ISSN: 2664-9640

# Research on Warm Mix Technology Based on Asphalt Pavement Disease Problem

Chunping Qiu[1], Junkai Liu[2], Yulai Wang[1], Huili Sun[1]

[1]School of Finance, Anhui University of Finance and Economics, Bengbu, China

[2]School of Business Administration, Anhui University of Finance and Economics, Bengbu, China

## Abstract

**With the continuous development of social economy and the continuous increase of transportation, asphalt is one of the main pavement materials. According to the research on warm mixing technology, it can be found that warm mixing technology can reduce the construction temperature in the application of modified asphalt mixture, which has the effect of energy saving and emission reduction and the effect of cooling on the high temperature performance, low temperature performance and water stability of asphalt mixture and fatigue performance. In short, warm mix technology is an inevitable development trend to achieve the goal of "carbon neutrality", and it is also one of the important methods to meet the development concept of green roads.**

## Keywords

**Asphalt pavement; disease problem; modified asphalt; warm mix technology.**

## 1. Introduction

In recent years, with the rapid development of the economy, the transportation of large and heavy trucks has become more and more frequent. Asphalt pavement is one of the most frequently and widely used materials in modern road construction. However, with the continuous rolling of vehicles, various diseases such as cracks, ruts, looseness, and cracks will appear on the road surface, which will reduce the driving comfort of the vehicle and increase the safety hazards of road traffic. Therefore, only timely discovery and effective treatment Maintenance can minimize road risks and ensure people's travel safety. This article is based on the analysis and research of maintenance technology based on the disease of asphalt pavement

## 2. The importance of asphalt pavement disease maintenance technology

Asphalt pavement is an important part of modern highways, and it is mainly constructed by mixing raw materials such as asphalt binder, aggregate, and filler. However, due to long-term exposure, the pavement surface is easily affected by external factors and pavement diseases occur. Therefore, at this stage, when conducting technical analysis of common highway diseases, the staff takes how to effectively maintain the diseased road surface as one of the key topics of discussion.

In recent years, with the continuous development of social economy and the increasing number of road construction projects, the maintenance technology for common diseases of asphalt pavement has also made great progress. Influenced by factors such as load, it is inevitable that pavement defects, such as cracks, ruts, and cracks, will appear. Once such diseases appear, it will seriously affect the service life of the road surface, and at the same time, it will also reduce the driving speed of the vehicle, causing the vehicle to bump and sag, which virtually increases the driving risk of the vehicle. Therefore, at this stage, technicians need to analyze and study

ISSN: 2664-9640

the maintenance technology of common diseases of asphalt pavement, and adopt practical and effective treatment methods to ensure the stable passage of roads.

# 3. Common diseases of asphalt pavement and their causes

## 3.1. Crack disease of asphalt pavement

Asphalt cracks are mainly divided into longitudinal cracks, transverse cracks and network cracks.

First of all, the transverse cracks are perpendicular to the direction of the vehicle, mainly due to the self-shrinkage or deformation caused by the influence of temperature, plus the upper load force, resulting in the formation of transverse cracks. Secondly, the causes of longitudinal cracks are more complicated, mainly related to the stress conduction of the upper load, and may also be affected by other external factors. It is generally considered that longitudinal cracks smaller than 3 mm are minor diseases, but if the asphalt pavement If the standard is met, the rapid expansion of longitudinal cracks may be accelerated, thereby affecting the driving quality. Reticular cracks are caused by the simultaneous appearance of longitudinal cracks and transverse cracks, also known as cracks. Generally speaking, it is the structural pavement separation caused by long-term lack of maintenance of asphalt pavement or a large number of overloaded vehicles.

The causes of crack disease are diverse. One is that asphalt materials are greatly affected by the ambient temperature. When there is a temperature difference, it is easy to cause asphalt cracks on the road surface. Second, during the use of asphalt roads, the vehicle load carried by the road surface is relatively large, which may exceed the asphalt pavement. The bearing capacity, which may cause the road surface to be overwhelmed due to continuous overloading, resulting in cracks. In addition, settlement cracks may also occur due to the settlement of the asphalt pavement subgrade or the settlement of the fill, which makes the causes of cracks in the asphalt pavement extremely complicated. It is necessary to combine the actual situation to make a reasonable analysis of the causes of cracks. gender analysis and research.

## 3.2. Rutting disease on asphalt pavement

With the rapid development of e-commerce in my country, the logistics and transportation industry in various regions has experienced explosive growth, and the frequency of material exchange between various regions has increased. Therefore, large-scale vehicles and heavy vehicles will cause certain fatigue to the road when driving. Permanent impact, especially the local deformation of the pavement after repeated rolling, if not maintained or repaired in time, it will aggravate the disease expansion of the asphalt pavement. The asphalt pavement itself has a certain degree of elasticity, which can improve the driving quality of the vehicle, but it is also easily deformed due to external stress, and once deformed, it is difficult to recover. The occurrence of rutting is due to the rolling of heavy vehicles or large vehicles. The most serious problem is that once a rut occurs, other subsequent vehicles will still travel along the route where the rut has already occurred, resulting in the gradual expansion of the rut problem. After the occurrence of ruts, it is easy to cause the wear of the vehicle tires, and the vehicle with a different width from the ruts is prone to instability problems during driving.

## 3.3. Loose disease of asphalt pavement

During the driving process of the vehicle, the loose condition of the asphalt pavement seriously affects the life safety of the driver. The existence of this phenomenon may permeate the entire asphalt pavement, but it may also permeate some local positions. Through relevant research, the position with heavy vehicle traces is the part where the asphalt pavement has a more serious loose phenomenon. There are also many reasons for this loose problem. First, in the actual construction of the asphalt pavement, due to the structure of the soil layer The difference

ISSN: 2664-9640

is reflected in the subsidence problems of different degrees in the local roadbed. Secondly, there are some weathered particles in the crushed stone structure in the asphalt pavement. If the asphalt pavement encounters a lot of water, the asphalt will be detached. In addition, the material used in asphalt pavement itself will be affected by external environmental factors, making its adhesion change compared with the past, and the mutual friction between tires and asphalt will cause some fine aggregates to be lost, resulting in pavement loose question.

### 3.4. Asphalt pavement cracking disease

Asphalt pavement cracking can basically be regarded as a common disease problem on asphalt pavement. From the perspective of the characteristics of the disease problem, cracking disease belongs to the problem of pavement cracks with intersecting characteristics. These cracks will divide the pavement into cracks of different sizes. Blocks, generally between 20 and 50 mm in length. Generally speaking, the cause of pavement cracking is mainly related to the degree of road load. When the degree of pavement cracking is relatively slight and the degree of pavement load is low, there will basically be no obvious deformation of the asphalt pavement structure. There will only be some slight parallel fine cracks, and there will be no problem of cross-type cracks. When it reaches moderate or severe conditions, the asphalt pavement will have obvious cross-connection cracks. For severe cracks, the entire asphalt pavement will form clear cracks that are visible to the naked eye, and the resulting scattering problem is very serious.

## 4. Application of warm mixing technology to reduce asphalt pavement diseases

### 4.1. Advantages of warm mixing technology

Warm mix technology was first developed by Shell and Kolo-veidekke in 1995 and is widely used around the world. Because warm mixing technology can reduce the temperature and viscosity of construction, it has environmental benefits, economic benefits and production benefits. During the construction of asphalt mixture, the emission of greenhouse gases is related to temperature. When the construction temperature is lower than 8.0 ℃, there is basically no emission of asphalt fumes and greenhouse gases. At 150 ℃, the emission of greenhouse gases only reaches 1mg h-1. increase in magnitude.

Warm mixing technology can significantly reduce the emission of harmful gases during the mixing process, and has good environmental benefits. The reduction of production temperature of warm mix asphalt mixture leads to the reduction of energy consumption, and the reduction of construction temperature weakens the aging of asphalt during construction, effectively prolonging the service life of asphalt pavement. During the use of high-viscosity asphalt, the use of warm mixing technology can effectively reduce the construction viscosity of asphalt mixture, provide better compaction effect, and improve production efficiency. Table 1 compares the cooling and emission reduction effects of warm mix asphalt and hot mix asphalt in different mixing plants at home and abroad, showing the important position of WMA technology in energy saving and emission reduction.

Table 1: Cooling and emission reduction effects of warm mix asphalt relative to hot mix asphalt in the mixing plant

| warm mix agent | asphalt type | Grading | HMA（WMA） | Emission reduction effect /% | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Stirring temperature /℃ | $CO_2$ | $SO_2$ | NOX | 粉尘 | CO | VOC |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Paraffin viscosity reducer | 70# | AC-13 | 165（135） | 25.5 | | | 29.8 | | 24.9 |
| Sasobit | SBS modified asphalt | SMA-13 | 170（130） | 78 | 97.7 | 94.3 | 62.2 | | |
| Sasobit | SBS modified asphalt | SMA-13 | 175（161） | 39.4 | 73.5 | 74.1 | 4.92 | 69.2 | |
| Evotherm | | | 150（120） | 60 | 75.2 | 72.6 | 47.9 | | >80.0 |
| Evotherm | South Korea SK70# | AC-13 | 160（140） | | 63.1 | 53 | 53.1 | 35.4 | 56.2 |
| Evotherm | SBS modified asphalt | | 179（158） | 42.8 | 40.1 | 33.7 | 1.38 | 23.7 | 72.8 |
| Water-based foam | | | 160（130） | 8.2 | 15.2 | | 8.7 | | |
| | | | | 3040 | 30～40 | 60～70 | 20～25 | 10～30 | 50 |

## 4.2. Effect of warm mixing technology on high and low temperature performance of modified asphalt mixture

The warm mixing technology can adopt the way of external admixture and the way of adding water to foam. Different warm mixing methods have different effects on the high and low temperature performance of asphalt mixture. A dynamic shear rheometer (Dynamic Shear Rheometer, DSR) and bending beam rheometer (Bending Beam Rheometer, BBR) to evaluate the high and low temperature performance of warm mix asphalt. Studies have shown that Sasobit can enhance the anti-rutting performance of SBS modified asphalt. At 76 °C, the rutting factor of 4% SBS modified asphalt is 3.77 times higher than that of the original asphalt. At the same time, adding 4% Sasobit and 4% The rutting factor of SBS modified asphalt is 5.56 times higher than that of the original asphalt; and in the creep compliance analysis, it is found that when the temperature is reduced from -12 °C to -24 °C, the Sasobit warm mix rubber asphalt and rubber modified asphalt The compliance ratios increased from 1.41 and 1.26 to 2.38 and 2.12, respectively, indicating that the two kinds of asphalts have good performance advantages below the temperature in the winter temperature region. It can be seen that the organic viscosity reducer Sasobit can improve the high-temperature performance of SBS-modified asphalt, which can further improve the low-temperature performance of rubber-based modified asphalt.

Table 2 Cooling effect of warm mix asphalt technology

| type | warm mix agent | Dosage /% | Stirring temperature of hot mix (warm mix) /℃ | Hot mix (warm mix) compaction temperature /℃ | Changes in road performance compared to HMA |
|---|---|---|---|---|---|
| Organic viscosity reducer | Sasobit | 3 | 170.0（130.0） | 160.0（120.0） | Improved high temperature rutting resistance, water stability and fatigue performance, low temperature crack resistance decreased |
| | EC-120 | 3 | 171.3（143.1） | 161.3（130.3） | Improved high and low temperature performance with little change in water stability |
| | Deurex | 2.00、3.00、4.00 | 170.0（drop 20.0～30.0） | | With the increase of the amount of warm mix agent, the rutting factor first increases and then decreases, and the high temperature performance is the best at |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 3%; the low temperature performance decreases with the increase of the amount of the mixture |
| | polyethylene wax | 0.50～2.00 | 180.0（drop 25.0～27.0） | | Improve high temperature anti-rutting performance, the best dosage is 1% |
| | Cetyltrimethylammonium Chloride | 0.50～2.00 | 180.0（drop 29.0～32.0） | | Improve high temperature anti-rutting performance, the best dosage is 1% |
| | Kaowax | 2 | 157.0（drop 134.0） | 142.0（118.0） | Has good fracture resistance |
| | WMa-1、WMa-2 | 2.00～10.00 | | | WMa-1 can improve the high-temperature performance of asphalt, but it is unfavorable to the low-temperature performance of asphalt; WMa-2 is the opposite |
| | SAR | 1.00～5.00 | | | Reduce temperature sensitivity of asphalt |
| Surfactant | Evotherm DAT | | 160.0（30.0～40.0） | 143.0（115.0） | High and low temperature performance and water stability meet the requirements of HMA, and the fatigue life is significantly improved |
| | Evotherm 3G | 0.5 | 163.0（138.0） | 152.0（127.0） | Little change in high temperature rutting resistance and low temperature crack resistance, improved water stability |
| | Rediset | 0.5 | 163.0（138.0） | 152.0（127.0） | The tensile strength and complex modulus are slightly lower than the control group, and the anti-rutting performance and fracture resistance are similar to the control group |
| | Sylvaroad | 2 | | | Decreased water stability and greatly improved fatigue performance |
| | Cecabase RT | 0.20～0.40 | | | Improved low temperature performance |
| | ET-3100 | 0.20～0.80 | 170.0（140.0） | | Slowing down the aging degree of asphalt will reduce the fracture resistance of asphalt |
| | WG-Ⅰ | 1.00～5.00 | 170.0（145.0） | | Improve the high temperature anti-aging ability, and the improvement of the strain capacity is conducive to improving the ability of asphalt mixture to adapt to deformation and self-healing |
| | S-Ⅰ | 5.3 | | 150.0（降 10.0～42.0） | Reduced high temperature stability with less change in low temperature performance and water stability |
| Asphalt foam type | Aspha-Min | 0.3 | 169.2（153.1） | 156.8（139.2） | Reduced high temperature performance and water stability, improved low temperature performance |
| | Advera | 4.00～7.00 | 162.0（157.5） | 148.0（145.0） | Improved high temperature performance, reduced low temperature performance |
| | low energy asphalt | 0.50～2.00 | 170.0（100.0） | 155.0（85.0） | No additives are used, which is more environmentally friendly, and the overall performance of asphalt is relatively poor |

The effect of foaming water content on the high temperature performance of warm mixing is more obvious. According to the research, when CR modified asphalt is foamed with different contents of foaming water (0, 1%, 2%, 3% and 4%), at 40 °C, the asphalt mixture with different foaming water contents The rutting factors were 375.3, 100.7, 70.63, 71.83, and 58.87 kPa, respectively, while the rutting factors were 7.8, 3.2, 2.9, 2.5, and 2.4kPa at 80°C. When the foaming water was 4%, the failure temperature decreased by 10.6%. It can be seen that the anti-rutting performance and failure temperature of modified asphalt after foaming decrease with the increase of foaming water content and test temperature.

It can be seen that the high and low temperature performance of modified asphalt obtained by warm mixing technology and modified asphalt mixture is quite different, which is mainly affected by the type of modified asphalt, the type and content of warm mix agent. Organic viscosity reducer and foaming technology have great advantages in improving high-temperature performance, which can effectively reduce the damage of cracks and cracks on asphalt pavement caused by the influence of temperature, and improve the wear resistance and service life of the pavement.

## 4.3. Effect of warm mixing technology on water stability of modified asphalt mixture

The hygroscopicity of warm mixing technology is one of the bottlenecks that limit the wide application of this technology. The water stability of warm mixing technology is affected by factors such as the type of warm mixing agent, foaming process and aggregate properties. The addition of organic viscosity reducers and surfactants to modified asphalt leads to changes in the number and shape of honeycomb structures, thereby changing the cohesion and adhesion of warm mix. Previous studies have analyzed the adhesion performance of Sasobit and Evotherm to SBS-modified asphalt under dry and wet conditions. The area surrounded by the dispersed phase contains a slender and alternately black and white bee-like structure and a continuous phase structure with strong adhesion. After the bee-like structure is immersed in water, small protrusions will appear in the recesses, resulting in the disappearance of the bee-like structure. With the appearance of water-induced uplift, the increase of the dispersed phase leads to the increase of surface roughness, and the decrease of the continuous phase leads to the decrease of the adhesion performance. Some studies have also mixed Sasobit and Evotherm into rubber-modified asphalt. Through AFM, the annual cohesion and adhesion of asphalt before and after immersion were tested by using -OH, -COOH probes and silicon nitride probes. After immersion, the temperature of Sasobit The cohesion of mixed asphalt is 53% lower than that of the original asphalt, and Evoherm has the most significant effect on improving the adhesion of water-soaked rubber asphalt, with an increase of 89%.

Asphalt mixture is a multiphase system composed of asphalt phase, aggregate phase, asphalt binder and aggregate interface phase. The influence of warm mixing technology on the water stability of modified asphalt mixture mainly focuses on the single modification of asphalt binder, while the research on the modification of aggregate phase is relatively less. In order to improve the adhesion performance of warm mix asphalt-aggregate system, it is necessary to develop the compound modification of asphalt and aggregate to overcome the limitation of single modification. Once this limitation is overcome, the adhesion performance of the asphalt pavement can be greatly improved, the ability of the asphalt pavement to resist external disturbances can be improved, and the occurrence of loose diseases can be minimized.

## 4.4. Effect of warm mixing technology on fatigue performance of modified asphalt mixture

Selecting a suitable warm mix agent among organic viscosity reducer, chemical additive and foaming technology can effectively improve the fatigue resistance of asphalt mixture. For modified asphalt binder, the foamed asphalt has good fatigue resistance. In the Strategic Highway Research Program (SHRP), the United States proposed to use the ultimate fatigue temperature corresponding to the fatigue factor of 5.0 MPa to evaluate the fatigue performance of asphalt. The lower the temperature, the better the fatigue performance. Studies have found that when the foaming water content is 1%, 2% and 3%, the ultimate fatigue temperature is 17.13 ℃, 15.46 ℃ and 15.59 ℃, respectively. It shows that when the foaming water content of SBS modified asphalt is 2%~3%, its anti-fatigue performance is obviously improved; there are also studies comparing the ultimate fatigue temperature of foamed asphalt, EC120 warm mix asphalt and Sasobit+polyethylene wax warm mix asphalt, It is found that the fatigue temperatures of the three are 19.7 ℃, 22.7 ℃ and 24.3 ℃, respectively, indicating that foamed asphalt has good fatigue properties.

Asphalt foaming can improve the fatigue performance of asphalt, and controlling the appropriate foaming water content can effectively improve the production of foamed warm mix and ensure that the fatigue performance of warm mix modified asphalt mixture meets the requirements. Evotherm is a typical representative of surfactants to improve the fatigue life of asphalt mixture, and can effectively improve the fatigue resistance of asphalt pavement. After comparing the fatigue performance of AC-13 densely graded SBS modified asphalt mixture with Evotherm warm mix technology and grade HMA mixture, the results show that the fatigue performance of warm mix mixture is significantly better than that of HMA mixture; by comparing Evotherm warm mix and Fatigue performance of ordinary hot mix AC-13 asphalt mixture, when the strain levels are 1.5×10-4, 3.0×10-4 and 4.5×10-4, the fatigue life of asphalt mixture increases by 5.01%, 4.70 % and 1.04%. The fatigue life of Evotherm warm mix asphalt mixture is improved compared with hot mix asphalt mixture, and the increase rate gradually decreases with the increase of strain level. The fatigue performance of asphalt mixture can be further improved by compound modification of organic viscosity reducer and modifier.

Through various studies and comparisons, it has been shown that choosing a suitable warm mix agent in foaming technology can effectively improve the fatigue resistance of asphalt, and applying this to asphalt pavement can greatly alleviate cracks caused by external factors such as temperature. A series of diseases can prolong the service life of asphalt pavement, and the safety of vehicles will be more guaranteed.

## 5. Conclusion

To sum up, the application of warm mix technology to modified asphalt mixture and recycled asphalt mixture is reviewed through the mechanism of warm mix agent. Combining with various diseases and problems of current asphalt pavement, the two can be organically combined. In this way, the construction temperature of asphalt roads can be reduced through warm mixing technology, energy consumption and gas emissions can be reduced, while improving the quality of asphalt pavement roads, the concept of green environmental protection can be taken into account, and the advantages of environmental benefits, economic benefits and production benefits can be fully utilized. Under the background of adhering to the concept of green development and accelerating the promotion of "carbon peak" and "carbon neutrality", warm mix technology can become one of the mainstream directions for the development of green and environmentally friendly asphalt pavements in the future, providing a basis for sustainable development. Certain technical support.

## References

[1] Liu Linfang. Research on Disease Problems and Maintenance Construction Technology of Asphalt Pavement of Expressway [J]. Traffic World, 2023(Z1):167-169+178.

[2] Shu Jing. Thoughts on Construction Technology and Quality Control of Asphalt Pavement in Highway Engineering [J]. Juye, 2022(12): 7-9.

[3] Liu Xinglong, Wu Shidong. Research on Highway Asphalt Pavement Diseases and Detection Technology [J]. Science and Technology Innovation and Application, 2022,12(30):169-172.

[4] Zhang Jun. Cause analysis and treatment measures for common diseases of asphalt pavement [J]. Heilongjiang Transportation Science and Technology, 2022, 45(10): 46-48.

[5] Ma Chao. Research on Construction Technology of Asphalt Pavement Surface in Road Engineering [J]. Stone Materials, 2022(10): 79-81. DOI: 10.14030/j.cnki.scaa.2022.0124.

[6] Zhuang Liangting. Construction Technology and Quality Control of Asphalt Pavement in Road Engineering [J]. Bulk Cement, 2022(06):140-142.

ISSN: 2664-9640

[7] Liang Bo, Zhang Haitao, Liang Yuan, Wang Xiaofeng, Zheng Jianlong. Research progress on the application of warm mixing technology in asphalt [J/OL]. Journal of Transportation Engineering:124[20230323].