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Abstract

Nowadays, intensive work is being done on the evaluation of household waste and during the production of various products. This study compiles studies investigating the usability of wastes such as marble dust, fly ash, phosphogypsum, and glass dust in asphalt pavement mixtures. Marshall stability samples were prepared by using asphalt cement at 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, and 6.5 ratios to determine the optimum binder ratio. The optimum bitumen percentage was determined by applying the Marshall stability test to the prepared samples. Marshall stability test was applied to the samples for the optimum bitumen percentage found as 4.9%. The variation of Marshall stability and yield values in bituminous mixtures using industrial waste fillers were investigated. In addition, the usability of used engine oils in the modification of bituminous binders has also been mentioned. For this purpose, bitumen was modified by mixing horse engine oil in 5 different ratios ranging from 1% to 5% from 70/100 penetration class to bitumen using a standard method. The changes in the bitumen as a result of the modification were investigated on basic engineering properties such as penetration, softening, flash point, and viscosity. At the same time, it was revealed how the temperature sensitivity of the bitumen and the mixing and compaction temperatures changed after the bitumen was modified with used engine oil. In addition, the modification index is defined for each test method. As a result, a significant change has occurred in the basic engineering properties of the modified bitumen samples using different ratios of used engine oil additives. It was determined that the softening point, flash point, and viscosity values of the bitumen with an increase in the penetration value were decreased. According to the evaluations made on the basic engineering properties of bitumen, it was predicted that it would be possible to recycle used engine oils by using them in bitumen modification.

Keywords: Transportation Engineering, Pavement, Waste Materials, Circular Economy, Civil Engineering

INTRODUCTION

The storage or abandonment of various products obtained as waste creates great difficulties and brings great problems to a society, including environmental pollution. Today, intensive work is being done on the evaluation of by-products or wastes obtained during the production of various products. Different applications are seen in obtaining high-performance mixtures. Among these applications are the use of various additives, material selection with high-performance value, high-quality control, different design methods, and up-to-date testing techniques. One of the methods applied in the production of high-performance bituminous hot mix used on roads is the use of industrial waste materials as an additive. With the evaluation of waste materials, environmental pollution caused by wastes is prevented and some properties of roads are improved by using these wastes. In addition, the evaluation of waste, considering the principles of circular economy, it also contributes to the national economy.

METHODS

Waste engine oil was added to the supplied bitumen samples at the rates determined by the bitumen weight (from 1% to 5%) and the modification was carried out.

(i) Heating the bitumen at 145±5 °C, discharging the bitumen into containers of 500 grams,

(ii) Adding the waste engine oil additive to the bitumen at the determined rates,

(iii) Processing the bitumen-waste engine oil mixture at 140±5 °C at 1000 revolutions per minute. It is mixed for hours.

In the study, the physical and mechanical effects of industrial wastes with different properties (marble dust, fly ash, phosphogypsum, and glass dust) on the asphalt concrete wear layer were investigated. Bituminous mixtures prepared with fixed bitumen content and different stone dust and industrial waste fillers (marble dust, fly ash, phosphogypsum, and glass powder) ratios. Marshall stability test was performed and the variation of void, stability, and yield values were investigated.

In another different type of study, the changes in the basic engineering properties of modified bitumen obtained by adding Waste Engine Oil at different rates were investigated. In this study, penetration, softening point, viscosity, and flash point tests were carried out to determine the changes in bitumen.

RESULTS and DISCUSSION

According to the penetration test results, it will be seen that there is a significant increase in the penetration value with the increase in the ratio of Waste Engine Oil added to the bitumen. According to the penetration classification system, bitumen modified with Waste Motor Oil up to 3% remains in the pure bitumen class (70/100). However, modified bitumen containing 4 and 5% WASTE ENGINE OIL changes the existing bitumen class. Waste Engine Oil modified bitumen samples at the specified rates provide 100/150 bitumen class penetration values. In addition, it is observed that with each unit increase of Waste Engine oil up to 3%, approximately 5 units of penetration increase occurs, but at 4%, the increasing amount is 10 units compared to 3%, and 5% of the increasing amount is 4%.

According to softening test, as the waste motor oil and additive ratio increases, there is a significant decrease in the softening point of the modified bitumen. In addition, an increase in the ratio of one unit of Waste Engine Oil caused a decrease in the softening point of 2°C on average.

It has been revealed that the flash points of bitumen modified with different ratios of Waste Motor Oil decrease up to 30 °C. It has been observed that the bitumen modified with 5% waste engine oil has reached the limit value defined in the TS EN 12591 standard, 230 °C, for most of the bitumen samples. For this reason, it becomes necessary to inspect the modified bitumen obtained by adding 5% and more Waste Engine oils to the bitumen in terms of safety.

According to the viscosity test results, the viscosity value was found to be high for all samples at temperatures of 110 °C. However, the viscosity values measured in the modified bitumen with Waste Engine Oil were lower than that of the pure bitumen. In addition, the decrease in viscosity becomes more pronounced as the waste-engine oil ratio increases. A similar trend is observed at other temperatures (135 and 165 °C). However, no large differences were observed between the measurements made at high temperatures compared to those made at low temperatures. For example, in the viscosity measurements made for pure bitumen at 165 °C, a value of 139 cP was reached, while this value was determined as 90 cP in modified bitumen with 5% Waste Engine Oil. However, considering the viscosity values at 110 °C, this value was measured as 2263 cP for pure bitumen, and 1154 cP for modified bitumen with 5% Waste Engine Oil.

In another different type of study, the results of the tests (void values in terms of %, and yield values in mm) performed for mixtures with filler additives such as marble powder, phosphogypsum, fly ash, glass powder and stone powder are shown in Figure 1.

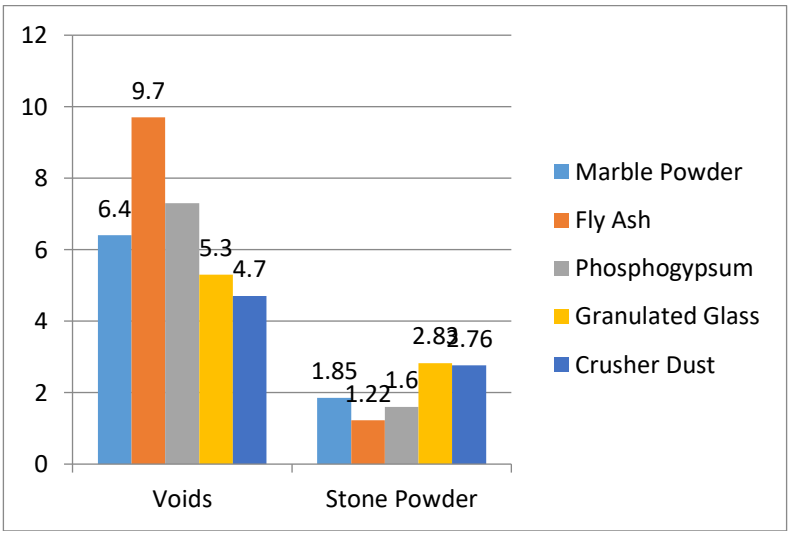

Figure 1. Test Results for different filler types

The changes occurring in pure bitumen with a penetration class of 70/100 modified with AMY at intervals ranging from 1% to 5% by bitumen were investigated over the basic engineering properties of bitumen. And as a result, as the rate of waste engine oil increases;

(i) Increase in penetration values,

(ii) Decrease in softening points,

(iii) Decrease in flashpoints,

(iv) Decrease in viscosity values,

(v) Increased sensitivity to temperature

(vi) A decrease in mixing and compaction temperatures was observed.

In the other type of study, Marshall stability tests were applied to the samples with the same grain distribution and optimum bitumen content, prepared by using natural fillers in the aggregate and industrial waste materials instead of natural fillers. Evaluations of the results were made with void, stability, and yield values. The void percentage values of the mixtures prepared with the addition of marble dust and glass powder fillers are between 3 - 5%, which are the specification limits, and the fly ash and phosphogypsum void values are well above the specification limits. Therefore, it is concluded that it cannot be used in special cases where impermeability is required. The stability values of the mixtures with marble dust, fly ash, phosphor, and glass powder fillers were above the lower limit value of the specification, 900 kg. The yield values of the mixtures with marble powder, phosphogypsum, and glass powder fillers remain between the specification limits of 2 mm – 4 mm. The flow values of fly ash fillers are below the specification limits. These values show that fly ash behaves like a brittle material with increasing filler ratios.

In general, as the waste filler ratio increases, the void ratio and stability values increase and the flow values decrease in all industrial wastes except glass powder waste.

In experimental studies, it was determined that the most suitable industrial waste filler ratio in terms of Marshall stability test results was 4% stone dust - 3% industrial waste filler. Even at the rate of 0% stone dust - 7% industrial waste filler, specification limits are provided.

The test results show that industrial waste filler materials can be used at a rate of 7% instead of stone dust filler in hot bituminous mixtures. It is thought that the coating layers produced by using marble dust, fly ash, phosphogypsum, and glass dust industrial waste fillers in hot bituminous mixtures will have good strength.

CONCLUSION

Industrial enterprises generally do not expect any financial income from waste. The circular economy, on the other hand, aims to preserve their value for as long as possible by minimizing waste generation and returning materials and resources to the product cycle at the end of their use. They want to get rid of these wastes that occupy the field unnecessarily. Therefore, in road pavement works, taking into account the transportation cost, using industrial wastes as fillers, or adding waste materials to bituminous mixtures, both economic gain will be achieved and these materials that cause environmental pollution will be evaluated in this way.

REFERENCES

Aruntaş, H., Y., Uçucu küllerin inşaat sektöründe kullanım potansiyeli, Gazi Üniversitesi Mühendislik Mimarlık Fakültesi Dergisi, Ankara, Cilt 21, No 1, 193-203, (2006).

Deniz, M.T., Sönmez, İ., Yıldırım, S. A., Eren, B. K., Kullanılmış otomobil lastiklerinin bitümlü sıcak karışım performansına etkisi, 6. Ulaştırma Kongresi, İstanbul, 349, (2005).

Güngör, M.M., Afşin Elbistan uçucu külünün esnek yol kaplamalarında filler olarak kullanımı üzerine bir araştırma, M.Sc. Tezi, Fırat Üniversitesi Fen Bilimleri Enstitüsü, Elazığ, (1996).

Gökalp, İslam & Yildiz, Ali & Eren, Muhammed & Uz, Volkan. (2019). ATIK MOTOR YAĞI MODİFİYELİ BİTÜMÜN MÜHENDİSLİK ÖZELLİKLERİNİN ARAŞTIRILMASI. 27. 184-193. 10.31796/ogummf.571513.

Üstünkol, F. N., Endüstriyel atıkların karayolu üstyapısında değerlendirilmesi, BAÜ FBE Dergisi, Balıkesir, Cilt:11, Sayı:1, 15-27, (2009).