

Comparison of Fatigue Crack Resistance and Permanent Deformation to Asbuton Modified Asphalt and Rubber Modified Asphalt

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ABSTRACT

One of the efforts to reduce road damage due to excessive loads is to increase the quality of the asphalt mixture by improving or increasing the quality of asphalt (bitumen). The use of *Asbuton* or crumb rubber as an additive in the pavement mixture will have a different effect on the properties of the mixture itself. The purpose of this study was to determine the comparison of the criteria for damage to *Asbuton* modified asphalt and asphalt modified SIR 20 crumb rubber against fatigue crack resistance and permanent deformation based on the mechanical rheological properties of asphalt and to determine the optimum levels of *Asbuton* and the optimum levels of crumb rubber SIR 20 that meet the specifications. The research method was carried out by examining the mechanistic rheological properties of asphalt with a Dynamic Shear Rheometer (DSR). The results of this study indicate that *Asbuton* modified asphalt is more resistant to permanent deformation than rubber modified asphalt while rubber modified asphalt is more resistant to fatigue cracking than *Asbuton* modified asphalt.

Keywords—Asbuton modified asphalt, rubber modified asphalt, fatigue cracking, permanent deformation

1. INTRODUCTION

Research on *Asbuton* modified asphalt technology and rubber modified asphalt technology have been carried out by previous researchers. The performance of the asphalt pen 60/70 modified pure *Asbuton* based on its rheological properties and its performance in the mixture obtained an optimum level of 10% pure *Asbuton* [1,2]. In addition, it was also seen that the performance of the asphalt pen 60/70 mixture modified *Asbuton* filler was obtained an optimum level of 2.01% [3] and obtained better results if the mixture of asphalt pen 60/70 modified pure *Asbuton* and *Asbuton* filler [4]. Then, the rheology evaluation of pen asphalt 80/100 modified pure *Asbuton* resulted in a greater optimum content of 30% pure *Asbuton*. Based on the resistance to damage, the addition of pure *Asbuton* to the addition of *Asbuton* to oil asphalt will increase the resistance to permanent deformation, but reduce the resistance to fatigue cracking [5,6].

The technology of asphalt mixed with latex, at high temperature makes the latex particles expand and absorb light oil on the asphalt, making the asphalt thicker and more elastic [7]. At low temperatures, asphalt is prone to cracking. Adding latex can increase its elasticity and viscosity so that the asphalt mixture is not easily cracked. At high temperatures, latex acts as a membrane that is resistant to melting asphalt and increases shear strength [8].

The performance of the asphalt mixture is strongly influenced by the rheological properties of the asphalt, namely the chemical composition and physical properties of the asphalt. Evaluation of the rheological performance of Polyoctenamer in Rubber Asphalt showed that the addition of polyoctenamer could increase the viscosity of asphalt rubber and has the same stiffness performance with and without polyoctenamer [9]. Therefore, the rheological properties of asphalt need to be known before making the asphalt mixture, because a change in one of the factors will change the other's properties. Determination of the physical properties of natural rubber modified asphalt with various types and doses of latex obtained by cationic latex at a dose of 5% which can increase the softening point [10].

The use of Ribbed Smoked Sheet (RSS) can prevent the occurrence of foam and foaming during the mixing process and improve the physical characteristics of asphalt with the optimum content of RSS is 6% [11]. Comparison of the use of *Asbuton* modified asphalt and asphalt rubber (AR) from used tire powder results that Asphalt Rubber has better resistance to permanent deformation and fatigue cracking. In contrast, the addition of *Asbuton* to asphalt pen 60/70 will increase resistance to permanent deformation, but reduce resistance against fatigue cracks [12].

Natural rubber can increase elasticity and viscosity so that the asphalt mixture is not easily cracked due to changes in environmental temperature [8,13-16]. Meanwhile, *Asbuton*

reduces elasticity and penetration. Therefore, this study aims to compare the fatigue cracking and permanent deformation resistance of Asbuton modified asphalt and rubber modified asphalt based on the mechanical rheology evaluation of asphalt and to provide recommendations for optimal rubber content that meets the specifications against these two damage criteria. It aims to obtain innovative products from modified asphalt pen 60/70 with Asbuton and natural rubber that is resistant to Permanent Deformation and Fatigue Cracking with the hope of providing the best technology in the development of modified asphalt

2. RESEARCH METHOD

This research was conducted using asphalt pen 60/70. The pure Asbuton used was extracted from Asbuton grains T5 / 20 and the natural rubber used was crumb rubber with type SIR 20. The quality specification of SIR 20 with maximum requirements is that it contains 0.2 impurities, 0.1 ash, 0.8 volatile matter, 0.6 nitrogen and brown color. The reason for choosing the raw material such as pen 60/70 asphalt, pure Asbuton, and crumb rubber is to produce better modified asphalt quality.

The quality of modified asphalt that meets the specification requirements is that it can increase the bond between the asphalt and the aggregate so that the road surface is not easy to peel and has high stiffness at high temperatures that can minimize deformation. Low stiffness at low temperatures can minimize the appearance of cracks on the road surface.

This research method uses a laboratory test method with three stages. The first is to make a mixture of asphalt pen 60/70 with pure Asbuton and make a mixture of asphalt pen 60/70 with crumb rubber SIR 20 at variations in the levels of pure Asbuton and crumb rubber SIR 20 are 0 %, 4%, 6%, 7%, 8%, 9%, 10%, and 20%.

Furthermore, the second stage is to test the mechanical rheology properties carried out by using a Dynamic Shear Rheometer (DSR) based on the AASHTO T315-10 testing standard on an asphalt pen 60/70 mixture and SIR 20 crumb rubber [17]. Then the third stage is to analyze the fatigue crack resistance and permanent deformation on pure Asbuton modified asphalt and rubber modified asphalt. After that, determine the optimum levels of pure Asbuton asphalt and rubber modified asphalt which meet the specifications for the two damage criteria

3. RESULTS AND DISCUSSION

Bitumen that has a value of $|G^*|/\sin \delta$ greater than 1 kPa is bitumen that can be strong against the damage criteria of Permanent Deformation. Whereas bitumen that has a value of $|G^*|.\sin \delta$ less than 5,000,000 Pa is bitumen that can be strong against the damage criteria of Fatigue Cracking [18]. Analysis of the criteria for permanent deformation damage was carried out at a temperature of 640C while fatigue cracking was carried out at a temperature of 250C [6]. From the results of the analysis of the permanent deformation damage criteria for Asbuton modified asphalt by increasing the Asbuton content into the asphalt mixture, the value of $|G^*|/\sin \delta$ is getting

bigger. In Fig. 1, it is explained that all variations of Asbutone levels are substantial against permanent deformation. At 20% Asbuton content, the value of $|G^*|/\sin \delta$ was obtained for 5135.66 Pa. The greater the Asbuton content in the asphalt mixture, the more resistant it is to permanent deformation.

Whereas for rubber modified asphalt with increasing rubber content, the value of $|G^*|/\sin \delta$ decreases. The greater the rubber content in the mixture, the lower the permanent deformation resistance. Based on the criteria of permanent deformation, the optimum rubber content that can withstand permanent deformation is at 9% rubber content.

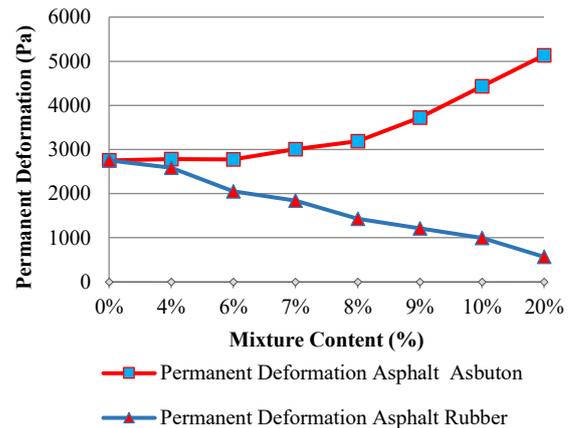


Fig 1. Comparison of the resistance to permanent deformation of Asbuton Modified Asphalt and Rubber Modified Asphalt

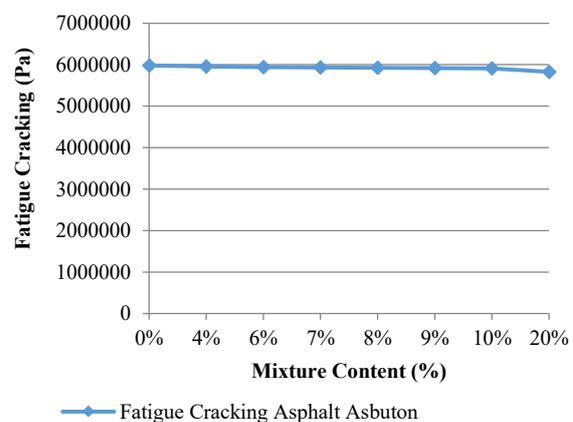


Fig 2. Fatigue Cracking of Asbuton Modified Asphalt

Fig. 2 shows that there is no Asbuton mixture level that falls within the fatigue cracking criteria limit. Based on the limitation of fatigue cracking criteria with increasing levels of Asbuton, bitumen is not able to withstand fatigue cracking well. Whereas for rubber modified asphalt with increasing rubber content, the value of $|G^*|.\sin \delta$ is getting smaller. The greater the rubber content in the mixture, the stronger it is to resist fatigue cracking.

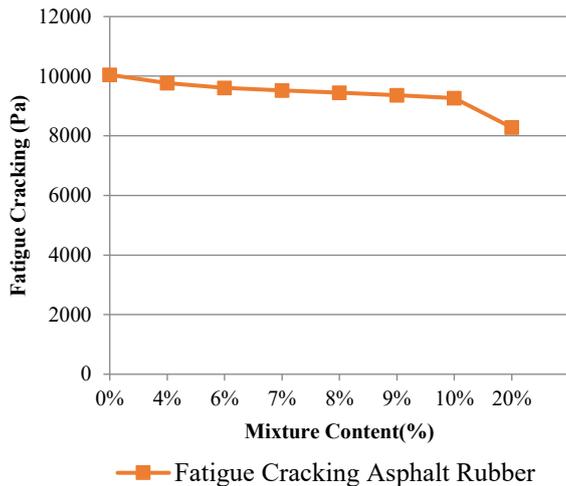


Fig 3. Fatigue Cracking Asphalt Modified Rubber

4. CONCLUSION

Permanent deformation damage criteria for Asbuton modified asphalt by increasing the Asbuton content into the asphalt mixture, the more resistant it is to permanent deformation. Whereas for rubber modified asphalt with increasing rubber content, the lower the permanent deformation resistance. Based on the permanent deformation criteria, the optimum rubber content that can withstand permanent deformation is at 9% rubber content.

For the criteria for fatigue cracking damage for Asbuton modified asphalt with increasing levels of Asbuton, the bitumen is not able to withstand fatigue cracking well. Whereas for rubber modified asphalt, with increasing rubber content in the mixture, it is stronger withstand fatigue cracking.

REFERENCES

- [1] E. W. Indriyati, B. S. Subagio, H. Rahman, and S. S. Wibowo, "Study on Improvement of Rheology Characteristics of Visco-Elastic Asphalt with Addition of Asbuton using Complex Shear Modulus" [Kajian Perbaikan Sifat Reologi Visco-Elastic Asphalt dengan Penambahan Asbuton Murni Menggunakan Parameter Complex Shear Modulus]. *Inst. Teknol. Bandung*, 2012.
- [2] B. Sitompul. Penentuan Kadar Aspal Optimum Pen 60/70 dan Asbuton T5/20 Terhadap Kinerja Pada Campuran Aspal Concrete-Wearing Course (ACWC). Final Report, Civil Engineering Dept., Universitas Abdurrab. Pekanbaru, 2017. Unpublished.
- [3] F. Ramdhani, S. Suhanggi, & B. H. Rhoma, "Optimum Filler Asbuton Aggregate T5/20 in AC-WC" [Kadar Optimum Filler Asbuton Butir T. 5/20 Dalam Campuran Perkerasan Asphalt Concrete-Wearing Course (AC-WC)] *J. Kaji. Tek. SIPIL*, vol. 3, no. 1, pp. 32–38, 2018.
- [4] F. Ramdhani, H. Saputra, & R. Tisnawan, "Pengaruh Campuran Aspal Pen 60/70 Dan Bahan Modifikasi Ekstraksi Asbuton T5/20 Dengan Filler Asbuton T5/20 Terhadap Kinerja Campuran, Prosiding Seminar Nasional Aplikasi Sains dan Teknologi (SeNASTeK) Universitas Abdurrab, 2018
- [5] E. W. Indriyati, B. S. Subagio, and H. Rahman, "Improvement of Rheology Characteristics of Asphalt with Addition of Asphalt by Considering Stiffness Modulus and Criteria of Pavement Damage " [Perbaikan Sifat Reologi Aspal Dengan Penambahan Asbuton Murni Dalam Tinjauan Modulus Kekakuan dan Kriteria Kerusakan Perkerasan] *Din. Rekayasa*, vol. 11, no. 2, pp. 67–77, 2015.
- [6] F. Ramdhani, "Evaluasi reologi campuran aspal pen 80/100 dan bahan modifikasi Asbuton ekstraksi penuh sebagai dasar penentuan kadar bahan modifikasi optimum". Final Report Civil Engineering Dept. Institut Teknologi Bandung. Bandung, 2013, unpublished
- [7] N. Tuntiworawit, D. Lavansiri, C. Phromsorn, and C. Engineer, "The modification of asphalt with natural rubber latex," in *Proceedings of the Eastern Asia Society for Transportation Studies*, 2005, vol. 5, pp. 679–694.
- [8] Y. Wen, Y. Wang, K. Zhao, and A. Sumalee, "The use of natural rubber latex as a renewable and sustainable modifier of asphalt binder," *Int. J. Pavement Eng.*, vol. 18, no. 6, pp. 547–559, 2017.
- [9] K. L. N. Ng Puga, "Rheology and performance evaluation of Polyoctenamer as Asphalt Rubber modifier in Hot Mix Asphalt," 2013.
- [10] H. Prastanto, Y. Firdaus, S. Puspitasari, A. Ramadhan, and A. F. Falaah, "Sifat Fisika Aspal Modifikasi Karet Alam Pada Berbagai Jenis Dan Dosis Lateks Karet Alam, [Physical Char. of Modified Asphalt]" *J. Penelit. Karet*, vol. 36, no. 1, pp. 65–76, 2018.
- [11] V. Nopparat, P. Jaratsri, and N. Nuchanat, "Modification of asphalt cement by natural rubber for pavement construction. Rubber Thai. J. 1, 32–39 (2012)," *J. home page www.rubberthai.com*.
- [12] E. W. Indriyati, "Study on the Comparison of Modified Asphalt Asbuton and Asphalt Rubber for Highway Infrastructure" [Kajian Perbandingan Penggunaan Aspal Modifikasi Asbuton Dan Asphalt Rubber (AR) Untuk Infrastruktur Jalan], *J. Tek. Sipil*, vol. 14, no. 2, pp. 94–100, 2018.
- [13] M. A. Shafii, M. Y. A. Rahman, and J. Ahmad, "Polymer modified asphalt emulsion," 2011.
- [14] N. S. Mashaan, A. H. Ali, S. Koting, and M. R. Karim, "Performance evaluation of crumb rubber modified stone mastic asphalt pavement in Malaysia," *Adv. Mater. Sci. Eng.*, vol. 2013, 2013.
- [15] E. Shaffie, J. Ahmad, A. K. Arshad, D. Kamarun, and F. Kamaruddin, "Stripping performance and volumetric properties evaluation of hot mix asphalt (HMA) mix design using natural rubber latex polymer modified binder (NRMB)," in *InCIEC 2014*, Springer, 2015, pp. 873–884.
- [16] R. A. Al-Mansob, A. Ismail, N. I. M. Yusoff, S. I. Albrka, C. H. Azhari, and M. R. Karim, "Rheological characteristics of unaged and aged epoxidised natural rubber modified asphalt," *Constr. Build. Mater.*, vol. 102, pp. 190–199, 2016.
- [17] AASHTO, "Standard method of test for determining the rheological properties of asphalt binder using a dynamic shear rheometer (DSR)," *Am. Assoc. state Highw. Transp. Off*
- [18] A. Institute, *Superpave: Performance Graded Asphalt Binder Specification and Testing*. Asphalt Institute, 2000.