ISSN: 2414-1895 DOI: 10.6919/ICJE.202411_10(11).0010

Research Progress on the Application of Reclaimed Mixed Asphalt

Wei Liu, Xiaohong Kang, and Yang Shao

China Energy (Xin Jiang) Engineering Quality Inspection Co., Ltd, Urumqi 830023, China

Abstract

Reclaimed asphalt is a material composed of various organic substances and binders, commonly used for paving roads or reprocessing. This paper provides an overview of the research progress on the application of reclaimed asphalt mixtures, introduces the application of reclaimed asphalt and its mixtures in the pavement base course, and discusses the modification mechanisms. By summarizing and reviewing research findings, the paper outlines the applications of reclaimed asphalt and its mixtures, analyzes existing issues, and forecasts future research directions for the engineering application of reclaimed asphalt.

Keywords

Reclaimed Asphalt Mixture; Pavement Base Course; Modification Mechanism.

1. Introduction

With the acceleration of urbanization and the continuous expansion and renewal of transportation infrastructure, asphalt, as a core material for road construction, is consumed in vast quantities. However, the resulting reclaimed asphalt mixtures are increasingly becoming both an environmental and resource utilization challenge. In traditional road resurfacing projects, old asphalt is often excavated and then either carelessly piled up or buried, occupying large amounts of land and potentially polluting the environment due to the presence of heavy metals and volatile organic compounds in asphalt[1]. In terms of resource recycling, the reutilization rate of reclaimed asphalt remains far below its potential, leading to excessive extraction of fresh asphalt and aggregates. If a significant amount of reclaimed road materials could be recycled, it would not only reduce substantial investments but also benefit environmental protection, contributing to pollution reduction, land conservation, and the construction of more roads with less investment[2]. The functional properties of reclaimed asphalt mixtures are only partially degraded; apart from the partial aging of the asphalt, the coarse and fine aggregates such as sand and stones have not failed in terms of performance. To address these issues, the recycling and reuse of reclaimed asphalt mixtures are becoming increasingly urgent. Reclaimed asphalt pavement recycling technology can save large amounts of raw materials like asphalt, sand, and gravel, while also helping to protect the environment and dispose of waste materials. As an environmentally friendly technology, asphalt pavement recycling can fully utilize the “residual value” of reclaimed road materials, achieving the recycling of these materials, conserving resources, and protecting the ecological environment[3].

In recent years, the application of reclaimed asphalt in road engineering and the research on modifying reclaimed asphalt have gradually increased, becoming a new focus in the recycling of waste materials[4-7]. From the perspective of actual demand in the reclaimed asphalt road engineering field, this paper discusses the application, recycling, and modification mechanisms of reclaimed asphalt.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202411_10(11).0010

2. Utilization of Reclaimed Asphalt

2.1 Asphalt Recycling

Over 80% of China's highways use asphalt pavements, and currently, highway maintenance accounts for 99% of the total road network. Annually, more than 10 million tons of reclaimed asphalt mixtures are generated, making the efficient recycling and reuse of this material a critical challenge for the sustainable green development of China's roadways. Asphalt material recycling technology is a hot research area, with the goal of maximizing the efficiency of resource recycling through regenerated materials. Zhou Zihao et al. found that by analyzing old materials and controlling the milling process, the impact of excessive variation in the reclaimed material could be reduced, ensuring a uniform and stable asphalt mixture. Combined with related simulation tests, they analyzed the effects of different rejuvenators on aged asphalt and mixtures, exploring regeneration patterns through physical performance indicators and selecting appropriate types and dosages of rejuvenators. Yu Senkai et al. studied the use of crushed waste epoxy-based GFRP (glass fiber-reinforced plastic) and polyurethane-based GFRP powders (diameter < 0.075 mm) as asphalt reinforcing materials. They compared the effects of silane coupling agents on the reinforcement, finding that while GFRP powders alone did not significantly enhance the asphalt, surface treatment with silane coupling agents greatly improved the interaction between the GFRP powders and asphalt. This treatment enhanced the rheological properties and surface free energy of the asphalt and lowered the glass transition temperature, with the epoxy-based GFRP showing better improvement than the polyurethane-based GFRP.

Lou Na et al. proposed a maintenance plan for laying foam asphalt cold-recycled base layers, focusing on raw materials, mix design, and key construction techniques to promote the sustainable development of highway projects. Huang Yu et al. conducted aging tests on asphalt concrete and used polymer solution theory to explain the basic principles of rejuvenating aged asphalt, providing a theoretical basis for the recycling of aged asphalt pavements. Based on gradation tests and other indicators of old pavement asphalt mixtures, they used the Marshall test method to determine indicators such as the optimal oil-to-stone ratio, the amount of rejuvenator, and the proportion of new asphalt added. The test results showed that hot-recycled mixtures exhibited excellent performance and could be widely applied to the renovation of aged and damaged asphalt pavements, significantly reducing the cost of such projects.

In summary, although the initial investment in low-energy cold recycling technology is higher, it saves more energy in the long term and significantly reduces emissions. On the other hand, hot recycling technology, while having a lower initial cost, results in higher carbon dioxide emissions over its lifecycle compared to cold recycling. Therefore, future research should focus on the suitability of cold and hot recycling technologies in different regions and climate conditions, with a focus on adapting technologies to specific areas.

2.2 Application of Reclaimed Asphalt in Pavement Base Layers

Reclaimed asphalt mixtures contain high levels of dust and appear grayish-white, primarily composed of asphalt and aggregates. Due to uneven crushing, some of the particles appear as clumps, with portions of the aggregate covered in asphalt. The reclaimed material often contains dust from old pavements, as the road surface becomes contaminated with dirt and debris, and repeated vehicular loads cause the materials to break down, introducing more dust into the milled materials. The main applications of reclaimed asphalt mixtures in road construction include:

Filling and paving coarse aggregate in pavement structures, such as for drainage holes, rainwater wells, and pothole repairs; surface dressing: in base layer construction, reclaimed asphalt mixtures can be used for surface dressing to enhance the waterproofing and load-bearing capacity of the road; localized repairs: Reclaimed asphalt can be used for localized repairs of damaged pavement, such as filling cracks and potholes.

Mou Tao et al. studied the feasibility of using rubberized asphalt in road maintenance projects. They used AR-AC-13 gap-graded dense aggregate to determine the optimal asphalt content. Through

ISSN: 2414-1895 DOI: 10.6919/ICJE.202411_10(11).0010

laboratory testing, they confirmed the road performance of reclaimed rubberized asphalt mixtures and applied it in actual road maintenance. Results showed that the reclaimed rubberized asphalt mixture achieved a dynamic stability greater than 3,000 cycles, and both residual stability and residual strength ratios met the requirements for rubberized asphalt mixtures on highways. The mixture was effective for road maintenance. In summary, the processing and handling of reclaimed asphalt mixtures require rigorous procedures to ensure their quality and performance meet the relevant standards and specifications. Moreover, measures must be taken during utilization to prevent environmental pollution and protect human health.

2.3 Modification of Reclaimed Asphalt Mixtures

Reclaimed asphalt mixtures suffer from issues such as aging, reduced adhesion, and decreased strength. Therefore, modifying reclaimed asphalt mixtures is essential. Common methods of modification include physical, chemical, and biological modifications. Fang Cong et al. developed an asphalt rejuvenator using furfural oil, SBS modifier, stabilizer, and kerosene to effectively restore the performance of aged asphalt and asphalt mixtures. They designed a four-factor, four-level orthogonal test and analyzed the orthogonal test results to determine the impact of each material on the rejuvenation effect. Then, they conducted a gray correlation analysis to determine the optimal composition ratio. Finally, they verified the high- and low-temperature and water stability of the rejuvenated asphalt and mixtures. Results showed that furfural oil had the most significant rejuvenation effect, followed by SBS, with kerosene having the least impact. The optimal rejuvenator composition was 2% furfural oil, 5% SBS modifier, 0.6% stabilizer, and 1% kerosene. The rejuvenator improved the ductility and penetration of aged asphalt by over eight and two times, respectively, and the performance of the rejuvenated asphalt mixture in terms of dynamic stability, maximum flexural strain, freeze-thaw splitting strength ratio, residual stability ratio, and overall stability met the standards for grade I-C SBS-modified asphalt, showcasing the advantages of waste material utilization. Cheng Peifeng et al. investigated the effect of reclaimed asphalt pavement (RAP) content on the mixing and compaction temperature of SBS-modified hot recycled asphalt mixtures. Through laboratory testing, they established relationships between RAP content, recycled gradation, mixing and compaction temperature, and volumetric properties of the recycled mixtures. With a target air voids rate of 4%, they determined the optimal mixing and compaction temperature for AC-16 recycled SBS-modified asphalt mixtures. Results indicated that the bulk density of the recycled mixtures did not have a linear relationship with the mixing and compaction temperature, showing a peak with temperature variations. Superpave gradation was unsuitable for the standard compaction method. At the same mixing and compaction temperature, the air voids in the mixture increased with higher RAP content. When RAP content was between 20% and 40%, the optimal mixing and compaction temperature increased by about 5°C for every 10% increase in RAP content. At 40% RAP content, the road performance of the recycled SBS-modified asphalt mixture met the regulatory requirements.

Lu Zaihong et al. investigated the feasibility of using waste polyolefin materials as modifiers for asphalt mixtures. Their research, conducted on the Dandong to Xilinhot national expressway (Daban to Jingpeng section), focused on mixing waste polyolefin materials with three different types of base asphalt. The study found that waste polyolefin materials significantly improved the temperature sensitivity and high-temperature performance of the base asphalt. By testing pavement rutting and water permeability in the test sections, the researchers comprehensively evaluated the improvement in high-temperature performance and water stability of the asphalt mixtures modified with waste polyolefins. This research provides a reference for the large-scale application of polyolefin-modified asphalt mixtures under typical climate conditions in Inner Mongolia.

2.4 Mechanism of Reclaimed Asphalt Recycling

The recycling mechanism of reclaimed asphalt primarily includes the aging and rejuvenation processes. Aging refers to the changes in the physical and chemical properties of asphalt due to heat, light, and chemical erosion, leading to hardening, brittleness, and a decrease in viscosity.

Rejuvenating agents can improve the wetting, penetration, diffusion, and dissolution properties of asphalt, promoting the rejuvenation process. Additionally, the performance of reclaimed asphalt mixtures can be enhanced by adding fresh asphalt materials and modifiers. In summary, the recycling of reclaimed asphalt requires a comprehensive consideration of the degree of aging, the recycling method, and the selection of rejuvenating agents. With appropriate processes and technologies, the recovery, processing, and reuse of reclaimed asphalt mixtures can be achieved while ensuring safety, environmental protection, and quality.

3. Conclusion

With the acceleration of global urbanization and the continuous development of transportation infrastructure, the amount of reclaimed asphalt mixtures is increasing, and their proper disposal and resource utilization have become pressing issues. Various recycling technologies such as hot recycling, cold recycling, plant-mixed hot recycling, and in-situ hot recycling have matured, each with its advantages for different scenarios and needs. Despite significant progress in the recycling of reclaimed asphalt, there are still technical challenges and bottlenecks. The performance of recycled asphalt mixtures is still inferior to that of new asphalt materials, particularly in terms of high-temperature stability and fatigue resistance. Moreover, the type, dosage, and production process of rejuvenating agents have a significant impact on the recycling effect, which needs further optimization and improvement.

Future research on reclaimed asphalt should focus on the following areas: First, deepening the understanding of asphalt aging mechanisms and developing more efficient and environmentally friendly rejuvenating agents. Second, optimizing the design of the mix ratios of recycled asphalt mixtures to improve their road performance. Third, exploring the application of intelligent and automated technologies in the production of recycled asphalt mixtures to increase production efficiency and product quality. Fourth, strengthening the research and evaluation of the long-term performance of recycled asphalt mixtures.

Acknowledgments

School-Enterprise Joint Program (2024HX139).

References

[1] Guthrie W, Cooley D, Eggett D. Effects of Reclaimed Asphalt Pavement on Mechanical Properties of Base Materials, Transportation Research Record Journal of the Transportation Research Board, vol. 2005 (2007), 44-52.

[2] X Y Yang , W C Zhang , Z X Zhao. Study on properties and mechanism of asphalt modified with nano-calcium carbonate/waste polyethylene composite, China Plastics, vol. 37(2023), 85-92.

[3] Information: https://www.sohu.com/a/165326095_99915349.

[4] Magar S, Xiao F, Singh D, et al. Applications of reclaimed asphalt pavement in India–A review[J]. Journal of cleaner production, vol. 335(2022): 130221.

[5] Stroup-Gardiner M, Wagner C. Use of reclaimed asphalt pavement in Superpave hot-mix asphalt applications[J]. Transportation Research Record, vol. 1999, 1681(1999): 1-9.

[6] Mariyappan R, Palammal J S, Balu S. Sustainable use of reclaimed asphalt pavement (RAP) in pavement applications-a review[J]. Environmental Science and Pollution Research, vol. 2023, 30(2023): 45587-45606.

[7] Yu B, Gu X, Wu M, et al. Application of a high percentage of reclaimed asphalt pavement in an asphalt mixture: blending process and performance investigation[J]. Road Materials and Pavement Design, vol. (2017): 753-765.