Experimental Study on the Road Performance of Geothermal Regeneration Modified Asphalt Based on Network

Yan Zhou*, Rong Hu
Chongqing Vocational College of Transportation, Chongqing, China, 404100

*E-mail: 1138383616@qq.com

Abstract. With the implementation and continuous progress of road projects in China, the use of modified asphalt has been recognized in the process of building high-grade roads. At present, its application is more and more common. According to the overall statistics of highway performance testing in China, we find that the aging speed of modified asphalt is faster and faster under the influence of vehicle load and natural factors. In many areas, the aging degree of modified asphalt is very large. This situation will seriously threaten the safety of vehicle driving. The application of recycled asphalt technology is more and more common. In this paper, through the study and analysis of the experimental details, the road performance of the modified asphalt with geothermal regeneration is discussed, and the final conclusion is drawn.

Keywords: Network, Regeneration, Asphalt, Road Use Value

1. Introduction

With the rapid progress and renewal of economic construction in our society, the construction of road engineering in our country has entered the process of high-speed operation. With the increase of traffic flow in our country, the construction network of highway is more and more large. However, due to the rapid implementation of road engineering in China, the lag of road maintenance management gradually appears. The aging degree of modified asphalt is more and more serious. According to the theory of highway materials, the average service life of modified asphalt is 15 years[1].

However, due to the influence of natural factors and high load vehicles, the service life of modified asphalt is only ten years. The aging of modified asphalt will destroy the safety of highway. This phenomenon will seriously affect the safety of driving. Therefore, the renovation of the road can not wait. The recycling technology of asphalt mixture plays a very important role in the process of road renovation[2]. This paper will take the geothermal regeneration technology as an example to study the road performance of recycled asphalt through the specific analysis of experiments[3].
2. Study and analysis on the regeneration mechanism of modified asphalt

2.1. Main components of modified asphalt

Modified asphalt refers to the mixture of rubber, plastic and other polymer into the asphalt to be modified according to the appropriate proportion, and the asphalt mixture is produced by mixing it with the ordinary asphalt evenly. In the production process of modified asphalt, modifier is essential. Modifier refers to the natural or synthetic material added in asphalt mixture, which can improve the road performance of asphalt[4].

2.2. Aging of modified asphalt

In the process of transportation and use of asphalt, the base asphalt in asphalt materials will have physical and chemical reactions under the action of natural conditions. It includes evaporation, dehydrogenation and oxidation[5]. After a period of physical and chemical reactions, asphalt will gradually become flat and cracked. This property is called the aging of asphalt.

2.3. Regeneration principle of aged modified asphalt

According to the theory of chemical reaction, we can think that the regeneration technology of asphalt is the reverse reaction of asphalt aging reaction. According to the principle of natural reaction, the aging process of asphalt is the process of conversion of aromatics to asphaltenes. In theory, this reaction is irreversible. However, recycled reagent or asphalt material with appropriate consistency can change the rheological process of asphalt aging. The researchers found that if we can reverse the behavior of the old asphalt material, we can revive the old asphalt[6].

3. Study on the technology of geothermal regeneration of asphalt mixture

According to the working temperature, we can simply divide the asphalt regeneration technology into hot regeneration technology and cold regeneration technology. According to the difference of mixing site, we can divide the asphalt recycling technology into plant mixing recycling technology and in-situ recycling technology. Therefore, according to the theory of industrial asphalt recycling, we can divide the recycling technology into factory hot recycling technology, factory cold recycling technology, on-site cold recycling technology and geothermal recycling technology. In this experiment, we mainly study the technology of geothermal regeneration.

According to the principle of asphalt production, the technology of geothermal regeneration of asphalt refers to adding regenerant or asphalt material with proper viscosity into the old asphalt to make it meet the comprehensive performance of the raw asphalt material. In short, the geothermal regeneration technology is to heat and mix the new and old materials in proper proportion to produce the new recycled asphalt mixture. There are three ways of geothermal regeneration. They are surface regeneration method, compound mixing method and resurfacing method.

4. Comprehensive study on the test of road performance of geothermal regeneration modified asphalt based on network technology

4.1. High temperature stability
People like to think that the high temperature stability of asphalt is the ability of asphalt to resist permanent deformation under load. The researchers believe that rutting test can clearly reflect the high temperature stability of asphalt. The experimental materials used are rutting machine and rutting test piece. The calculation formula of dynamic stability in the experiment is as follows:

$$ DS = \frac{60 - 15}{d_2 - d_1}N \times C_1 \times C_2 $$  \hspace{1cm} (1)

$d_1$ and $d_2$ are the deformation of the test piece at different times.

$N$ is the travel speed of the test wheel.

$C_1$ is the correction factor for the type of testing machine.

$C_2$ is the coefficient of the test piece.

According to the analysis and research of dynamic stability, we can find that the dynamic stability of recycled modified asphalt is significantly higher than that of the original asphalt. Therefore, the high temperature stability of recycled asphalt is very good.

4.2. Water stability

The water quality of asphalt pavement refers to the ability of asphalt to resist water erosion. The researchers believe that the immersion Marshall test can clearly reflect the resistance of asphalt mixture to water erosion. Two groups of Marshall specimens were placed in hot water for half an hour and two days respectively. Comparing the stability of the two, we can evaluate the water stability of the mixture (see Table 1). The calculation formula of residual stability in the experiment is as follows:

$$ MS_0 = \frac{MS_1}{MS} \times 100 $$  \hspace{1cm} (2)

$MS$ is the water stability when the test piece is immersed for 30 minutes.

$MS_1$ is the water stability when the test piece is immersed for 48 hours

| Table 1. Marshall test results of raw asphalt and recycled asphalt |
|---------------------------------------------------------------|
| Type of mixture | Original modified asphalt | Recycled modified asphalt |
| Residual stability | 92.9% | 80.85% |
| Specification value | 80% | 80% |

4.3. Low temperature crack resistance

The cracking of asphalt pavement is a frequent problem in the construction of road engineering in China. The road cracking caused by the temperature reduction will seriously affect the driving of the car. Therefore, it is necessary to study the low temperature crack resistance of asphalt. The researchers think that the bending test of the small beam can well reflect the low temperature crack resistance of asphalt. The main process of this experiment is to reduce the temperature of the trabeculae rapidly and observe
the cracking of the trabeculae (see Table 2). The formula of flexural tensile strength and maximum flexural strain in the experiment is as follows:

\[ R_B = \frac{3LP_B}{2bh^2} \]  
\[ \varepsilon_B = \frac{6kd}{L^2} \]  

\( R_B \) is the bending tensile strength of the test piece.  
\( \varepsilon_B \) is the maximum bending tensile strain of the test piece.  
\( b, h \) and \( d \) are the width, height and midspan deflection of the section of the test piece.  
\( P_B \) is the maximum load when the test piece is damaged.

**Table 2.** Experimental results of flexural tensile strength and maximum flexural strain of specimens

| Project                        | Displacement | Pressure | Strength | Strain |
|--------------------------------|--------------|----------|----------|--------|
| Recycled modified asphalt      | 0.85         | 2.17     | 8.14     | 4080   |
| Specification requirements    | -            | -        | -        | >3000  |

4.4. **Mixture leakage test and Kentucky dispersion test**

Free asphalt will be produced when regeneration reagent, new asphalt and old asphalt cannot be fully mixed. Leakage test can detect the content of asphalt in the mixture. Kentucky scatter test is used to test the adhesion of asphalt. It can measure the damage resistance of asphalt (see Table 3). The specific methods of the two experiments can be found by referring to the relevant literature. This article will not be described in detail.

**Table 3.** Experimental results of leakage and dispersion of original asphalt and recycled modified asphalt

| Project                        | Flying loss | Leakage loss |
|--------------------------------|-------------|--------------|
| Recycled modified asphalt      | 2.03%       | 0.091%       |
| Original modified asphalt      | 5.01%       | 0.05%        |
| Specification value            | <15%        | <0.01%       |

5. **Conclusion**

The use of recycled asphalt can save a lot of land resources in China. It can effectively save the use of asphalt materials. In the past, the use of recycled asphalt was just a fantasy. Now, we use the experimental details to study the road performance of the asphalt regenerated from geothermal energy. We found that the road performance of recycled asphalt is not lower than that of the original asphalt.
References

[1] Ning S, Zhi-Gang Z, Wen-Can Y, et al. Experimental Study on Regeneration Performance of Aging SBS Modified Asphalt[J]. highway, 2017.

[2] Guo-Xian Y U, Xiao-Long Z, Ya-Qing J, et al. EXPERIMENTAL STUDY ON THE REGENERANT OF WASTE ASPHALT[J]. Acta Petrol Sinica(Petroleum Processing Section), 2006.

[3] Qiao, Jiangang, Liu, Xiaomin. Study on the Mechanical Properties of the Surface Layer Thickness and the Viscoelastic Properties of the Geothermal Regeneration[C] International Conference on Advances in Energy & Environmental Science. 2015.

[4] Li H, Liu G, Dong B, et al. Research on the development and regeneration performance of asphalt rejuvenator based on the mixed waste engine oil and waste cooking oil[J]. International Journal of Pavement Research & Technology, 2019, 12(3):336-346.

[5] Liu H, Ma D, Wang X, et al. Study of the Thermal Regeneration Process of Ready Mixed Hot Asphalt Mixture Based on Diffusion Theory[C] Second International Conference on Sustainable Construction Materials: Design. 2012.

[6] Hamed M H, Kabeel A E, Omara Z M, et al. Mathematical and experimental investigation of a solar humidification–dehumidification desalination unit[J]. Desalination, 2015, 358:9-17.