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Effect of Blasting Waste as An Additive in Bitumen Mixtures

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ABSTRACT

The use of blasting waste in road pavement mixes is one of the new alternatives in Malaysia. Therefore, this study aimed to look at the potential of blasting waste as an additive in bitumen mixtures in road construction. Several percentages of blasting waste additive were studied, namely 0%, 5%, 10%, 15% and 17%. The parameter values of each of these mixtures were obtained through the Marshall test. A total of five sets of specimens were prepared for the Marshall test, with each set containing three samples. From the test result, all the percentages of blasting waste as an additive in the bitumen mixture passed the Public Works Department (Jabatan Kerja Raya or JKR) specifications. It was also concluded that 10% of blasting waste as an additive is the optimum value, with a stability value of 82.5kN as compared to the stability value of the control sample at 37.7kN. The flow and Marshall Quotient values for the 10% sample were 4mm and 20kN/mm, respectively. All values obtained from this study were in accordance with JKR specifications, indicating that blasting waste has great potential in improving the specification values of bitumen mixtures.

Keywords: Bitumen mixtures; blasting waste; additive

INTRODUCTION

Pavement premix is an important foundation for the construction of road structures. Premix paving works are often carried out by contractors appointed by the government or local authority. The basic materials to produce pavement premix are water, aggregates and sand.

There are various pavement repair techniques practiced, such as the restoration and resurfacing methods. For restoration works in Malaysia, patching is the most extensively used technique. Patching is carried out by replacing damaged surfaces with appropriate membrane mixtures to maintain road surface conditions (Tan Chin, Chien, 2006). Due to the prevalence of this technique, studies should be carried out constantly to ensure that the patchwork and materials involved meet the requirements set.

MATERIALS AND METHODS

This study was conducted by using existing bitumen used by the JKR in road maintenance works. The blasting waste was obtained from Bredero Shaw (Malaysia) Sdn. Bhd and used as an additive in the bitumen mixtures in this study. The percentages of blasting waste additive selected were 0%, 5%, 10%, 15% and 17% (Richard et, al, 2020). The total number of bitumen samples produced was 15 units. Parameters observed during this study involved the bulk density, stability, flow value and Marshall Quotient value of the samples. Corresponding to the number of percentages of blasting waste selected, a total of five sets of specimens were prepared for the Marshall test, with each set containing three samples. Each set of the Marshall test specimens required at least 1,300g of weight per set. All specimens were subjected to the Marshall stability test according to the JKR road work specification standard method, which refers to the ASTM D 6972.

RESULTS

Before the Marshall test was applied to the specimens, the characteristics of each sample were measured and recorded. These findings were vital in investigating the effect of blasting waste as an additive on bitumen mixtures. The characteristics of each sample are as tabulated in Table 1.

TABLE 1. Sample characteristics.

Blasting Waste Percentage (%)	Sample	Weight in air (g)	Weight in water (g)	Bulk volume (cm^3)	Bulk density (g/cm^3)
	S1	1068	581	487	2.2
0	S2	1090	584	506	2.2
	S3	1137	584	553	2.1
	S1	908	536	372	2.4
5	S2	1247	690	557	2.2
	S3	1202	655	547	2.2
	S1	1131	747	384	2.9
10	S2	1270	712	558	2.3
	S3	1027	563	464	2.2
	S1	1149	650	499	2.3
15	S2	1197	633	564	2.1
	S3	1100	592	508	2.2
	S1	1021	502	519	2.0
17	S2	1086	506	580	1.9
	S3	905	443	462	2.0

Figure 1 shows an increase in bulk density up to the 10% blasting waste samples, while the bitumen mixtures with 15% and 17% blasting waste exhibited a decrease in bulk density. This is because blasting waste which is filler-like had increased the filler content of the mixture and reduced the bitumen capacity in the mixture.

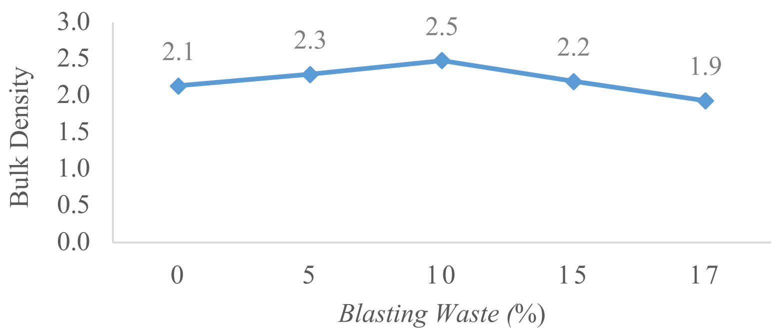

FIGURE 1. Percentage of blasting waste against bulk density

During the Marshall test, data for the stability and flow of each sample were recorded. The stability value indicates the maximum load that can be imposed onto the sample before failure occurred. Adequate stability obtained through the Marshall test is required to ensure that the road pavement can withstand the traffic load. The higher the maximum load value is, the better the bitumen mixture is for roads with high traffic loads. On the other hand, a high flow value is undesirable as it indicates that the mixture of the pavement will easily move under compaction loads. Table 2 below shows the average stability and flow value at each blasting waste additive percentage.

TABLE 2. Marshall tests stability and flows data.

Blasting Waste Percentage (%)	Bulk density (g/cm^3)	Stability (kN)	Flow (mm)	*Marshall Quotient* (kN/mm)
0	2.1	37.7	5	7
5	2.3	66.6	4	27
10	2.5	82.5	4	20
15	2.2	52.6	3	18
17	1.9	8.8	3	3

The highest Marshall stability occurred in the sample containing 10% blasting waste, with a stability value of 82.5kN, whereas the lowest stability was recorded for the sample containing 17% blasting waste, with a stability value of 8.8kN. Nevertheless, all five types of bitumen mixtures recorded a stability value exceeding the minimum stability requirement of 8kN for the wearing course and binder course, as shown in Table 3. The results showed that additive has the potential to improve the stability value of bitumen mixture, as proven by the highest stability value which was approximate twice the stability value of the control sample.

TABLE 3. Test and analysis parameters.

Parameters	Wearing Course	Binder Course
Stability, S	>8000N	>8000N
Flow, F	2.0 - 4.0 mm	2.0 - 4.0 mm
Stiffness, S/F	> 2000 N/mm	> 2000 N/mm

Source: Table 4.3.5 JKR/SPJ

From the flow test, there was a decreasing trend in flow value with increasing blasting waste content. The flow values were within the range of the test and analysis parameters specified in the JKR specification, which is 2mm to 4mm. The control sample had the highest flow value of 5mm, while the samples containing 5% and 10% had a flow value of 4mm. The lowest flow value of 3mm was recorded for the samples containing 15% and 17% blasting waste. These findings illustrated that additive has the potential to improve flow performance in bitumen mixtures.

The optimum percentage of blasting waste was determined through the highest value of the Marshall stability. Based on the findings of this study, the maximum value of stability was recorded for the 10% blasting waste sample. The stability value obtained was 82.5kN, approximately double the stability value of the control sample at 37.7kN. The flow value of 4mm for the 10% blasting waste sample was also in the range of the JKR specification, and it was lower than the control sample value of 5mm.

The Marshall Quotient (or Stiffness) is the value of the ratio of stability to flow. The Marshall Quotient for the 10% blasting waste sample was 20kN/mm, which was also in the range of the JKR specification. This value also indicated the potential to provide better resistance to permanent deformation due to its high stability value. In a nutshell, 10% blasting waste as an additive is the optimum mixture with great potential in improving the specification values of a road pavement.

DISCUSSION AND CONCLUSION

The use of blasting waste as additive influences the parameters of a bitumen mixture in terms of bulk density value, stability, flow and Marshall Quotient. The optimum content of blasting waste additive in the bitumen mixture was found to be 10%. A comparison with the study of Subham et al. (2017), who had studied bitumen mixtures with rubber and plastic materials, is shown in Table 4.

TABLE 4. Comparison with findings by Subham et al. (2017).

Optimum Mixture	Bulk density (g/cm^3)	Stability (kN)	Flow (mm)	*Marshall Quotient* (kN/mm)
100% Bitumen + 10% Blasting Waste (from this study)	2.5	82.5	4	20
90% Bitumen + 10% Rubber (Subham et al., 2017)	2.3	13.1	3.7	3.5
92% Bitumen + 8% Plastic (Subham et al., 2017)	2.4	10.5	3.4	3.1
84% Bitumen + 6% Plastic + 10% Rubber (Subham et al., 2017)	2.3	13.9	3.9	3.6

The comparison from Table 4 shows that 10% blasting waste additive in a bitumen mixture can provide improved performance. It is hereby proposed that, in future studies of blasting waste as an additive in bitumen mixture, analysis of selected aggregates to obtain the percentages of air voids and gaps in the mixture should also be carried out. This is because small percentages of voids will cause the bitumen on the pavement to leak when receiving traffic loads. As a result, the road surface will become slippery and subsequently endangers road users. On the other hand, very large gaps in a bitumen mixture will cause the road pavement to have wheel marks when receiving traffic loads. The reference for the optimal air void percentage can be obtained from the JKR specification standard.

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DECLARATION OF COMPETING INTEREST

None

REFERENCES

Amin Chegenizadeh, Nuha Mashaan, Alireza Rezagholilou and Nikraz, H. 2019. Review on using waste polymer as additive in asphalt mixture. *International Journal of Advances in Science, Engineering and Technology (IJASEAT)* 7: 58-60.

Amin Chegenizadeh, Scott, W., Hanson, Hamid Nikraz and Kress, C. S. 2022. Effects of ground-granulated blast-furnace slag used as filler in dense graded asphalt. *Applied Sciences* 12(6): 2769.

Anda Ligia Belc, Erdem Coleri, Florin Belc and Ciprian Costescu. 2021. Influence of different warm mix additives on characteristics of warm mix asphalt. *Materials (Basel)* 14(13): 3534.

Chegenizadeh, A., Keramatikerman, M., Dalla Santa, G. & Nikraz, H. 2018. Influence of recycled tyre amendment on the mechanical behaviour of soil-bentonite cut-off walls. *Journal of Cleaner Production (Elsevier)* 177: 507–515.

Hu, C., Mai, Y., Cannone Falchetto, A. and Tartari, E. 2021. Experimental investigation on the use of Selenice natural bitumen as an additive for pavement materials. *Materials* 14: 1023.

Lermen, R. T., Prauchner, M. B., de Almeida Silva, R. and Bonsembiante, F. T. 2020. *Using Wastes from the Process of Blasting with Steel Shot to Make a Radiation Shield in Mortar*. Sustainability, MDPI.

Maninder Singh, Kunal Jain and Sukhjinder Singh Kahlon. 2020. Use of sulphur as an additive in bitumen: A review. *International Research Journal of Engineering and Technology*.

Mashaan, N. S., Chegenizadeh, A., Nikraz, H. & Rezagholilou, A. 2021. Investigating the engineering properties of asphalt binder modified with waste plastic polymer. *Ain Shams Engineering Journal* 12: 1569–1574.

Md Tareq Rahman, Abbas Mohajerani and Filippo Giustozzi. 2020. Recycling of waste materials for asphalt concrete and bitumen: A review. *Materials (Basel)* 13(7): 1495.

Mohsen Zahedi, Ali Zarei and Omid Janmohammadi. 2020. Experimental determination of the optimum percentage of asphalt mixtures reinforced with Lignin. *SN Applied Sciences* 2: 258.

Remisova, E. 2018. *Improvement in Properties of Bitumen Using Selected Additives*. Cetra.

Remisova, E. and Holy, M. 2017. *Changes of Properties of Bitumen Binders by Additives Application*; IOP Conf. Series: Materials Science and Engineering.

Ruikun Dong, Mengzhen Zhao and Naipeng Tang. 2019. Characterization of crumb tire rubber lightly pyrolyzed in waste cooking oil and the properties of its modified bitumen. *Construction and Building Materials* 195: 10-18.

Shubham Bansal, Anil Kumar Misra dan Purnima Bajpai. 2017. *Evaluation of* modified bituminous concrete mix developed using rubber and plastic waste material. *International Journal of Sustainable Built Environment*: 442-448.

Standard Test Method for Indirect Tensile (IDT) Strength of Bituminous Mixture, ASTM D6931, 2012.

Tan Chin, Chien. 2006. A Review On The Incident Of Flexible Pavement Defects In Malaysian Road / Tan Chin Chien,CV 00047.T161 2006. Universiti Teknologi Petronas, Seri Iskandar, Tronoh Perak.

Tartari, E. 2021. The natural bitumen additive Selenizza® SLN: A promising alternative for producing high-performance asphalt mixes. *Journal of Civil Engineering and Environmental Sciences* 7(2): 034-043.