RUTTING

Leave it to the Deer!

By Kent Hansen

Outside the pavement industry, the word "rutting" is usually associated with the mating habits of animals. Those of us inside the industry have had a mission to eliminate it from our vocabulary and would be content to leave it in the lexicon of park rangers.

In recent years, the asphalt industry has made significant advancements in the design and construction of Hot Mix Asphalt (HMA) pavements to improve performance with respect to fatigue cracking, thermal cracking, and rutting. This has occurred with the advent of QC/QA practices, the development and implementation of performance-graded (PG) binders, mixtures designed using the Superpave system, and the introduction of Stone Matrix Asphalt (SMA) and rut-resistant large stone mixtures. The prevention of rutting requires three elements: proper structural design, correct materials selection and mix proportioning, and good construction. This article will highlight the rut-free path to better performing HMA pavements.

Causes of Rutting

There are two basic origins of rutting: 1) deep structural problems and 2) asphalt mixture rutting near the surface. Deep structural rutting occurs in the unbound layers, aggregate base, and subgrade below the HMA. Typically, only thin pavement sections, less than about 8", exhibit subgrade rutting. This thickness will depend on the pavement materials, subgrade strength, and traffic loads.

Mix-related rutting occurs when the HMA materials deform under traffic. In the most severe case, the mix will be pushed out and up at the edge of the wheel paths. In most cases this is limited to the top 4" of HMA. Below this depth, the shear stresses, which cause this deformation, are usually lower. However, there are rare cases where rutting may be caused by HMA materials further down in the pavement. This usually happens in pavements that have had at least one rehabilitation, in which an unstable mix has been left in the pavement structure. Georgia and Maryland offer examples of how mix-related rutting can be corrected.

In Georgia, a section of freeway rutted soon after being overlaid as part of a widening project. A thorough investigation including an exploratory trench revealed an unstable HMA layer about 4" to 6" below the surface. The solution on subsequent sections of the widening project was to mill the surface to remove the unstable layer prior to placing the overlay. The rutting problem disappeared.

In Maryland, there was an intersection with severe recurring rutting, which required milling every year to remove ruts. The industry was given the opportunity to show that they could solve the rutting problem. They conducted a thorough investigation of the existing pavement structure first.

Similar to Georgia, the investigation included cutting a trench and taking cores. Testing and visual observations from the trench revealed that the existing HMA mixes were defective. They also performed a structural analysis to determine what thickness of HMA was required. The
solution was to remove and replace the existing asphalt layers with Superpave mixes, which had not been used in Maryland at the time.

The Superpave mixes were tested in the laboratory using a Hamburg wheel-tracking device to ensure they would hold up under the heavy traffic. Finally, the contractor constructed a test strip at their plant to allow them to make adjustments to the mix before they placed it on the roadway. The result is an intersection that, after five years of heavy traffic, has less than 1/8” of rutting.

These examples show that a thorough investigation must be done in order to determine what is causing the problem. You can’t fix a pavement if you don’t know what’s wrong. It would be like trying to fix a car transmission by changing the tires. The design, materials selection, and construction must work together to address rutting.

**Key Elements in Design**

There are a number of key elements to consider in designing rut resistant pavements, including traffic data, site investigation, structural analysis, materials, and construction.

**Traffic Data**

Obtaining good traffic data often may require conducting a traffic survey which can range from traffic counts with vehicle classifications to obtaining load data from weigh-in-motion devices or truck weigh stations. Weights may be the most important data you can obtain, and the better the information, the better your pavement design.

**Investigation**

For new pavements, a thorough soil investigation should be conducted using soil borings or test pits. Soil should be tested to determine in-place and compacted strength characteristics. If soil modification is required, the soils should be tested to determine the optimum amount of soil modification and resulting strength. Tests may include CBR, R-value, and resilient modulus. There are other methods that may be used in the field to measure the in-place strength of soils, including field CBR or dynamic cone penetrometer.

For existing pavements, the investigation should include a distress survey, materials sampling, deflection testing, and a soil investigation. The depth of the investigation depends on the amount and severity of distress, traffic volumes, and road classification.

Roads showing severe distress, having higher traffic loading, or with greater importance (interstate vs. local road) require a more thorough investigation. For these conditions it is more important to determine the root causes of the rutting and properly characterize the strength of materials.

For moderate to severe rutting, the ideal investigation would include cutting a trench across the road to see what layers have deformed and obtaining cores to determine the strength of the materials. If trenching...
is not an option, three to five cores may be taken across the roadway – two in the wheel paths, with a minimum of one between the wheel paths, and preferably two more outside the wheel paths. A stringline can be stretched across the roadway and measurement taken from the stringline to the road surface at core locations to reconstruct a transverse profile of the road surface and lower pavement layers. Figure 1 shows an example of this.

Cores should be examined to see if any layers have moisture-related damage or stripping since this may be causing the rutting. At a minimum, core layers should also be tested for air voids, since low air voids (less than 2.5 percent) may be an indication of an unstable layer. Core layers may also be tested to determine layer strengths using devices such as the Asphalt Pavement Analyzer, Hamburg rut tester, Superpave shear tester, or other strength tests.

At a minimum, aggregate base and soils below the pavement surface should also be sampled and tested for moisture content and density tests. In-place testing may include field CBR or dynamic cone penetrometer tests. Deflection testing on existing pavement can be used to determine the consistency and stiffness of the supporting soil, which can then be used in a structural analysis of the pavement.

Unstable Layers
Unstable asphalt layers may be revealed by field observations such as transverse variations in layer thicknesses and stripping, as well as through laboratory evaluations such as density and strength tests. If unstable asphalt layers are present, they should be removed. If these layers are not removed, rutting will occur, and eventually the pavement will need to be rehabilitated at a sooner date and greater cost than planned.

Structural Analysis
Once all soil, materials, and traffic data have been collected, a structural analysis may be performed to determine what section is required. Structural analysis should be performed in accordance with established procedures such as those of the American Association of State Highway and Transportation Officials, Asphalt Institute, Federal Aviation Administration, or local procedures. The structural analysis should be used to determine whether additional pavement layers are needed to support the expected traffic. Once the required thickness of the pavement has been established, the materials need to be selected to ensure rutting resistance.

Materials
It is important to select the HMA materials to optimize the performance of the pavement structure. Higher traffic loads and stopping or slow moving traffic will require stiffer mixtures as provided by more crushed aggregates and stiffer asphalt binders.

For guidance on selecting appropriate mixes, refer to the HMA Pavement Mix Type Selection Guide, produced by the National Asphalt Pavement Association and Federal Highway Administration. To order a copy, contact NAPA's Publications Coordinator at 888-468-6499 or e-mail publications@hotmix.org.

Construction
The last and most important step in obtaining a rut-resistant pavement is construction. The mix must be produced to meet the requirements for the traffic and environment. If the density of the mixture is inadequate, a number of problems related to rutting may occur, including densification under traffic and moisture damage due to excessive permeability. Constructing a test strip is always a good idea, especially when using a new mix. This provides an opportunity to make adjustments to the mix and establish rolling patterns to obtain proper density. Good construction and quality control are very important to the long-term performance of the road.

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Key Elements in Design, Materials, and Construction

New pavements:
• Get traffic data and determine design equivalent single axle loads (ESALs).
• Perform a thorough soil investigation and analysis.
• Perform a structural analysis to determine the required thickness of materials.
• Select materials based on traffic, pavement layer, and environmental conditions.
• Pay attention to good construction techniques.

Rehabilitation:
• Perform a thorough field investigation of the existing pavement including laboratory testing.
• Obtain good traffic and loading information to determine ESAL.
• Perform structural analysis to determine the required pavement thickness for the future.
• Determine if there is any unstable pavement material that should be removed.
• Select appropriate mixes.
• Pay attention to good construction techniques.