Highway design was never easy. Increasing scrutiny and critical public opinion only have added to the challenges facing transportation engineers. With each project, there always seems to be someone upset with the proposed location, the number of lanes, and the type of pavement. Environmental issues have taken a front seat in roadway planning and design, and now there is a growing concern about the noise levels generated by traffic.

The push to reduce noise produced by the traveling public has resulted in the search for new abatement technologies and alternatives. Research is proving that specific types of pavement surfaces can reduce noise levels significantly on roadways. State DOTs are investigating quiet pavements as an alternative to more traditional methods of noise abatement, such as noise walls and vegetative screening.

Noise emanating from roadways has become more of an issue with changing population density and an increasing number of noise sources. A rapidly growing population with a tendency to settle in urban areas creates a situation in which a larger number of people are affected by passing vehicles.

The U.S. government first attempted to address noise concerns by passing the Noise Control Act in 1972. The act, last updated in 1978, has proven to lack the effectiveness hoped for by supporters and is not strictly enforced. But road noise is annoying, and the residents living near highways are demanding that the government reduce noise levels.

According to the report, *Reducing the Impact of Environmental Noise on Quality of Life Requires an Effective National Noise Policy* (available at www.volpe.dot.gov/acoustics), the time is now for a new national noise policy. The authors suggest that establishing such a policy will be challenging because many noise producers also have a beneficial side and actually improve quality of life. Cars provide mobility and convenience, and few people would be willing to sacrifice several trips in order to decrease their contribution to traffic noise. Instead, policy makers will have to find a balance between the demand for noise abatement and the need to take advantage of benefits provided by noise producers.

**MEASURING NOISE**

Noise can be considered as any unwanted sound that adversely affects qual-

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Above: A device monitors noise levels in a residential neighborhood adjacent to a Quiet Pavement Pilot Program freeway segment. Photo: Arizona DOT. Below: This trailer—built by the National Center for Asphalt Technology—is used to directly measure tire/pavement noise levels using the close-proximity method. Photo: NCAT
ity of life by interfering with speech, sleep, learning, leisure, and property values. But noise can be subjective—one person may enjoy loud music while the person next door may be annoyed by the sound. To translate noise levels into a definitive measurement, sound pressure levels are measured along a logarithmic scale in decibels (dB). An A-rating network, or correlation, is used to equate this value to one that is more representative of that perceived by the human ear. When sound levels have been corrected in this manner, the unit is designated as dB(A).

Noise measurements range from a level 0 dB(A) at the threshold of human hearing to 140 dB(A)—the point where serious hearing damage can occur. Noise levels on a quiet night may reach 30 dB(A) and a rock concert typically can produce a sound level of 120 dB(A). Noise from highways can range from 65 to 85 dB(A).

Studies have shown that doubling the distance from a noise source will result in a decrease of 3 dB(A). For example, if the sound level measured at 16 feet from a source is 85 dB(A), then moving to 32 feet from the source will result in a decrease in sound levels of 3 dB(A) to a reading of 82 dB(A). In areas along highways with “soft” ground, this decrease can amount to 4.5 dB(A). Also, a change in sound levels of 10 dB(A) will be perceived by humans as a doubling or halving of the loudness of a specific sound.

GENERATING TRAFFIC NOISE

The level of traffic-related noise is dependent on traffic volume, traffic speed, and the type of vehicle. A vehicle produces noise from the engine, the exhaust system, and the tires. When a vehicle is traveling more than 50 mph, 75% to 90% of all the noise it generates is produced at the contact point between the tires and the pavement.

Robert J. Bernhard, director of the Institute for Safe, Quiet, and Durable Highways at Purdue University, and Roger L. Wayson, P.E., associate professor of the Civil & Environmental Engineering Department at the University of Central Florida, authored—along with other contributors—a research report titled An Introduction to Tire/Pavement Noise (SQDH 2005-1), which describes in detail this tire/pavement interaction. The report indicates sound is produced at this interface through several mechanisms referred to as tread vibration, air pumping, slip-stick, and stick-snap (adhesion). The sound produced is then enhanced by other factors such as horn and organ-pipe effects related to the tire geometry and acoustical resonance related to excitation of air in the tire.

A thorough understanding of this sound-producing mechanism can be used to better determine the noise-reducing capabilities of a particular pavement type. The SQDH 2005-1 report lists pavement porosity as one influencing factor. Porosity allows for absorption of sound and decreases the strength of air pumping and the effects caused by the horn and resonance mechanisms. Gap-graded, thin overlays with small aggregates also help to lessen noise production at the tire/pavement interface. These pavements are similar to stone-matrix asphalt and small aggregate Superpave mixtures.

The report also lists pavement texturing, specifically negative texturing, as a pavement characteristic influencing...
noise production. Conclusions from the report call for a better understanding of the problems surrounding these issues in order to obtain more accurate predictions of noise, optimal quiet pavement designs, and better measurements of actual noise reductions.

REGULATING TRAFFIC NOISE

The Federal-Aid Highway Act of 1970 required the Federal Highway Administration (FHWA) to develop standards for mitigating highway traffic noise. In implementing this mandate, the FHWA developed a manual, the Highway Traffic Noise Analysis and Abatement: Policy and Guidance. This report, accessible online at www.fhwa.dot.gov/environment, aids designers in meeting the Federal Regulation 23 CFR Part 772, “Procedures for Abatement of Highway Traffic Noise and Construction Noise.” This regulation requires a determination of traffic noise impacts for any type of road project designated as a Type 1 project. These involve new roadways, addition of new lanes to existing roadways, or significant horizontal or vertical realignments.

When sound levels are predicted to approach or exceed the Noise Abatement Criteria (NAC) set forth by the FHWA, noise mitigation must be considered. The FHWA has established a table for the NAC, listing a specific decibel level for certain activity categories, such as residences and churches. For highways near residences, this level is set at 67 dB(A). The FHWA stresses that “the NAC should not be viewed as federal standards or desirable noise levels; they should not be used as design goals for noise barrier construction.” Instead “the NAC should only be used as absolute values which, when approached or exceeded, require the consideration of traffic noise abatement measures.”

As of May 2005, sound level predictions necessitated by the regulation must be established through the use of the FHWA Traffic Noise Model (TNM) software, a computer program used for predicting noise impacts near highways. The Acoustics Facility of the Volpe National Transportation Systems Center, a federal organization within the U.S. DOT, provided technical oversight for the development of the FHWA TNM. The program is available for purchase through the McTrans Center at the University of Florida. More information about the TNM program is at www.trafficnoiseismodel.org.

If a noise impact approaches or exceeds that established by the NAC or a substantial noise increase is predicted—in the range of 5 to 15 dB(A), a level specifically established by each state—then a noise abatement strategy is chosen based on whether it is reasonable and feasible. This is determined by the implementation characteristics and cost as it relates to the amount of noise reduction.

Currently, the FHWA does not recognize quiet pavements as a noise abatement strategy on federally funded projects. The use of quiet pavements is allowed on Type 1 projects but will not be considered as a noise reduction benefit.

DEVELOPING A PILOT PROGRAM

The cost of noise abatement can be high. One typical strategy is the construction of sound-absorbing barrier walls, the average cost of which can range from $1 million to $2 million per mile. There are

Europe—the quiet continent

Quiet pavement is nothing new to Europeans. The technology has been widely used in Europe for many years. In spring 2004, an International Scanning Tour—sponsored by the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the Transportation Research Board—visited Denmark, the Netherlands, France, Italy, and the United Kingdom to learn more about general noise reduction practices in Europe.

Tour participants found that three major pavement technologies are used in Europe to mitigate noise. These include the use of thin surfaced, negatively textured gap-graded asphalt mixes primarily used in urban locations and areas subject to severe winter weather; single- and double-layer, highly porous asphalt mixes used in rural locations with moderate winter conditions; and exposed-aggregate pavements used in areas of concrete pavement construction.

European countries are continuing in their commitment to lower traffic noise levels along roadways. The United Kingdom established a goal to resurface 60% of major roads with quieter materials over a 10-year period. The countries of the European Union have agreed to map noise contours along all existing roadways by 2007. Then each country will develop an action plan to address noise-related problems identified by this map.

More information about the team’s findings can be found at http://146.6.177.170.
also some limitations with barrier walls. Noise reduction only occurs within sightlines, so little to no benefit is realized in some topographical areas.

The use of vegetation sometimes is considered an abatement strategy, but due to the expanse of trees and shrubs required to mitigate noise, this can result in the need for large areas of right of way.

These factors have further added to the interest in quiet pavements. The FHWA has developed a Quiet Pavement Pilot Program (QPPP) to offer states an opportunity to investigate the use of quiet pavements as a noise mitigation strategy. A QPPP is implemented according to specific requirements established by the FHWA, and guidance for this program is at www.fhwa.dot.gov/environment/noise.

To be approved by the FHWA, a QPPP must account for documented noise reduction benefits of pavement types; include post-construction monitoring of projects including acoustic, texture, and friction measurements over a 5- to 10-year period; document the public’s reaction to the project; and include commitments to provide the required noise reduction into perpetuity.

The QPPP must also be state-specific, although a group of state DOTs can submit a joint plan. Each QPPP must have a Program Plan and a Data Acquisition Plan, which are reviewed and approved by the FHWA.

Under this program, quiet pavement research also can be conducted. This research can be used to help substantiate possible future policy changes allowing the use of a pavement adjustment factor in traffic noise predictions. Additionally, the work may lead to the use of pavement types or surface textures as noise-abatement measures. To begin research under the program, an applicant must submit a Quiet Pavement Research Plan with an outline of the intended purpose, a detail of data acquisition, and periodic reporting requirements.

Those considering implementation of either a QPPP or the Quiet Pavement Research Plan must understand the differences between the two programs. A state may establish a QPPP only after submitting acceptable documentation on a specific pavement type along with predicted noise reductions and safety capabilities over time. Only then can the state adjust for pavement type in the noise level predictions and use specific pavement types as a noise reduction strategy. States conducting research cannot make any such adjustments until the required documentation is acquired through completion of the research plan.

A QPPP also must commit to the monitoring of noise levels over time and take appropriate actions, such as construction of an overlay, if noise reduction benefits do not last into perpetuity. Repaving also may be required if the pavement constructed through implementation of a QPPP or research plan fails structurally to the point that driver safety is compromised. Those conducting a research plan are not required to make such commitments.

ARIZONA’S QUIET PAVEMENTS

Arizona, in cooperation with the Maricopa Association of Governments, was the first state to implement a QPPP. This three-year, $34 million program involves resurfacing 115 miles of freeways in the Phoenix area with rubberized asphalt. The plan was

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What's the concrete industry doing about noise?

The concrete pavement industry is working to address one form of noise—sound at the tire/pavement interface—commonly called tire/pavement noise. The American Concrete Pavement Association (ACPA) is pursuing research and testing with two things in mind, said Gerald F. Voigt, ACPA president and CEO. “We will not trade off safety or long-term performance, and we will strive to avoid significantly increasing initial costs or lifecycle costs,” he said.

The answer to achieving a relatively quiet concrete pavement often lies in the pavement’s texture. Since the late 1970s, the Federal Highway Administration (FHWA) has required concrete pavement surfaces being used on federally funded highway applications to be textured. This led to the widespread use of transverse tining on concrete pavements, now known to produce loud, whining road noise in many areas.

The concrete pavement industry presently has powerful tools to produce quiet, safe, and smooth pavements, according to Steve Waalkes, P.E., ACPA’s managing director of technical service. “We’re opening up the industry to new ideas,” said Waalkes. “There are alternative textures that are just as safe as transverse tining.”

He cited longitudinal tining, AstroTurf drag, and other methods for imparting texture. Diamond grinding also can improve both smoothness and sound qualities, Waalkes said. “Diamond grinding is used successfully to restore the smoothness and texture of existing pavements, and in some cases to enhance the qualities of new pavements.”

A number of tire-pavement noise research and testing initiatives are currently underway, according to Larry Scofield, P.E., ACPA’s director of environmental engineering, including:

Field experiments—The Center for Portland Cement Concrete Pavement Technology/FHWA/ACPA are working together on a far-reaching research project to evaluate pavement surface characteristics. The research seeks to understand the relationship between noise and pavement texturing (and grinding for imparting texture); to evaluate the noise/textured time relationship; and to develop construction techniques that are repeatable and cost-effective.

Laboratory testing—At Purdue University—and with support from the ACPA and its affiliate, the International Grooving and Grinding Association (IGGA)—testing is being conducted using a custom-built grinding head, a key component of the tire-pavement test apparatus.

Sound intensity testing—ACPA has invested in an apparatus to conduct tire/pavement noise testing. Scofield noted that ACPA and the IGGA are conducting limited evaluations for contrac-
tors and agencies using a well-defined and consistent protocol that employs a standard test vehicle and specific brand and type of tires.

Other field testing—ACPA has conducted or participated in field experiments in Arizona, Kansas, and California. Scofield noted that these field evaluations are yielding some surprising and positive results that underscore the benefits of certain existing technologies used to impart surface characteristics.

For questions or additional information about tire/pavement noise and pavement surface characteristic research initiatives, contact Larry Scofield at 480-775-0908.

—This piece was adapted from the Aug. 12, 2005, issue of ACPA’s electronic newsletter, Concrete Pavement Progress. For the complete newsletter, visit www.pavement.com.

announced in December 2002 and work began on the first 21 miles in September 2003. The state expects to finish the project by December 2005.

The use of rubberized asphalt pavement in Arizona began more than 20 years ago. At the time, one of the primary purposes had been to recycle used tires. Arizona reports the use of more than 4.2 million tons of rubberized asphalt since 1988, resulting in the recycling of 15 million old tires. Studies and public perception have indicated that asphalt-rubber pavement also provided noise reduction benefits, providing an average decrease in traffic noise levels of 4 dB(A).

The city of Phoenix also has been active in placement of rubber-asphalt overlays, with more than 200 miles surfaced with 450,000 tons—an effort resulting in the use of 1.1 million old tires. The city has found that this pavement does not reflect cracks in existing pavement, the surface is more durable and skid-resistant than conventional asphalt, and the traffic noise is reduced providing a smoother and quieter ride. Noise studies have shown a reduction of 10 dB(A) in noise levels.

Rubberized pavement may not be the answer for every state. To achieve successful placement, the material must be placed when the pavement surface temperature is between 85° and 145° F.

More information about quiet pavements can be found at www.quietpavements.com, a site developed to provide information about traffic noise and the use of quiet pavements as a noise abatement strategy. The site provides reports, PowerPoint presentations, videos, and even an interactive tool—Sound Town USA. In Sound Town USA, users can try their hand at abating noise along a roadway using different noise abatement strategies.

As information about quiet pavements increases and states implement quiet pavement research, using quiet pavement as a noise abatement strategy may one day find acceptance within the FHWA regulations. For more information about Arizona’s QPPP program, visit www.quietroads.com. PW

—Browak is a freelance writer in LaSalle, Ill.

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