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Effect of Using Waste Concrete as Coarse Aggregate Substitution and Polyethylene Terephthalate as Asphalt Substitution in Asphalt Concrete Pavement

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Abstract

The dominant layered pavement structure requires aggregate, the higher construction level needs a lot of new materials and to minimize the problem of natural damage due to rock mining, one alternative is substituting concrete waste for coarse aggregate. The concrete waste that will be used is the quality of K-225 as a coarse aggregate substitution material and asphalt modified by polymer (plastic) type PET (Polyethylene Terephthalate) which is mineral bottle. This study aims to determine the characteristics of asphalt concrete base course (AC-BC) mix using waste concrete as coarse aggregate substitution and 6% PET as asphalt substitution. The total specimens are 75 specimens with variations of waste concrete as coarse aggregate substitution are 5% and 15%. The use of waste concrete as coarse aggregate substitution and 6% PET as asphalt substitution according to the specifications of Bina Marga 2018 Revision 2 (2020). The results in this study the best concrete waste, namely at 5% variation at lower 5.68% asphalt content with a stability is 1168.70 kg, flow is 3.63 mm, density is 2.44 t/m^3, VIM (Void in mix) is 3.86%, VMA (Void in mineral aggregate) is 17.29%, VFA (Void filled by asphalt) is 77.67% and MQ (Marshall quotient) is 323.98 kg/mm. The durability for the best mix composition is 91.71% which means the mix has durability according to specifications.

Keywords

Waste concrete, Coarse aggregate, Polyethylene terephthalate, Marshall method, Asphalt concrete base course

Introduction

Roads are one of the most important infrastructures to support activities in various fields. Therefore, the construction of transportation is a priority for the government. Indonesia is a developing country, resulting in an increase in infrastructure development, one of which is road construction. The dominant pavement structure requires aggregates, the higher development needs a lot of new materials. The problem of natural damage caused by excessive rock mining and the disposal of concrete waste encourages researchers to recycle concrete waste from a building construction as an alternative aggregate.

Concrete waste will be used as a mix substitution material and to know a positive impact on stability, and asphalt material modification is adding additives (asphalt modifiers) aimed at improving the quality of road pavement or stabilities of asphalt. In this study additives are polymers (plastics) that will be used in PET, generally used as mineral bottles. The use of plastic waste is reduced packaging waste so that it does not cause bad impacts but give a good impact on environment. This study aims to determine the characteristics of the AC-BC mix using concrete waste as coarse aggregates substitution and PET as asphalt substitution.

This study were 75 test objects with variations concrete waste, namely 0%, 5% and 15%, 6% PET waste of the asphalt content.

Materials and Method

The research was conducted at the Highway Laboratory, Department of Civil Engineering, Faculty of Engineering, Universitas Syiah Kuala. The material used is taken in the Indrapuri, Aceh Besar District, penetration asphalt 60/70, concrete waste from waste building construction and PET waste. In determining the optimum asphalt content (OAC), five asphalt contents variations are used, namely 5%, 5.5%, 6%, 6.5%, and 7%. Each specimen was compacted for 2 x 75 blows. Then tested using the Marshall method to get OAC. In this study were 75 of test objects with variations of concrete waste, namely 0%, 5%, and 15%, PET waste substitution is 6% of the asphalt content. The data analysis used is analysis of variance to determine the effect of using the concrete waste on coarse aggregates substitution and PET on asphalt substitution in concrete asphalt mix. Materials used were nanomaterials.

Results and Discussion

Based on the Marshall parameters are stability, flow, and Marshall quotient and volumetric are of density, VIM, VMA and VFA, the results of Marshall test analysis are based on asphalt content variations, namely 5%, 5.5%, 6%, 6.5%, and 7%. The OAC graph of the Marshall parameter concrete asphalt mix can be seen in figure 1 which is an overlapping from Marshall characteristic results to obtain the OAC. The OAC obtained is 6.18%. Then, OAC varies into 3 asphalt content with a range of OAC ±0.5%, namely 5.68% 6.18%, and 6.68%.

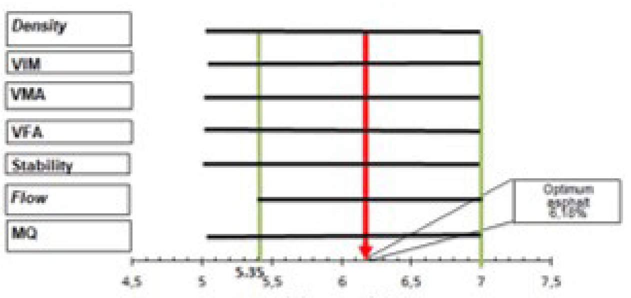

Figure 1: Graph of determination of OAC.

Based on the results on the best substitution concrete waste as coarse aggregates and PET as penetration asphalt 60/70 substitution is found 5% with the OAC is 5.68% and a stability is 1168.70 kg that has fulfilled the specifications Bina Marga 2018 revision 2 (2020). Figure 2 shows that the highest density is found in 15% concrete waste variation with 5.68% asphalt content is 2.44 t/m^3 while the lowest is found in 5% concrete waste with 6.68% asphalt content is 2.41 t/m^3. Figure 3 shows that the VIM has decreased in line with the increasing of concrete waste. The VIM value for each concrete waste substitution has fulfilled the specified requirements. Based on the Bina Marga 2018 Revision 2 (2020) [1] specifications, the VIM in the concrete asphalt mix AC-BC has an

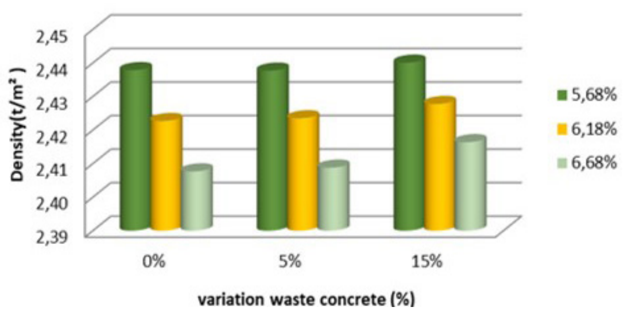

Figure 2: Graph of the effect concrete waste variation + PET on density.

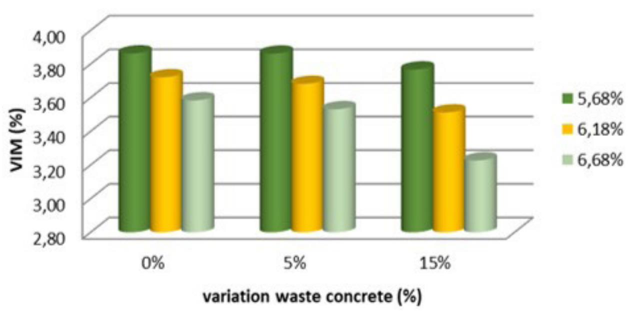

Figure 3: Graph of the effect concrete waste variation + PET on VIM.

interval of 3% to 5%. The VMA for concrete waste variation and PET waste has fulfilled the 2018 Bina Marga Revision 2 specification (2020) which is at least 15% [2]. The results show that VMA decreased because the aggregate of concrete waste has a higher absorption compared to the new aggregate. Voids quantity affects the performance of an asphalt mix. When the VMA is too large, creates more space for asphalt blankets. The results of VMA can be seen in figure 4. Based on figure 5, the VFA for AC-BC mix increases with the increas-

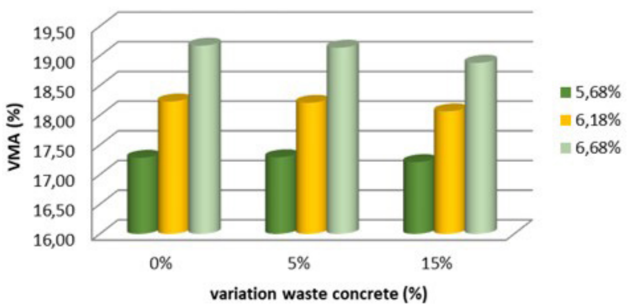

Figure 4: Graph of the effect concrete waste variation + PET on VMA.

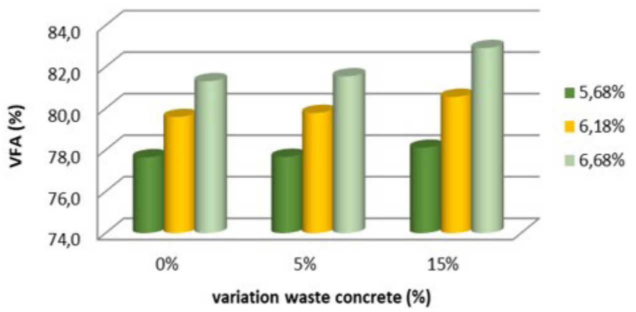

Figure 5: Graph of the effect concrete waste variation + PET on VFA.

ing concrete waste variations. This occurs because with each addition of concrete waste, the VFA also increases, thus the mixture has high impermeability to water and air. Based on the results, the VFA obtained fulfills the specifications whereas the minimum is 65%. Figure 6 indicates that the stability decreases with increasing the concrete waste in the paved mix. The highest is found at 5% concrete waste, which is 1168.70 kg on 5.68% asphalt content and the lowest at 912.49 kg on 6.68% asphalt content. This happens because the strength of concrete waste is worse than the new aggregate. Based on the specifications of Bina Marga 2018 Revision 2 (2020) the minimum stability is 800 kg and the addition of all variations of coal bottom ash fulfills the specified requirements [3]. Figure 7 indicates that the flow at concrete waste substitution + 6% PET on AC-BC tends to increase. This occurs because the use of concrete waste substitution into coarse aggregates absorbs asphalt higher so that the asphalt in the mix require increases. Based on the specifications of Bina Marga 2018 Revision 2 (2020) the flow is interval 2 mm to 4 mm [4]. According to figure 8, the MQ decreases with increasing concrete waste substitution. The MQ without concrete waste is 361.65 kg/mm while with the highest concrete waste is found at 6.18% asphalt content is 338.31 kg/mm and the lowest value is found in the KAO -0.5% which is 212.49 kg/mm. This is because the stability is getting smaller while the flow is getting higher. Refer to the 2018 Revision 2 (2020) highways specifications, the minimum MQ is 250 kg/mm [5]. Figure 9 shows that the durability for AC-BC with 5% concrete waste and 6% PET fulfill the requirements of Bina Marga Specification 2018 Revision 2 (2020) is ≥ 90% [6]. The durability obtained is 91.71% which means the mixture is durable [7].

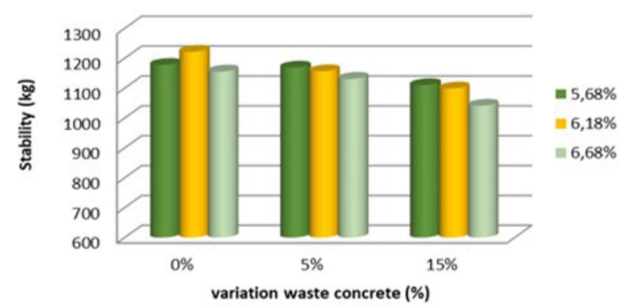

Figure 6: Graph of the effect concrete waste variation + PET on stability.

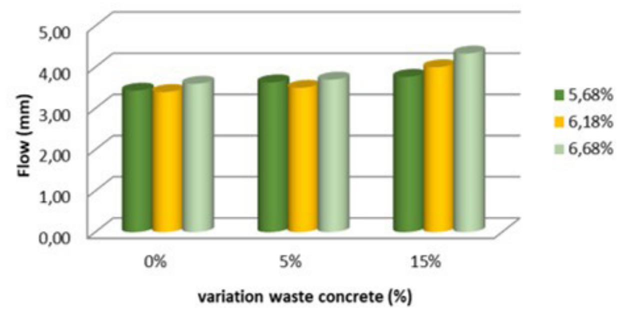

Figure 7: Graph of the effect concrete waste variation + PET on flow.

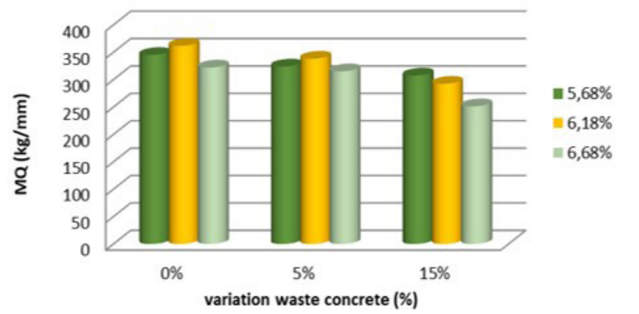

Figure 8: Graph of the effect concrete waste variation + PET on MQ.

Figure 9: Durability of AC-BC with 5% concrete waste + 6% PET.

Conclusions

Based on the results the effect of using waste concrete as coarse aggregate substitution and PET as asphalt substitution in asphalt concrete pavement some conclusions, namely:

- The OAC of AC-BC with concrete waste as a substitution on the coarse aggregate and 6% PET are varies, namely, 5.68%, 6.18%, and 6.68%.
- The Marshall parameter results of AC-BC with concrete waste as a substitution on the coarse aggregate and 6% PET fulfil the specifications except for the flow at 15% concrete waste.
- The best asphalt content of concrete waste substitution on coarse aggregates and 6% PET used for durability testing is at 5% concrete waste and 5.68% asphalt content.

Acknowledgements

None.

Conflict of Interest

None.

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