WAPA
WISCONSIN ASPHALT PAVEMENT ASSOCIATION

TECHNICAL BULLETIN

CONTENTS

Asphalt for Traffic Noise Reduction

Traffic noise is a concern for transportation authorities and highway owners at all levels. Noise is a recognized pollutant that can cause a wide range of negative societal impacts. This document provides an overview of the issue of traffic noise. It presents traffic noise abatement options and focuses on the benefits of using pavements designed to reduce noise generated at its source.

How noise is measured

Noise, or undesired sound, is measured in **decibels**. Environmental and industrial noise is commonly measured and regulated according to a decibel scale weighted for how humans hear sound, the "A scale" or **dBA**. Like all decibel scales, the dBA scale is not linear: An increase of 10 dBA is equivalent to an increase in loudness level by a factor of 10, and an increase of just 3 dBA is equivalent to doubling the sound intensity.

The dBA scale starts at zero, the threshold of human hearing. The threshold of pain for humans is about 140 dBA. Common sound levels across this range are shown in Table 1. Low levels of noise are disruptive and a nuisance to the public. Exposure to higher levels of noise (as low as 80 dBA for extended periods) can cause hearing loss and permanent auditory damage.

Table 1 Comparison of Noises on the dBA Scale (Adapted from the Asphalt Pavement Alliance)

Noise	Sound Level (dBA scale)
Threshold of pain	140
Jet flyover at 1,000 feet	110
Gas lawn mower at 3 feet	100
Diesel truck at 50 feet	**90**
Garbage disposal at 4 feet	80
Vacuum cleaner at 10 feet	70
FHWA requirement for road noise abatement measures	**67**
Dishwasher in the next room	50
Library	35
Threshold of human hearing	0

Road noise

Road traffic comprises 60 percent of urban noise (Figure 1) and is by far its biggest component, far outpacing noise caused by neighbors, business and other forms of transportation.

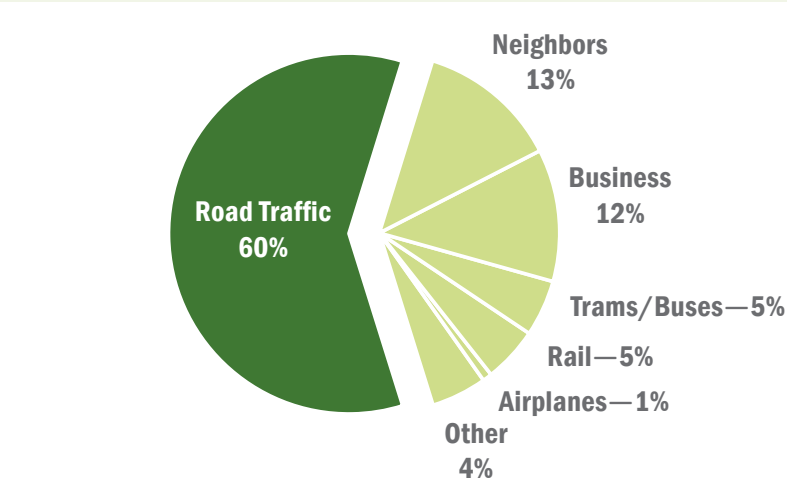


Figure 1 Sources of urban noise. (Adapted from the Asphalt Institute)

Government and industry alike take road noise seriously. Rules governing road noise for federally funded highway projects are given in the Code of Federal Regulations, Title 23, Part 772, "Procedures for Abatement of Highway Traffic Noise and Construction Noise" (wispave.org/cfr23-772). Table 1 of the Code (wispave.org/cfr23-772-t1) shows that for most outdoor settings, such as residences, parks and recreation areas, average noise levels greater than 67 dBA require noise abatement measures.

At the state level, the Wisconsin Department of Transportation outlines standard provisions related to noise in Chapter 23 of its Facilities Development Manual (https://trust.dot.state.wi.us/static/standards/fdm/23-00toc.pdf). The chapter addresses noise generated both during construction and regular highway operations.

Figure 2 Special equipment measures noise generated from the interaction of tires and the pavement. (Image courtesy of the Asphalt Institute)

Noise abatement techniques

The most effective way to achieve lower noise levels is to reduce the amount of sound generated. Abatement measures that involve blocking sound generally represent a less desirable solution. WisDOT's Facilities Development Manual makes this point: "The designer should always attempt to realize maximum benefit from the establishment of design features before considering other mitigative measures" (https://trust.dot.state.wi.us/static/standards/fdm/23-35.pdf).

Asphalt: the quiet pavement

Because asphalt has long been the quieter option for pavements, it is well-suited to meet the challenges of urban noise. Marquette University published the 2000 WisDOT report "Noise and Texture on PCC Pavements: Results of a Multi-State

Study" (on.dot.wi.gov/wisdotresearch/database/reports/wispr-08-99noiseandtexture.pdf). Although the study focused on concrete pavements, researchers also looked at asphalt pavements for comparison data and found that asphalt pavements were among the quietest studied (Figure 3).

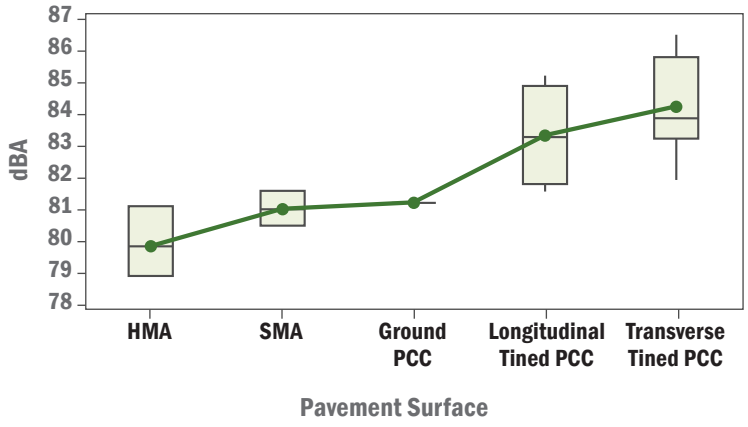


Figure 3 Exterior noise test results for Wisconsin pavement surfaces. (Source: "Noise and Texture on PCC Pavements: Results of a Multi-State Study," Marquette University, page 45)

The study confirms findings in the 1998 National Cooperative Highway Research Program Synthesis "Relationship Between Pavement Surface Texture and Highway Traffic Noise" (www.trb.org/Main/Blurbs/154363.aspx): "In general, when dense-graded asphalt and [portland cement concrete] pavements are compared, the dense-graded is quieter by 2 to 3 dBA." This finding is particularly important for highways because as the report notes, while vehicle-generated noise comes from a variety of sources—engine, exhaust system, air friction and pavement/tire interaction—at speeds above 50 mph, pavement/tire noise becomes the dominant source.

Quiet pavement designs

Asphalt can reduce road noise even further with quiet pavement designs. The Marquette University report states: "In regard to asphalt pavements, both a dense-graded asphalt and especially open-graded asphalt, generally showed the greatest potential for noise reduction." Open-graded asphalts have a significant air void structure in their wearing or friction courses—from 4 percent to 15 percent. When traffic tires interact with these pavements, a portion of the energy that would otherwise become noise is instead absorbed into this void structure.

A range of benefits are associated with quiet pavements:

→ **Reduced noise**

Research and deployment of quiet pavements over the last several years have shown that these designs significantly reduce noise at its source. As noted on the Asphalt Pavement Alliance's Web page (asphaltroads.org/quiet-pavement/quiet-pavement.html), research in the United States and Europe shows that a **stone matrix asphalt** (Figure 4) or **open-graded friction** course can reduce highway noise by 3 dBA to 5 dBA.

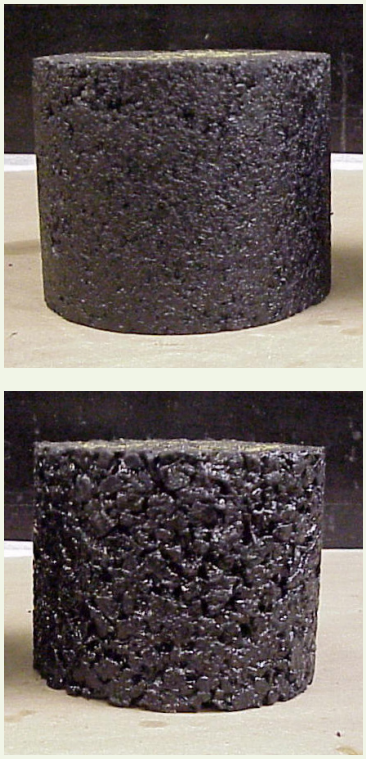


Figure 4 Compared with dense-graded asphalt (top), air voids in stone matrix asphalt (bottom) are more visibly apparent. (Image courtesy of the University of Washington)

Those are significant values. Reducing pavement noise by 3 dBA is equivalent to either doubling a listener's distance from the noise source or cutting the traffic volume in half (Figure 5). Neither of those alternatives is a realistic abatement solution for most projects.

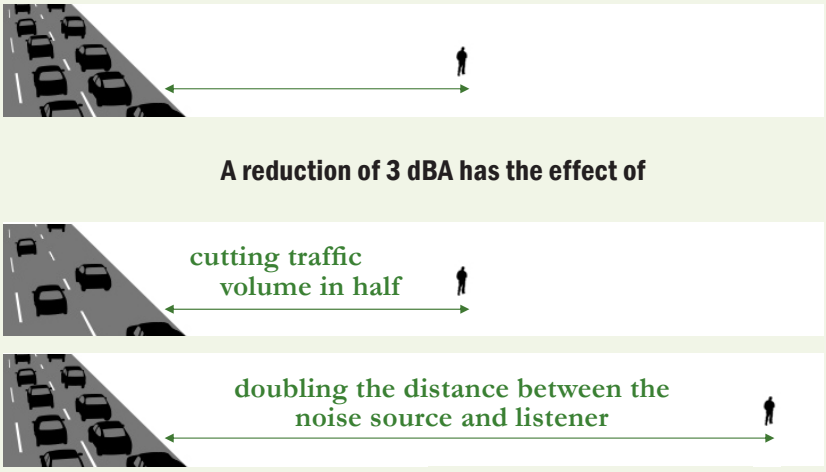


Figure 5 Reducing pavement noise by just 3 decibels cuts sound intensity in half.

Rebecca McDaniel of the North Central Superpave Regional Center at Purdue University describes recent research in the *HMAT* magazine article, "Open Graded Friction Course in Indiana: Durable and Quiet" (www.nxtbook.com/nxtbooks/naylor/NAPS0309/index.php#/20). This project demonstrated the long-term noise reduction benefits of advanced open-graded friction courses.

Figure 6 The open graded friction course shown in the left lane reduces standing water and pavement noise. (Image courtesy of Asphalt Pavement Alliance)

→ **Quieter in wet conditions**

Porous surface layers have the added benefit of eliminating standing water on the roadway (Figure 6) and further reducing noise generated on wet pavements. A study in the United Kingdom showed that a porous asphalt reduced pavement noise at the source by 4 dBA in dry conditions and 8 dBA in wet conditions. (For details, see the National Asphalt Pavement Association publication "That's the Sound of a Quiet Asphalt Pavement" at www.quietpavement.com/docs/ThatsTheSoundOfQuietAsphaltPavement.pdf.)

→ **Inexpensive**

The difference in cost between a standard pavement and a quiet pavement is minimal. A pavement can become a quiet pavement either at the time of initial construction or during scheduled rehabilitation.

→ **Versatile**

A quiet pavement can be constructed anywhere a standard pavement can go. Limitations on real estate, line of sight and other issues related to barrier walls (discussed in the next section) don't apply to quiet pavements.

→ **Approved in Wisconsin**

Quiet pavements are already approved for use in Wisconsin highways. SMA is specified in detail in WisDOT's Standard Specifications, Section 460, "Hot Mix Asphalt Pavement" (**https://trust.dot.state.wi.us/static/standards/stndspec/Sect460.pdf**).

The costly alternative: barrier walls

Barrier walls (Figure 7) remain common throughout Wisconsin and the United States. They act to physically shield areas from highway noise, but their drawbacks are numerous.

Figure 7 Barrier walls are costly and have limited effectiveness.

→ **Expensive to build**

Barrier walls are extremely expensive. Estimates vary, but recent WisDOT lettings provide data for comparison purposes. Following are the costs of adding noise abatement features to a four-lane highway for one mile:

Cost to build noise barriers: $616,000

Assume two walls, each 1 mile long by 21 feet tall at a unit price of $25 per square yard

Cost to build a quiet pavement layer: $201,240

Assume a 2-inch SMA surface layer at a unit price of $65 per ton (includes liquid asphalt) and 774 tons per lane mile

Barrier walls are **three times the cost** of the quiet pavement option. For projects where barrier walls *and* a new pavement surface are required, the quiet pavement is even more favorable.

→ **Expensive to maintain**

The costs of barrier walls do not end with construction. Like pavements and all other highway infrastructure, barrier walls carry maintenance costs as well.

→ **Ineffective**

When a noise barrier wall is constructed, there is a drop in noise immediately behind the wall. However, buildings on hillsides, at intersections or near wall openings will not experience any noise reduction benefits.

→ **Counterproductive**

In some cases where noise barrier walls are built parallel to one another, noise reflections and echoes between the walls can actually increase noise levels.

These drawbacks all compound the primary disadvantage of barrier walls: They only treat a symptom. Unlike quiet pavements, barrier walls fail to reduce the amount of noise generated.

Meeting the public's needs

Ultimately, a road agency serves the public, with a mission to deliver facilities that will meet the public's needs at the right price. Quiet pavements have proved to be an effective, low-cost alternative to barrier walls that address pavement noise at its source. The Wisconsin Asphalt Pavement Association expects to keep seeing new quiet pavement projects in Wisconsin, particularly as taxpayers demand alternatives to noise barrier walls.

WAPA can provide additional guidance on implementing quiet pavements like those described in this guidance document. Please contact WAPA at 608-255-3114, **strand@wispave.org** or **www.wispave.org**.

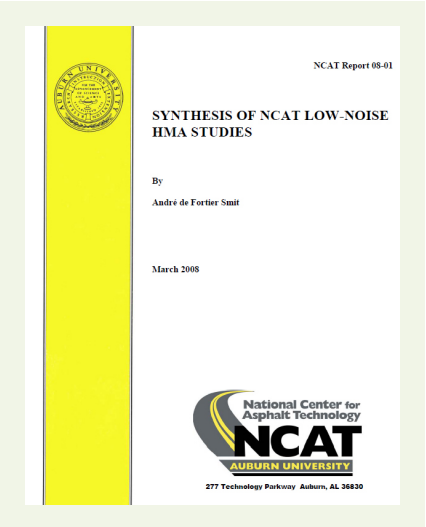
Additional resources

Facts about quiet pavements

Quiet Pavement website
quietpavement.com

"Synthesis of NCAT Low-Noise HMA Studies"
National Center for Asphalt Technology Report 08-01
www.eng.auburn.edu/files/centers/ncat/reports/2008/rep08-01.pdf

"Asphalt: The Quiet Pavement"
Asphalt Institute presentation
www.apa-mi.org/docs/Asphalt-thequietpavement.pdf



Noise abatement

"Highway Traffic Noise Analysis and Abatement Policy and Guidance"
FHWA report
www.fhwa.dot.gov/environment/polguid.pdf

Pavement/tire interaction

FHWA's Tire Pavement Noise Web page
www.fhwa.dot.gov/environment/noise/tire_pavement_noise

"An Introduction to Tire/Pavement Noise of Asphalt Pavement"
Technical guidance by Robert Bernhard, Purdue University, and
Roger Wayson, University of Central Florida
www.quietpavement.com/docs/AnIntroductiontoTire-PavementNoiseofAsphaltPavement.pdf

"Measuring Tire-Pavement Noise at the Source"
NCHRP Report 630
onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_630.pdf