ROAD TO PERFORMANCE

Advancements in asphalt materials and design methodologies

By R. Buzz Powell, Contributing Author

FOR DECADES, the asphalt pavement community has pursued the common goal of better performance; however, performance has not always been easy to define, measure or predict.

Mix designs and design methodologies have evolved alongside changes in traffic loading, materials, construction practices and public expectations. What has remained constant is the need for practical tools that can be implemented during construction and provide timely feedback on whether the asphalt mixture being produced will deliver the intended performance.

The road to performance has been long, and it has not been straight. It has included meaningful advances and ambitious

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concepts that proved impractical. Recently, it has led to the emergence of balanced mix design (BMD) as a framework that links materials, design and construction in a way that is performance oriented and implementable.

ASPHALT MIX DESIGN EVOLUTION

Asphalt mix design in the United States has evolved through several distinct eras, each reflecting the state of knowledge, available equipment and prevailing performance concerns of the time. Early approaches emphasized empirical relationships between mixture properties and observed field behavior. These methods were simple, reasonably repeatable and practical, even if they lacked a direct mechanistic link to pavement performance.

Over time, the industry sought more rational approaches that could better address emerging challenges, such as heavier traffic loads, increased tire pressures and environmental distress mechanisms.

This evolution culminated in the development of the Superpave system during the Strategic Highway Research Program (SHRP), which fundamentally reshaped how asphalt materials and mixtures are specified in the U.S.

For readers seeking a concise overview of this evolution, The Asphalt Handbook (MS-4) published by the Asphalt Institute provides an accessible evolution of asphalt mix design philosophies without the need for including excessive detail or reliance on original research citations within this practical article.

MIX QUALITY BEFORE SUPERPAVE

Before Superpave, mix design methods such as Marshall and Hveem incorporated measures intended to reflect mixture quality, even if indirectly.

The Marshall method, in particular, used stability and flow parameters generated with a relatively simple press and loading apparatus. While there was no mechanistic meaning of these values, the test equipment was rugged, affordable and well-suited for use in field laboratories operating under less-than-ideal conditions.

Importantly, these methods provided contractors and agencies with rapid feedback. Mix properties could be evaluated during production, and adjustments could be made before large quantities of material were placed. While there was no actual performance prediction, the system worked because it balanced technical rigor with practicality.

Superpave sought to advance this balance by grounding mix design more firmly in material properties and performance-related concepts. In doing so, it introduced new tools that, while theoretically elegant, proved difficult to implement outside of controlled research environments.

THE SUPERPAVE SHEAR TESTER

The Superpave Shear Tester (SST) was a key component of the original system. It was intended to characterize mixture behavior under loading conditions representative of traffic. From a theoretical standpoint, the SST addressed important distress mechanisms and aligned with mechanistic design principles.

In practice, though, the SST was complex, expensive and sensitive to operating conditions. It required highly controlled environments, specialized training and substantial testing time. These realities made it unsuitable for widespread deployment, particularly in state DOT mix laboratories and field laboratories supporting active construction projects.

As a result, the SST never achieved meaningful implementation, and Superpave mix design moved forward without it.

THE AMPT

The Asphalt Mixture Performance Tester (AMPT) was later developed to fill the gap between theory and practice. The AMPT provided robust measurements of dynamic modulus and other properties that could be directly incorporated into mechanistic-empirical pavement design.

As a research tool, the AMPT proved extremely valuable. It improved understanding of mixture behavior, supported calibration of design models and advanced the science of asphalt materials.

However, similar to the SST before it, the AMPT faced practical limitations. The equipment is costly, testing protocols are time-consuming and environmental control requirements are stringent.

These factors limited usefulness in field laboratories where harsh conditions and rapid decision-making are essential. While the AMPT strengthened the link between materials and performance at the design level, it did not provide a workable solution for assessing mix quality during construction.

LOADED WHEEL TESTING

In the early 2000s, loaded wheel testers, such as the Asphalt Pavement Analyzer (APA) and the Hamburg Wheel-Track Test (HWTT), gained widespread acceptance. These devices offered a more direct evaluation of rutting susceptibility and moisture sensitivity and were far more practical than earlier performance-based tools.

As agencies implemented these tests, rutting performance improved markedly across much of the U.S. asphalt pavement network. However, cracking performance proved more elusive. Wheel tracking tests provided little insight into a mixture's resistance to cracking, particularly fatigue and thermal cracking, which are often the dominant distresses in long-life asphalt pavements.

The industry had made progress, but performance evaluation remained unbalanced.

BMD AND INDEX TESTS

Balanced mix design (BMD) represents a shift from single-distress evaluation toward a framework that considers rutting and cracking resistance. Central to this approach is the use of index tests that are relatively simple, repeatable tests that provide meaningful indicators of mixture performance.

Rather than attempting to replicate exact field conditions, index tests focus on differentiating mixtures based on their relative resistance to key distress mechanisms. When properly selected and validated, these tests allow agencies to set

Good paving practices matter regardless of the asphalt mix used.
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performance thresholds that align with project-specific risks and expectations.

The development and validation of BMD test methods marked a turning point by demonstrating that performance-oriented testing could be both technically sound and practically feasible.

FIELD VALIDATION MATTERS

A critical step in establishing confidence in BMD test methods was the Cracking Group (CG) experiment conducted at the NCAT Pavement Test Track in the 2015 and 2018 (3-year) research cycles. This highly controlled full-scale experiment evaluated a wide range of asphalt mixtures subjected to identical traffic and environmental conditions.

The CG experiment demonstrated that several laboratory tests correlated well with observed surface cracking performance. This validation provided the industry with something it had long lacked, which was clear evidence that certain laboratory metrics could meaningfully differentiate field performance. However, correlation alone was not sufficient for widespread adoption.

WHY IDEAL-CT ENABLED ADOPTION

Despite multiple tests showing good correlation with cracking in the CG experiment, only one offered the speed and simplicity required for routine construction use. The Indirect Damage-related Evaluation of Asphalt Laboratory Cracking Test (IDEAL-CT) can be performed using common laboratory equipment, requires minimal specimen preparation and delivers results the same day the mix is produced.

This rapid turnaround is not a convenience. It is essential.

Contractors and agencies cannot wait days or weeks to learn whether a mix met performance expectations. By that point, the pavement is already in place, and corrective action is impractical or impossible. Same-day feedback allows mix adjustments during production, aligning quality control with construction reality.

IDEAL-CT bridged the gap between performance theory and field implementation, enabling BMD to move from concept to practice.

UNLOCKING INNOVATION WITH CONFIDENCE

With BMD test methods now capable of differentiating mix performance during construction, the industry is positioned to responsibly adopt innovative materials. Highly polymer-modified (HiMod) asphalt mixtures are a prime example.

These mixtures often feature low in-place air voids and binder contents that exceed traditional volumetric limits. Under legacy specifications, such mixtures would be rejected outright. However, BMD testing demonstrates that HiMod mixes can exhibit exceptional resistance to rutting and cracking due to the combined effects of high-quality binders and increased effective binder content.

BMD provides the verification needed to ensure that innovative mixtures perform as intended, protecting taxpayer investment while enabling advancement beyond prescriptive requirements.

PERFORMANCE REQUIRES PRACTICAL TOOLS

The evolution of asphalt materials and design methodologies has shown that performance cannot be achieved through theory alone. Tools must be accurate, repeatable and (most importantly) practical for use during construction.

BMD, supported by practical index tests such as IDEAL-CT, represents a milestone in aligning materials innovation, design intent and construction quality. By enabling real-time assessment of mix performance, BMD offers a path forward where accountability and innovation coexist. The road to performance is no longer theoretical. It is being paved one balanced decision at a time. **R&B**

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