LOUISIANA TRANSPORTATION RESEARCH CENTER

Technical Summary

LTRC Report 711

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Assessment of Long-Term Performance of Louisiana Asphalt Pavements

Introduction

The construction of road infrastructure is a capital-intensive endeavor, requiring long-term performance to justify substantial initial investments. Federal regulations (23 CFR 626.3) mandate that pavement designs meet current and future traffic demands in a safe, durable, and cost-effective manner. However, State Highway Agencies (SHAs) frequently face challenges in building pavements that resist common distresses like cracking and rutting under varying traffic and environmental conditions.

To address these durability issues, SHAs have adopted various techniques, including the use of warm-mix asphalt (WMA) for improved compaction, optimizing air void and asphalt contents, and implementing balanced mix designs (BMD) to achieve expected lifespans. The Louisiana Transportation Research Center (LTRC), for instance, has extensively researched factors influencing flexible pavement performance. The work of LTRC researchers has focused on improving durability through modifications in asphalt mixture design and enhanced construction techniques. These researchers have demonstrated improved resistance to cracking and rutting using methods such as WMA additives, preventing temperature segregation during placement, and increasing asphalt content beyond optimum levels. Beyond these approaches, other researchers have refined mixture design methods by incorporating different component materials and altering design criteria. Studies show that polymer additives, anti-strip additives, and fibers significantly enhance overall asphalt mixture performance. Additionally, there is a growing emphasis on integrating sustainable materials like WMA additives, crumb rubber (CR) particles, and reclaimed asphalt pavement (RAP) to conserve resources and protect the environment.

SHAs are continuously exploring techniques to improve asphalt mixture durability, moving from traditional method-based specifications to performance-based approaches. Balanced mixture design (BMD) is a prominent example of this shift, gaining popularity among SHAs. BMD identifies typical pavement distresses and employs suitable mechanical or performance tests to address them, proving successful in several U.S. states. Emerging construction techniques are also crucial for pavement durability. Contractors and road agencies leverage innovative technologies to enhance in-place density and overall pavement performance. A recent Federal Highway Administration (FHWA) study confirmed that increased flexible pavement density improves rutting and fatigue resistance. This study utilized WMA additives, intelligent compaction, paver-mounted thermal profiling (PMTP), and material transfer vehicles (MTV) to achieve higher in-place densities. Another critical factor for flexible pavement performance is interlayer shear strength (ISS). Researchers have investigated various tack coat types, application rates, and techniques to enhance ISS, leading to the development of the AASHTO TP 114 test. A one-year field study by LTRC recommended a minimum ISS of 40 psi for satisfactory pavement performance.

By integrating advanced mix design and construction techniques, SHAs can construct more durable pavements. Long-term studies remain essential to validate these benefits and guide road agencies in selecting the most effective methods for constructing durable road infrastructure.

Objective

Two primary objectives were considered in the study, which included evaluating the impacts of:
1. Enhanced mix design methods on performance; and
2. Enhanced construction techniques on performance.

Specific aims for the first objective included:
- Evaluating the effects of WMA additives and technologies on the long-term performance of asphalt pavements;
- Evaluating the effects of crumb rubber (CR) additives on long-term performance of asphalt pavements; and
- Validating the Louisiana DOTD-specified BMD criteria for Hamburg Wheel-Tracking (HWT) rut depth and Semi-Circular Bend (SCB) J_c values.

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Specific aims for the second objective included:

- Evaluating the effect of increased in-place density techniques on the long-term performance of asphalt pavements; and
- Validating the minimum ISS criteria recommended in NCHRP Project 9-40A using field performance data.

Scope

Field projects constructed across Louisiana since 1994 were used to assess the effects of enhanced asphalt mixture design methods and improved construction techniques on performance. This study considered five previous LTRC studies, two NCHRP studies, and one FHWA demonstration project to identify and select field projects for long-term performance evaluation.

Methodology

To evaluate the performance of flexible pavements built with improved asphalt mixture design methods and construction techniques in Louisiana, specific field projects were identified based on research studies conducted at the Louisiana Transportation Research Center (LTRC). These studies explored the effectiveness of enhanced asphalt mixture design methods and construction techniques in improving field performance. Critical to this research was the identification of 21 rehabilitation field projects, whose detailed information—including project number, control section, location (parish and district), section length (start and end log mile), traffic direction, and pavement structure—was obtained from the Louisiana Pavement Management System (PMS) database. All selected pavement sections within each project exhibited similar structures and were exposed to identical traffic and environmental conditions throughout the analysis period.

Field performance indicators such as rutting, roughness, and cracking were collected from the Louisiana PMS for analysis. This data was analyzed to determine the impact of construction technology or techniques, asphalt mixture materials, and mixture design criteria on rutting, alligator/fatigue cracking, transverse cracking, and ride quality. Additionally, Pavement Condition Index (PCI) data was gathered and analyzed to assess the influence of these factors on overall pavement performance. Initial laboratory performance indicator data, measured during construction, were analyzed to validate their predictive capability in ranking field performance. Furthermore, falling weight deflectometer tests were conducted, and field cores were collected from selected projects to ascertain the effects of improved construction techniques on structural capacity. An economic analysis was also performed to determine the cost-effectiveness of enhanced mix design methods, specifically the inclusion of crumb rubber (CR) particles in asphalt mixtures for sustainable pavement construction.

Conclusions

Flexible pavements incorporating crumb rubber-modified (CRM) mixtures generally demonstrated comparable or better resistance to rutting and cracking compared to conventional mixtures. This enhanced performance is attributed to the ability of CR to enhance binder viscosity, improving rutting resistance, while its natural rubber component enhances crack resistance. However, the higher initial cost of CRM often leads to less cost-effective projects, and limited laboratory tests have proven ineffective in predicting the field performance of CRM sections. Additionally, the study evaluated the long-term performance of warm-mix asphalt (WMA). WMA pavement sections typically exhibited similar or improved cracking resistance compared to their conventional hot mix asphalt (HMA) counterparts. While WMA test sections showed inconsistent results for transverse cracking, with some displaying better resistance due to unrelated factors, all WMA sections successfully met the Louisiana Department of Transportation and Development (DOTD) rutting depth criteria after five to eight years of service. Furthermore, the Hamburg Wheel-Tracking (HWT) rut depth and Semi-Circular Bend (SCB) strain energy release rate (J_c) values, integral to Louisiana's Balanced Mixture Design (BMD) framework, were validated in this study. The established HWT rut depth thresholds of 10 mm for Level 1 and 6 mm for Level 2 asphalt mixtures effectively assessed field rutting performance for pavement sections with eight to 18 years of service. Similarly, the minimum SCB J_c thresholds of 0.5 kJ/m^2 for Level 1 and 0.6 kJ/m^2 for Level 2 asphalt mixtures proved effective in evaluating field random and alligator cracking performance.

Regarding improved construction techniques, methods like Evotherm WMA and increased asphalt binder content (Plus AC) were effective in enhancing rutting and cracking resistance, particularly transverse cracking, compared to control sections. The temperature-segregation minimization technique also significantly improved rutting and cracking resistance, as well as ride quality. Notably, all techniques that increased in-place density—including Evotherm WMA, Plus AC, and temperature-segregation minimization—contributed to a higher overall Pavement Condition Index (PCI) rating for the evaluated sections. Finally, a minimum interface shear strength (ISS) value of 40 psi, evaluated per AASHTO T 407, proved effective in creating monolithic pavements with strong layer bonding. Sections built with this minimum ISS showed no significant cracking, rutting, or rouhgness after seven to eight years of service.

Recommendations

Field tests demonstrated that pavement sections incorporating various dosages of crumb rubber (CR) particles performed comparably to or better than conventional sections. However, previous LTRC research indicates that exceeding a 10% CR dosage by weight of asphalt binder can lead to instability and phase separation. Therefore, it is recommended that Louisiana DOTD continue to adhere to a maximum 10% CR dosage for CR-modified mixes. Furthermore, a Life Cycle Cost Analysis (LCCA) should be conducted on CR-modified pavement sections, utilizing current CR blending techniques, to assess their cost-effectiveness and environmental impact against conventional mixtures.

Currently, Louisiana DOTD prioritizes density and smoothness during mixture production and quality assurance. It is recommended to integrate performance tests, such as the Hamburg Wheel-Tracking (HWT) test for rutting and the Semi-Circular Bend (SCB) test for cracking, into the production phase alongside existing checks. These tests, typically used in the design phase, offer valuable quality control during production.

Based on increased density studies, it is recommended that Louisiana DOTD incentivize contractors to employ techniques like warm-mix asphalt (WMA), increased asphalt content, and temperature minimization to enhance field density and pavement performance. Additionally, Louisiana DOTD should adopt a 40 psi Interlayer Shear Strength (ISS) criterion for tack coat application in asphalt construction projects to improve ISS and mitigate distresses such as slippage, cracking, potholes, and shoving associated with lower ISS values.