INTRODUCTION

Currently in the USA the primary noise mitigation strategy for highway operations has been construction of noise barrier walls. However, these sound walls are expensive to build (often $1-2M per mile) and expensive to maintain. Graffiti control is a major maintenance issue for highway personnel and the disruption of communities and compromise of aesthetics are frequent complaints of the communities that the walls were built to protect. In addition, the noise benefit of barrier walls is limited, often to less than 400m from the roadway.

To address some of these shortcomings, agencies have recently started to consider other solutions for source control. Source control strategies could include quieter vehicles, quieter tires, speed control, additional building insulation, more aggressive building codes for new construction, zoning or right-of-way purchase or quiet pavements. Many of these alternatives have been investigated with mixed results. For example, new tire designs have produced quieter tires, but the recent trend toward wider tires for improved
handling and skid resistance has essentially negated this noise reduction benefit. There has been demonstration of quiet pavement in the United States that has illustrated that this approach has potential. Investigation of quiet pavement has longer history and is more extensive in Europe, and thus, their experience is valuable as more extensive implementation of quiet pavements is considered. The objective of the Quiet Pavements Scan team was to visit countries with the most experience in quiet pavement technology and learn from their experience.

The systematic reduction of noise associated with roadway operations has been a critical issue in Europe. Countries in the European Union (EU) have agreed to map noise contours along all existing roadways by the year 2007. These maps will be made available as public information. Each country will then develop an action plan to address problems identified in the noise map. Most countries have aggressive policy directives to limit noise along newly constructed facilities. In many countries of the European Union, new quiet pavement alternatives are being used as one of the alternative technologies to address noise problems.

The Quiet Pavements Scan team was composed of a cross-section of state, federal academic and industry representatives. The team visited five countries over a 17-day period. The trip was designed based on a comprehensive desk scan of published research summarizing where the technology was most used, where it was first used, and where innovation was still being explored. Although there were countries from which to choose, the team selected five that were visited in the following order: Denmark, The Netherlands, France, Italy and the United Kingdom. This sequence was established in an effort to reduce travel time, maximize meeting time with experts, and visit field sites in each country. While in transit from The Netherlands to France, six of the team members visited several sites in Belgium. The remaining team members later approved the use of the results of this “unofficial” side trip as an appendix to the official scan tour.

SIGNIFICANT FINDINGS

Although the full report will explore in detail the many significant findings by the team, the following were deemed to be of high general interest to executive or policy implementation readers:

1. **Policy** - Highway pavement noise has been studied in Europe for more than two decades and policies have been developed to mitigate this noise through an integrated approach that allows the use of quieter pavements to receive increasing consideration. All of the countries visited have implemented policy that requires consideration of quiet pavement where noise is anticipated to be a concern. Additionally, on June 25, 2002, the European Union (EU) implemented a significant Noise Directive which requires all member countries to: (a) determine exposure to environmental noise through noise mapping, including rural areas; (b) use uniform prediction methods of assessment common to the Member States; (c) ensure that information on environmental noise is made available to the public;
and (d) adopt action plans by the Member States, based upon noise-mapping results, with a view toward preventing and reducing environmental noise. The Directive requires all Member States to complete the strategic noise maps and adopt an action plan by June 30, 2007.

As is often the case in the United States, the implementation budgets for the countries visited were much smaller than deemed necessary to totally implement the policy directive. The primary implementation funds were carved out of the existing construction budget but a designated funding source did add status to the policy and direction to the program. The quieter surfacing costs were approximately 25 percent more than traditional surfacing.

2. **Design** – Based on European experience, the current focus of European quiet pavements effort is three major quiet pavement technologies; thin-surfaced, negatively textured gap-graded asphalt mixes (such as Novachip, micro-surfacing, and some SMA’s), single and double layer highly porous asphalt mixes (greater than 18 percent voids), and exposed aggregate concrete pavements. The emerging trend is to use the thin-surfaced gap-graded mixes with small aggregate in urban areas and areas subject to severe winter snow and ice accumulations. More porous gap graded asphalt surfaces are used in rural and high speed facilities with moderate winter conditions. Exposed aggregate concrete can be used where concrete pavement surfacing is allowed. Many highway projects are specified using performance specifications and are selected using best value. In many cases pavement vendors respond to agency performance criteria with innovative solutions that often carry unequal risk, but if found effective, can be held proprietary for future project applications.

3. **Noise Analysis** – The source level of quiet pavements are being incorporated into existing highway noise prediction models using varying methodologies. Harmonoise, the common EU model currently being developed, will incorporate pavement type in the prediction, along with other advanced prediction parameters such as meteorological effects. To determine the noise benefit of pavements, most countries use multiple methods including Statistical Pass-By (ISO 11819-1), Close Proximity (ISO 11819-2), and various Controlled Pass-By methods, along with pavement sound absorption measurements. Each method has different strengths. In terms of vehicle types, the influence of quiet pavements on heavy vehicles is less well understood than for light vehicles; this topic is being investigated. Pavement noise benefits of as little as 2 dB are being utilized in integrated noise strategies.

4. **Construction** – Normal construction equipment and technology are used to construct the quiet pavements. Porous asphalt mixes are used only on pavements that are structurally sound; other defects in the underlying pavement must be minimal. Vehicle spray reduction and improved skid resistance are the two main reasons that porous surfaces were first used in each of the five countries. Noise reduction was a side benefit in the effort to produce a safer pavement during wet weather conditions. Contrary to normal practice in the United States, factors
other than low bid are considered when awarding pavement construction contracts. Also, a contractor warranty of at least three years is typically included in the contract.

5. **Maintenance** - There are still minor but persistent disagreements about effective maintenance of these negatively textured and often highly porous pavements. Although some countries require pressure washing and vacuuming of the pavements at least twice each year, other countries contend that the practice may not only be useless, but perhaps even harmful. The team was unable to discover any reliable data that could be used to substantiate either claim. Winter maintenance remains a challenge, especially on the highly porous pavements. Winter maintenance relies on advanced use of pre-wetted salt to fight formation of “black ice” on the highly porous pavements resulting in a winter maintenance cost increase of 25-50 percent. Some countries visited have discontinued using highly porous pavements in snow and ice regions and instead are using SMA type pavements with small aggregate.

6. **Research** - Perhaps the most impressive finding of the team relates to the extensive amount of research on quiet pavement technology currently underway (Roads to the Future, SIRUUS, PREDIT, SILVIA and HARMONIZE) in the countries visited. It was obvious that research is a vital part of the European culture. Much of this research is conducted in partnership between government and industry. There are complex relationships with private entities to fund far-reaching research objectives. For example, under the SIRUUS program, companies are encouraged to submit innovative ideas that are then judged by a panel of topical experts. The best ideas are given permission to be constructed as experimental sections. Selection of the experimental idea is a highly sought after award and is often used as a marketing tool for other company products and services.

**IMPLEMENTATION RECOMMENDATIONS**

The team identified a significant number of implementation recommendations that were then categorized into short-term and long-term proposals. Some of these recommendations for immediate implementation include:

1. The European experience demonstrates that porous mixes are effective in reducing noise when used properly. Early evaluation results in Europe indicate that double-layer porous asphalt appears to have potential application on high-speed facilities and produce exceptionally quiet pavements. Thus, this system appears to merit additional evaluation and research in the United States. Porous mixes should not be placed in urban areas where the operating speed drops below 45 mph since highly porous mixes tend to clog under slow traffic.
2. For an immediate improvement in the noise-reducing properties of mixes, a reduction in aggregate size in the wearing surface should be considered. In Europe the aggregate sizes for quiet surfacing mixes are 0/4mm through 0/10mm. Since most State DOT’s use the Superpave aggregate gradings of 19mm, 12.5mm or 9.5mm, a drop in routine aggregate mix size to the next smallest gradation is recommended and should produce a noise reduction of 1 to 3 dB.

3. Thin textured surfacings using a small aggregate size are recommended for urban or low speed sections. To achieve noise reduction, texture should always be negative (pavement depressions). Positive textured pavements such as chip seals increase noise.

4. Diamond grinding blade configurations should be investigated and optimized to enhance noise-reducing properties of existing concrete surfaces in noise sensitive locations.

5. Exposed aggregate concrete pavements should be researched further and considered when constructing new concrete pavements.

6. A team of acoustical experts and pavement engineering personnel should begin the process of developing AASHTO protocols for measurement of the acoustical performance of quiet pavements. These protocols should capitalize on the extensive work completed and ongoing in Europe, as well as other locations in the world. Until new standards have been developed and adopted, state DOT’s should use Statistical Pass-By (ISO 11819-1), Close Proximity (ISO 11819-2), and various Controlled Pass-By methods to monitor existing pavement noise.

7. Current policy and traffic noise models should be revised to take advantage of the benefits of quiet pavement technology through an integrated approach with other noise mitigation alternatives.