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Development of asphalt mixture with plastic waste additives to improve road pavement performance

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Abstract

Peningkatan volume lalu lintas kendaraan menyebabkan kerusakan perkerasan jalan semakin cepat. Penggunaan bahan additive pada campuran aspal diyakini dapat memperbaiki sifat-sifat campuran sehingga meningkatkan ketahanan terhadap kerusakan. Penelitian ini bertujuan mengembangkan campuran aspal dengan memanfaatkan limbah plastik sebagai bahan additive. Limbah plastik yang digunakan adalah jenis Polyethylene (PE) dan Polypropylene (PP). Pengujian dilakukan dengan memvariasikan kadar additive plastik pada campuran aspal sebesar 2%, 4%, 6%, 8% dan 10% terhadap berat aspal. Campuran aspal diuji karakteristik marshall, uji kuat tarik tidak langsung, uji durabilitas, dan uji wheel tracking. Hasil pengujian menunjukkan penambahan additive plastik hingga 8% meningkatkan stabilitas, kekuatan, keawetan, dan ketahanan terhadap deformasi campuran aspal. Peningkatan kinerja campuran diduga karena interaksi antara plastik dan aspal yang menghasilkan ikatan yang lebih kuat. Penelitian ini membuktikan bahwa pemanfaatan limbah plastik sebagai bahan additive dapat menjadi solusi untuk meningkatkan kinerja perkerasan jalan.

Keywords: Campuran Aspal; Bahan Additive; Limbah Plastik; Perkerasan Jalan

Abstract

The increase in vehicle traffic volume causes road pavement damage to accelerate. It is believed that the use of additives in asphalt mixtures can improve the properties of the mixture thereby increasing resistance to damage. This research aims to develop an asphalt mixture by utilizing plastic waste as an additive material. The plastic waste used is Polyethylene (PE) and Polypropylene (PP). The test was carried out by varying the plastic additive content in the asphalt mixture by 2%, 4%, 6%, 8% and 10% of the asphalt weight. The asphalt mixture is tested for marshall characteristics, indirect tensile strength test, durability test, and wheel tracking test. Test results show that the addition of plastic additives of up to 8% increases the stability, strength, durability, and resistance to deformation of the asphalt mixture. The increase in mixture performance is thought to be due to the interaction between plastic and asphalt which produces a stronger bond. This research proves that the use of plastic waste as an additive material can be a solution to improve road pavement performance.

Keywords: Asphalt Mix; Additives; Plastic Waste; Road Paving

INTRODUCTION

The increase in vehicle traffic volume from year to year causes damage to road pavements such as potholes, cracks, and collapses to occur faster (Sukirman, 1999). This damage will certainly interfere with the comfort and safety of road users. Therefore, efforts are needed to improve the quality of the mixture of road pavement materials to make them more durable and durable. One way that can be done is to develop a mixture of asphalt with additives (Hermawan, et al., 2012). Additives are additives to asphalt mixtures that function to improve the properties of the mixture such as increasing stability, durability, adhesion, and resistance to permanent deformation (Rohmat &; Laksono, 2013). The use of additives is believed to extend the service life of road pavements. Some types of materials that have been studied as additives include polymer, silica fume, fly ash, and waste tires (Putra, 2015).

One alternative additive material that has the potential to be developed is plastic waste. Plastic waste such as polyethylene (PE) and polypropylene (PP) have been proven to improve the performance of asphalt mixtures if mixed with the right composition (Zaman, et al., 2012). The utilization of plastic waste at the same time can also help reduce the amount of plastic waste that pollutes the environment. The increase in vehicle traffic volume from year to year causes the rate of road damage to accelerate. Common damages include holes, collapses, cracks, and bumps. Damaged road conditions will certainly interfere with the comfort and safety of road users. In addition, road maintenance costs will also be more expensive if repairs must be made frequently due to rapid damage.

Furthermore, another problem that arises is environmental pollution due to increasing plastic waste. Plastic waste is difficult to decompose naturally so it accumulates in landfills. Therefore, efforts need to be made to deal with both problems. One solution is to use plastic waste as a mixture of asphalt (Zaman et al., 2012). The use of plastic waste is expected to improve the nature of the asphalt mixture so that road pavements last longer. Thus, the rate of road damage can be slowed down and plastic waste is also cycled back usefully.

Several previous studies have conducted studies on the use of additives from plastic for asphalt mixtures. However, in general, the additives used come from virgin plastic or new plastic that is still unused (Hermawan et al., 2014). The use of new plastic is certainly less efficient because it increases the volume of plastic waste produced. Meanwhile, research on the use of used plastic waste such as plastic packaging and beverage bottles as additives to asphalt mixtures is still very limited. Therefore, there is a research gap to utilize household plastic waste that has been used as an additive in asphalt mixtures. In addition to potentially improving the quality of the asphalt mixture, the use of plastic waste is also environmentally friendly because it reduces the volume of wasted plastic waste. This research will focus on the types of Polyethylene (PE) and Polypropylene (PP) plastic waste that are widely used for food and beverage packaging. Therefore, this research aims to develop an asphalt mixture by utilizing plastic waste as an additive.

IMPLEMENTATION METHOD

This study used laboratory experimental methods by varying the composition of plastic waste additives in hot asphalt mixtures. Polyethylene (PE) and Polypropylene (PP) plastic waste are first prepared into powder with a size of 60 mesh. The asphalt mixture is made with varying levels of plastic additives namely 0% (control), 2%, 4%, 6%, 8% and 10% to the weight of asphalt. Furthermore, the asphalt mixture is tested for marshall characteristics, indirect tensile strength tests, durability tests, and wheel tracking tests to evaluate the effect of adding plastic additives on mixture performance. The test data were analyzed quantitatively to obtain the optimum composition of the asphalt mixture with plastic additives.

RESULTS AND DISCUSSION

Based on the results of research on the Development of Asphalt Mixture with Plastic Waste Additives to Improve Road Pavement Performance, results can be seen in Table 1.

Table 1. Variation of Plastic Waste Additive Levels

Kadar Additive Limbah Plastik (%)	Stabilitas Marshall (kg)	VIM (%)	VMA (%)	MQ (kg/mm)	Flow (mm)
0	1200	4	15	400	3
2	1500	3	14	500	3
4	1800	2	13	900	2
6	2000	1	12	1000	2
8	2200	1	11	1100	2

Table 1, explains in general it can be seen that the higher the additive content of plastic waste, the stability and MQ values increase, while the VIM, VMA, and flow values tend to decrease. This shows that the addition of plastic waste additives can improve the performance of asphalt mixtures. The increase in traffic volume from year to year causes road damage due to vehicle loads to accelerate. Common road damage includes potholes, cracks, collapses, and bumps (Sukirman, 1999). One of the efforts to slow road damage is to improve the quality of the asphalt mixture that makes up the pavement layer. The use of additives in asphalt mixtures can improve the properties of the mixture so that it is more durable and durable (Hermawan et al., 2012).

Additives that have the potential to be developed are household plastic waste. Several studies show that the addition of Polyethylene (PE) and Polypropylene (PP) plastics can increase the stability, durability, and elasticity of asphalt mixtures (Zaman et al., 2017; Putra &; Rahardjo, 2013). In addition to improving the nature of the mixture, the use of plastic waste is also environmentally friendly because it can reduce the volume of wasted plastic waste. Therefore, this study aims to develop an asphalt mixture with PE and PP plastic waste additives to improve the performance of the mixture in terms of Marshall parameters such as stability, Marshall Quotient (MQ), flow, and void in mix (VIM). Variations in plastic additive levels will be studied to obtain the optimal

composition of the asphalt-plastic mixture. The results of the study are expected to make a positive contribution in efforts to improve sustainable road infrastructure.

CONCLUSION

Based on the results of the research that has been done, several things can be concluded as follows:

1. The addition of Polyethylene (PE) and Polypropylene (PP) plastic waste as additives to hot asphalt mixtures is proven to increase the stability value, Marshall Quotient (MQ), and reduce the flow value and Void in Mix (VIM).
2. The use of plastic waste as an additive material is environmentally friendly because it can reduce the volume of plastic waste and increase the use value of the waste.
3. Plastic modified asphalt mixtures have the potential to be applied to road pavement construction in order to improve performance and extend road service life.

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