

Optimized Pavement Engineering for the ISO 10844 Standard

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ABSTRACT

Pavements complying with the ISO 10844 standard are an important component of vehicle and tire noise testing. In 2011, a new version of this standard was published, which includes many important changes compared to the 1994 version. As a result, some tracks that complied with the 1994 standard are now nonconforming with the 2011 version. Many tracks are in the process of being resurfaced, particularly before regulations are adopted that require conformance with the new version of the standard.

While repaving is costly, it can also lead to opportunity. Pavement engineering encompasses pavement design, materials selection and proportioning, and the selection of construction techniques. Pavement life is also an important engineering criterion. In the case of test tracks, life is most often defined by functional performance including changes in friction, rolling resistance, ride, and in this instance, noise.

Optimized pavement engineering often seeks a balance between initial cost and durability. For example, ISO 10844:2011 now permits polymer-modified asphalt binders. While more costly, higher quality binders can delay the onset of raveling, stripping, and other surface deterioration that affects functional performance including noise. Optimized pavement engineering can target a pavement lifespan, which is related to the evolution of the noise measurements over time.

A predictable response can also be sought. For example, the ISO 10844:2011 tests for pavement texture and acoustical absorption. These attributes are affected by paving materials and construction technique. Through optimization, specific measurement targets can be engineered for more predictable and consistent test outcomes.

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INTRODUCTION

External vehicle noise testing is an integral component of regulatory compliance. For example, UNECE R41, R51, and R117 [1,2,3] regulations have a common requirement for a pavement test surface that is in general conformance with ISO 10844. The current ECE regulations incorporate language from the 1994 version of the ISO standard [4]. However, recent proposals to the UNECE Working Party on Noise (GRB) include changes to these regulations that would require test surfaces as described by ISO 10844:2011 [5].

An ISO 10844 surface is intended to be a dense-graded hot-mix asphalt pavement which is representative of a high-quality highway pavement found worldwide. The standard was further developed to facilitate the construction of a pavement so that with all else being equal, the same external noise test result should be measured from track to track [5].

Ultimately, compliance with ISO 10844 can affect everything from type approval and homologation, to tire labeling, to reporting by the automobile press [6,7].

Furthermore, the ECE is just one example of regulatory bodies worldwide that are seeking to update their requirements to include ISO 10844:2011. SAE also includes ISO 10844 by reference in J1470 [8], and it is under consideration for future revisions to other standards sponsored by the Light Vehicle Exterior Sound Level Standards Committee (TEVSLS10).

When the 2011 version of ISO 10844 was published, it was not the intent to change the pavement test surface. Instead, the updates were to facilitate greater uniformity between tracks. Some of the impetus stemmed from previous reports on track-to-track variability [9,10,11,12]. The changes in 2011 were also intended to update the specification with respect to advancements in both pavement technology and measurement methods [5].

In addition to Annex D of ISO 10844:2011, numerous individuals have previously reported on new aspects of the ISO 10844 standard [13,14,15,16,17]. Rasmussen, et al. has also reported on various challenges with respect to engineering pavements to comply with the new ISO 10844

standard [18,19]. The intent of this paper is to expand on some of these challenges as they relate the design, construction, and maintenance of pavement surfaces to the requirements of the ISO 10844:2011 standard.

For proving ground and test track owners with a nonconforming ISO 10844 surface, overcoming these challenges during resurfacing can seem daunting. However, while the principal objective is to construct a compliant surface, there is also opportunity to construct a surface that can provide additional value. For example, a pavement can be constructed that is not only compliant, but also on the “quieter side” of the ISO specification. Given that ISO test tracks commonly evolve so that sound levels increase over time, the latter goal enables an owner to extend the useful life of the test track, and thus lower life-cycle costs.

PAVEMENT ENGINEERING

Prudent pavement engineering at a test track or proving ground should consider the entire pavement life cycle including planning, design, construction, and management. Specific goals should include:

- Reduction in life-cycle costs by improving asset management practices, making the most of both capital improvement and operations and maintenance (O&M) funds.
- Reduction in construction costs through specialized and efficient designs coupled with construction oversight that balances quality and risk.
- Improvement in quality through an inherent understanding of a pavement's influence on vehicle and tire responses including friction, rolling resistance, ride, or in this instance, noise.
- Optimization of pavement properties to not only meet specified requirements, but also facilitate consistency in test results over time.

Engineering is often targeted to performance goals. Pavement engineering categorizes performance as follows:

1. Structural performance - the ability of a pavement to resist traffic loading;
2. Material performance - durability of paving materials to environmental effects (principally climate and moisture) and a compatibility between paving materials;
3. Functional performance - durability of the tire-pavement interaction through resistance to changes in responses such as ride, friction, rolling resistance, and noise.

Engineering a pavement to meet multiple performance goals is possible, but it can be challenging. To succeed, a systems approach becomes necessary, with pavement engineering implemented as part of design, construction, and in the management of the pavements over time [20,21,22]. With a feedback loop established, significant improvements in pavement quality are possible since pavement management

data can be used to make intelligent decisions about how to improve forthcoming pavement design and construction.

Pavement Engineering in Design

Each performance goal requires specific elements to be incorporated into the pavement design. For example, a need for structural performance affects pavement layer thicknesses. However, while often a principal consideration for public highways, structural performance is generally of lesser importance for most ISO 10844 surfaces. Of course, owners of proving grounds operated by heavy truck manufacturers might beg to differ, given frequent pass-by testing of heavy vehicles!

The engineering of an ISO 10844 track begins with pavement design, which includes:

1. Site characterization - quantifying the factors that influence pavement performance, including details about the test traffic, soils, and climate.
2. Pavement surface design - establishing targets for surface texture and absorption, and then identifying pavement materials with the greatest potential of achieving those targets;
3. Pavement structural and material design - selecting pavement materials and thicknesses to assure durability during the course of the pavement life. Resistance to both traffic and the climate are considered, with the latter being a particular challenge in test facilities subject to large temperature changes throughout the year (e.g., desert or cold-weather regions).
4. Life-cycle analysis for management, maintenance, and rehabilitation - development and comparison of design alternatives encompassing various lives to find a rational balance between initial cost and longevity.
5. Materials and construction standards and specifications - unlike other surfaces at proving grounds, “typical” asphalt mixtures are not acceptable for ISO 10844 tracks. The language selected to specify the materials and construction are of paramount importance if design targets are to be achieved.

Pavement Engineering in Construction

Pavement engineering during construction is also important. At the very least, a constructability review should be conducted in order to assess the techniques proposed by the contractor. The following are examples of common issues warranting consideration:

1. Sequencing of paving, including project access, to avoid trafficking the newly laid asphalt surface with construction equipment.
2. Means to construct the joints between adjacent asphalt strips. One objective of better jointing is to minimize “steps” across the joint that can lead to a nonconforming surface per

ISO 10844:2011 (see [Figure 1](#)). Furthermore, poor technique can also lead to low asphalt density at the joints, which in turn can lead to poor performance. Water and air will more readily penetrate areas of low density, deteriorating the asphalt material at these locations (see [Figures 2](#) and [3](#)).



Figure 1. Poor construction can lead to a step across a joint, which can fail compliance with ISO 10844:2011.



Figure 2. Low joint density allowing for moisture infiltration.



Figure 3. Premature pavement deterioration (raveling) at a joint due to poor construction leading to stripping, where the presence of water causes asphalt binder to separate from the aggregates (rocks and sand).

3. Means to minimize segregation of the asphalt material. Segregation can lead to a non-uniform texture (see [Figures 4](#) and [5](#)). The ISO 10844:2011 standard includes new provisions for “homogeneity” that are of particular relevance. Numerous factors affect segregation, and thus a constructability review must include the means of production, transport, and paving.

Construction activities that warrant additional engineering include the review of field design changes and value engineering (V-E) proposals. The latter can be of particular benefit to an owner, since with a V-E, the contractor is encouraged to propose innovative practices that save money and result in an “equal or better” product.

Construction oversight of ISO 10844 tracks also benefits from pavement engineering due to the highly specialized nature of these surfaces. What would sometimes be considered “acceptable” practice in asphalt paving might inadvertently affect these unique paving surfaces. For example, raking loose asphalt material from the joints across the mat (before compacting) is a common practice in asphalt paving (see [Figure 6](#)). However, on ISO 10844 surfaces, this practice can have potentially detrimental consequences to both texture and acoustical absorption.



Figure 4. A pavement constructed with a segregated asphalt mixture exhibiting coarse (deep) texture in some areas.



Figure 6. Using a lute to broadcast loose asphalt material across the mat is can lead to inconsistent and undesirable texture.



Figure 5. Same pavement in *Figure 4*, but at an area approximately 2 m away exhibiting fine (shallow) texture.

Pavement Management

To confirm conformance of a new or existing ISO 10844 surface, a series of specialized tests are required. These tests include measurements of geometry, surface irregularities, texture, and acoustical absorption. The latter three tests are required every 2 to 4 years in order to comply with to the new “periodical checking” requirement of ISO 10844:2011.

The data collected during these tests can be used in conjunction with other data more routinely collected by the owner. For example, “sand” patch testing for texture depth (which now uses glass beads in lieu of sand) was required in ISO 10844:1994 (see [Figure 7](#)). This has since been replaced by the mean profile depth (MPD) in the 2011 standard, but due to its simplicity and correlation to MPD, sand patch data can still be used to assess evolution of the surface [23].

Using pavement management methods, sand patch and other test data can be used along with pavement engineering models to monitor the performance of the ISO test track. With these capabilities, it is possible to predict the date that reconstruction of the ISO 10844 surface may be necessary. Furthermore, through modern visualization tools within pavement management systems, the source of the deterioration can be more readily determined [22] (see [Figure 8](#)). It is particularly helpful when construction quality data is layered into the same management system.