Experimental Study on Determining the Optimum Cigarette Butt Content of Modified Bituminous Mixture of Cigarette Butts

Yi CUI, Zhao-rong WU, Yali LI and Hang YANG

Department of Transportation Engineering, Tongji Zhejiang College, Jiaxing 314051, China

Abstract: China ranks first in the world as the number of smokers. The environmental pollution and recycling problems of waste cigarette butts are becoming more and more serious. How to make better reuse of waste cigarette butts has been taken action by some countries and regions in the world. In order to study the utilization value of the cigarette butt in road performance, this test takes No. 70 matrix bitumen and waste tobacco as raw material. The optimum amount of the content of the cigarette butt in the experiment is further determined based on the test performance of the modified asphalt mixture and the modified bitumen mixture is prepared by the addition method. The performance indexes of modified bituminous mixture with different dosages were tested and studied. Combined with production and economic realities, the optimum cigarette butt content of modified asphalt mixture is determined to make the road performance optimal. This paper focuses on the determination of the best bituminous content of the bituminous mixture. Through the toxicity test of the leachate published abroad to reflect the pollution of the cigarette butt to the environment and analyze the harm to the environment, combined with the development of global reusing technology and the economic benefits brought by cigarette butts, the prospect of the utilization of waste cigarette butts is forecasted.

Key words: Pavement performance, optimal dosage with cigarette butts, contrast test, economic performance.

1. Overview

According to the World Tobacco Development Report 2016 [1], there were about 60 million boxes of cigarette sales in the world in 2016. It is estimated that around 5 trillion and 600 billion cigarette butts are produced every year, and cigarette butts have become the largest number of solid wastes in the world. It is difficult to be degrade organic substances in cigarette butts, such as arsenic, chromium, nickel, cadmium and other heavy metals can be decomposed naturally in underground for many years. The harm of these harmful substances to the soil and water resources is self-evident, and the pollution to the water body is the most serious. The toxicity test of filtrate leachate has also been published abroad. The leachate can be classified into three types: (1) unused filters; (2)

smokeless cigarette butts; (3) cigarette butts with residual cigarettes; their leachate bio toxicity tests with LC50 [2] and EC50 [3], are to assess the indicators to determine its toxicity. The conclusions indicate that the leachate contains certain toxicity, and the leachate with the cigarette butt residue is the most toxic, and the environment is the most such material. The experimental results are shown in Table 1.

A company called “Tera cycle” in New Jersey, USA produces wood plastic composite flooring and plastic transport pallets. The cigarette butts are mixed with other materials that need to be recycled to make railway sleepers, Frisbee, ashtrays, and playgrounds for community parks. In Australia, it is used to pave the road, to make clay bricks with a cigarette butt, and to make paper in Brazil, and to make nail polish from the Jiangxi University of Science and Technology’s cigarette butts. These examples fully show that cigarette butts have great reutilization value.

Corresponding author: WU Zhao-rong, lecturer; research field: pavement materials.

Table 1 Cigarette leachate toxicity test.

Tested species	Concentration (single cigarette butt /L)			Test type
	Unused filters	Smokeless cigarette butts	Smoke cigarette	
Silver fish	4.6-15.7	1.5-2.0	0.95-1.3	LC50
Pimephales promelas	11.4-15.9	3.7-5.1	0.84-1.1	LC50
Water flea	1.4-2.06	0.09-0.27	0.05-0.08	EC50
Marine bacteria	> 970	1.21-1.33	0.53-0.63	EC50

Since twenty-first Century, the improvement of the ecological environment has become the key work of building an environment-friendly society in China. Good ecological environment is of great significance for improving the quality of people's life and promoting the sustainable development of social economy. But at present, there are still many problems in China's ecological environment. How to do garbage sorting and recycling has become an urgent task in today's social development. The policies on "Recycling and Management of Renewable Resources" and "Implementation Plan for the Classification System of Domestic Garbage" have also provided policy support for the recovery and reuse of the tobacco.

2. Determine the Optimum Cigarette Butt Content of Bituminous Modified Asphalt Mixture

2.1 Bitumen and Cigarette Butts

Through data search and technical analysis, this test selects No. 70 bitumen (the best asphalt content is 4.8% by the previous test, so the asphalt content of the asphalt mixture in this paper is 4.8%). And then it was dried and cut into a large segment of tobacco (3-5 times per root, about 0.6 mm, and then dried in an oven at 105 degrees). The bituminous modified asphalt mixture was prepared by external mixing method.

2.2 Test Content

The preparation of the bituminous bitumen mixture is divided into the internal mixing method and the addition method. This experiment uses the addition

method to cut the cigarette butt into the same size, and directly mix the cut tobacco into the ordinary asphalt mixture. It has been proved by previous studies that the road performance of the bituminous mixture has a great relationship with the content of the cigarette butt, so the optimum amount of the bituminous bitumen mixture is determined by the principle of optimal road performance.

2.3 Test Method

In this study, Marshall test, Rut test and other results were taken as evaluation indicators. The test standards involved in this study are in accordance with the "Test Code for Asphalt and Asphalt Mixture in Highway Engineering" (JTG E20-2011).

2.4 Analysis of Experimental Results

The initial test plan was to produce cigarette Bituminous Mixture Specimens with 1%, 3% and 5% cigarette butts. 3% and 5% specimens were not formed. After that, a sample of 2.5% content was produced. Therefore, the final test scheme was made for the content of 1%, 1.5% and 2% of the cigarette, and then producing 5 samples of the mixture weigh 1,200 g, 1,213 g and 1,215 g, respectively, which would be selected and placed for 12 hours with the high level of modified asphalt mixture.

2.4.1 Analysis of Damage Strength of Pavement

In this study, the stability of the bituminous mixture (the maximum failure load) can be used to evaluate the failure strength of the pavement. The stability contrast of different tobacco content is shown in Fig. 1. The experimental results of five groups of samples with different cigarette butts content were taken

respectively and the comparison was shown in Fig. 2.

From Fig. 1 and Fig. 2, it is known that with the increase of the content of the cigarette, the stability of the mixture increases gradually, indicating that the strength of the pavement is improved and the content of the cigarette is 2%. As can be seen from Fig. 2, the asphalt mixture with 2% bituminous content increased by 12.4% compared with the stability of 1.5%, so the stability of the bitumen mixture was the highest when the content of the cigarette butt was 2%.

2.4.2 Analysis of Deformation Resistance of Pavement

The anti-deformation ability of the bituminous mixture is evaluated by the flow value of the cigarette bituminous mixture (the maximum vertical deformation of the load) is achieved. The flow value comparison diagram for different content of cigarette butts is shown in Fig. 3. The experimental results of five groups of samples with different cigarette butts content were taken respectively and the comparison was shown in Fig. 4.

Fig. 1 A contrast diagram of the stability of a cigarette with different contents.

Fig. 2 The mean contrast diagram of the content stability of different cigarette butts.

Fig. 3 shows that with the increase of the content of the cigarette, the flow value of the mixture decreases gradually, indicating that the anti-deformation ability of the pavement is improved. The flow value of the asphalt mixture with 1.5% bituminous content is lower than 1% and 2% of the flow value from Fig. 4, so the anti-deformation ability of the bituminous mixture is the best when the content of the cigarette butt is 1.5%.

2.4.3 Analysis of High Temperature Resistance of Pavement

The dynamic stability of the bituminous bitumen mixture is used to evaluate the high temperature

performance of the pavement. The experimental results of five groups of samples with different cigarette butts content were taken respectively and the comparison was shown in Fig. 5. The contrast map of bituminous mixture and matrix asphalt mixture with 2% cigarette butts is shown in Fig. 6.

Fig.5 shows that with the increase of the content of the cigarette, the dynamic stability of the mixture increases gradually, indicating that the high temperature resistance of the pavement is improved, and the dynamic stability of the asphalt mixture with the content of 2% is the highest. As shown in Fig. 6, the mixture of 2% bituminous mixture increases the

Fig. 3 A comparison diagram of the flow value of a cigarette with different contents.

Fig. 4 The mean contrast diagram of the flow values of different cigarette butts.

dynamic stability of asphalt mixture by 12.2%, indicating that the high temperature performance is better than that of the ordinary asphalt pavement.

2.5 Test Result

Through the above tests of the road performance of bituminous modified asphalt, we can draw the following conclusions: (1) When the cigarette content is 2%, the stability and dynamic stability index of cigarette bituminous mixture are the best. At this time, the failure strength and high temperature resistance of the asphalt pavement are the best. (2) The anti-deformation ability of the bituminous

mixture is the best when the content of the bituminous mixture is 1.5%, and on this basis, the increase of the content of the cigarette butt (the content of the cigarette butt is not more than 2%) can increase the strength and the high temperature resistance of the bituminous mixture. (3) Compared with ordinary matrix bitumen, the bituminous bitumen mixture of the bituminous mixture is significantly improved in the high temperature resistance, so it can be used in the tropical area with the highest temperature in the perennial and the lowest temperature.

Considering the properties of cigarette bituminous mixture, it is recommended to use 2% bituminous mixture with cigarette butts.

Fig. 5 A contrast diagram of the dynamic stability of a cigarette with different contents.

Fig. 6 Comparison diagram of bitumen and matrix bitumen.

3. Epilogue

3.1 Economic Effect Analysis

(1) The use of cigarette butts as modifiers in asphalt mixture can improve pavement performance to some extent instead of some modifiers and save the cost of pavement construction.

(2) The main chemical composition of the waste tobacco is polypropylene. According to the report, saving 1 ton of polypropylene can save about 1.375 tons of crude oil, saving 1 kilogram of crude oil can reduce carbon dioxide by 3.06 kilograms. Like that, saving 1 kg of polypropylene can reduce carbon dioxide emission. Saving 1 ton of polypropylene can reduce 4.2075 tons of carbon dioxide emission. The annual savings of 7-21 tons of polypropylene can be reduced by 29.5-88.4 million tons of carbon dioxide emission. According to the investigation, each tree can absorb 465 kilograms of carbon dioxide a year on average, which is equivalent to planting more than 630-1,900 thousand trees a year, and the reasonable use of waste tobacco in road engineering is a good reduction way in carbon dioxide emissions [4].

(3) The research shows that the clay bricks made of waste cigarette butts are lighter and have better insulating properties, which means that houses built with this kind of bricks will reduce the cost of heating and cooling. And that only 1% of the cigarette head is added, the clay brick can save up to 58% of the energy during the firing process. In terms of energy demand, the production cost is lower, and the more cigarette butts, the more energy cost savings.

(4) Data show that cellulose acetate is extracted from the cigarette butt and mixed with other ingredients to synthesize a plastic mixture, which can be used to make plastic pallets. This kind of pallet has been put into use in many foreign countries, and has the advantages of recyclable and long service life (6~7 years). The initial material for this tray is low pressure high density polyethylene (PE plastic). Since the tobacco extract can be made into a plastic mixture, the

use of a cigarette making tray can reduce the purchase of PE plastic. According to the quotation quoted by the Hercynian plastics trading center today, May 3, 2018, the average factory price of PE in Sinopec Eastern China is about 10,000 per ton. That is to say, if cigarette butts are used instead of PE plastics, the production cost per ton can be saved by 10,000 RMB.

3.2 Prospect

With the vigorous development of environmental protection in various countries, the world continues to push forward tobacco control. According to the 9th phase "2016 World Tobacco Development Report" of the "China Tobacco" in 2017, the global cigarette sales in 2016 were about 60 million cases, about 3 trillion, down about 2% from a year earlier, continuing a slow decline and the global smoking rate was also generally declining. However, so many cigarettes will produce the same number of cigarette butts after smoking and most of them will be discarded as rubbish. According to the USA NIH survey, the number of cigarette butts discarded to the environment every year is about 6 trillion.

At present, the Terra Cycle Company has launched a project for the recovery project of a cigarette butt in more than 20 countries, with more than 63 million people involved and billions of cigarettes have been recovered. Its company, together with individuals, municipalities, individual organizations and enterprises, sets up public cigarette recycling points to store cigarette butt waste. It can be seen that in the future, more countries and regions will participate in the recovery plan of the cigarette butt, and the recycling model will be more efficient, the market prospects are broad, and the enterprises about the recycling of tobacco will also develop rapidly.

Cigarette butt recovery has a very important environmental significance and economic and social benefits. The development of cigarette butt recovery in China is relatively stagnant, and smokers are very backward in dealing with cigarette butts. China should

actively absorb the advanced experience of the recovery and utilization of cigarette butts from all countries in the world, cooperate with the tobacco department and the environmental protection department to carry out independent research and international exchanges and cooperation, master the related technology of the conversion and reuse of the tobacco, and strengthen the awareness of the recovery of cigarette butts, increase the publicity of the return of the tobacco and through the environmental protection department or nongovernmental organizations such as environmental protection carried out cigarette butt recycling. This will play an important role in promoting the development of China's environmental protection and reusing technology. As a "big smoking country", we can also

make a very important contribution to the world's environmental protection.

References

- [1] World Tobacco Development Report 2016. *Chinese Tobacco* 2017 (9).
- [2] Slaughter, E., Gersberg, R. M., Watanabe, K. Rudolph, J., Stransky, C., and Novtny, T. E. 2011. "Toxicity of cigarette Butts and Their Chemical Components to the Marine and Freshwater Fish." *Atherinops Affinis and Pimephales Promelas* 20 (1): 25-9.
- [3] Micevska, T., Warne, M. S. J., Pablo, F. et al. 2006. "Variation in, and Causes of, Toxicity of Cigarette Butts to a Cladoceran and Microtox." *Archives of Environmental Contamination and Toxicology* 50 (2): 205-12.
- [4] Oner, J., and Sengoz, B. 2015. "Utilization of Recycled Asphalt Concrete with Warm Mix Asphalt and Cost-Benefit Analysis." *Plos One* 10 (1): e116180.