
Formula 1 (160/220 bitumen)	45	45	10
Formula 2 (160/220 bitumen)	30	50	20
Formula 3 (50/70 bitumen)	30	50	20
Formula 4 (50/70 bitumen)	10	60	30

Fig. 1 The used materials and preparation of modified bitumen

Table 2 The properties of used bitumen, natural bitumen (gilsonite) and thinner oil in modified bitumen

Experimental type	Bitumen	Natural bitumen (gilsonite)	Thinner oil
Bitumen (%)	99	78	1–2
Ash and other insoluble materials (%)	1	22	–
Heating loss (%) (250 °C)	0.5	0.05	3
Flash point (°C)	230	270	119.3
Softening point (°C)	47	190	–
Density (g/cm)	0.98	1.1	0.849
Colour and granule size	Black, liquid at 120 °C	Black, 0–3 mm solid	Light yellow, liquid

Table 3 The physical properties of modified bitumen samples

Properties	Formula 1 (160/220)	Formula 2 (160/220)	Formula 3 (50/70)	Formula 4 (50/70)	Formula 5(160/220 + %4 Asphaltite)	Standards	Limit values
Penetration (25 °C, 1/10 mm)	56	51	43	48	47	ASTM D 5	50/70
Ductility (25 °C mm)	58	53	48	47	51	ASTM D 113	–
Heating loss (%)	0.1	0.1	0.1	0.1	0.1	ASTM D 6	0.5
Flash point (°C)	340	340	330	324	336	ASTM D 92	>230
Softening point (°C)	70–80	70–80	70–80	70–80	70–80	ASTM D 36	46–54
Resolution	99.5	99.5	99.5	99.5	99.10		–
Density (g/cm^3)	1.01	1.01	1.01	1.01	1.03	ASTM D 70	–

environmental effects, so the optimum mixing ratio (formula) of modified bitumen was determined in the laboratory.

The density, penetration, softening point, ductility and penetration test of modified bitumen were performed. Bituminous material hardness (consistency) in specified conditions was determined with penetration testing which classifies. In this experiment, 100 g of load, time 5 s and 25 °C in temperature were used as a standard (TS 120 EN 1427 2002). The test results of samples which were performed in accordance with the standards of ASTM and TS were given in Table 3. The laboratory-sized prototype pyrolysis (reactor) unit used in the experiments were given in Fig. 2. The sample preparation for the determining of density, penetration, ductility, softening–heating–flashing

points and solutions of samples obtained from the pyrolysis (Formula 1–4) were shown in Fig. 3. Also penetration and ductility of the specimen were given in Fig. 4.

Furthermore, Şirnak (Silopi) asphaltites of 2, 4 and 8 % by weight in ratio were added into B160/220 bitumen. The mechanical properties of original bitumen and modified bitumen additives with asphaltite were studied. It is seen that the addition of certain amounts of asphaltite to bitumen can effectively improve the mechanical properties and moisture resistance of hot bituminous mixes. It was determined that 4 % asphaltite content is optimum for the mixtures tested. Test results have shown that the penetration values of modified bitumen were good and the new type modified bitumen can be used in a warm site (Table 3, Formula 5).

3 Conclusions

In this research, different formulas of modified bitumen were obtained using natural bitumen (gilsonite), B160/220 and B50/70 bitumen and thinner oil different adding amount by weight with technical equipment available in the laboratories of Mustafa

Fig. 2 Prototype pyrolysis units for preparation of modified bitumen samples in laboratory conditions

Fig. 3 Samples preparation of modified bitumen for density, penetration, ductility, softening–heating–flash points and resolution testing

Fig. 4 Testing of penetration and ductility testing of modified bitumen samples

Kemal University, Petroleum and Natural Gas Engineering and Chemistry Department. Some engineering properties of these materials were investigated and testing results were compared with each other and ASTM standards. It is necessity to make a homogeneous mixture for allowing workable asphalt in low penetration and processing temperature and increasing of the softening point of modified bitumen by using natural bitumen as a substituting and additives materials. It was found that decreasing of standard penetration, increasing of viscosity and complex modulus, no noticeable changing of softening point and the phase angle values with the addition of natural bitumen into modified bitumen. Also, Şırnak (Silopi) asphaltites of 2, 4 and 8 % by weight in ratio were added into B160/220 bitumen and modified bitumen. The optimum content of 4 % asphaltite was found and can be used environmentally and low cost.

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