

Quiet Pavements Raise the Roof in Europe

Scanning tour reveals European practice for noise mitigation

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European cities have a combination of old world charm and modern industry. They're also known for their lively nightlife carried on in noisy clubs and pubs, but that's where they want to keep the noise – in the clubs, not on the roads. To that end, some European countries have developed integrated strategies that include policies, materials, and designs to minimize noise.

A recent agency-industry scanning tour was conducted to examine innovations across the Atlantic. The tour was sponsored by AASHTO and FHWA. Participants represented FHWA, Department of Transportation Volpe Research Center, Caltrans, North Carolina DOT, Missouri DOT, Arizona DOT, University of Texas, Purdue University, the Rubber Pavements Association, ACPA and NAPA. The countries visited included Denmark, The

Netherlands, France, Italy, and the United Kingdom. From April 30 through May 16 participants visited highway agencies, research institutes, and pavement test sites in all these countries. The result was a better understanding of road noise, how to measure it, the pavement's contribution, and what can be done about it.

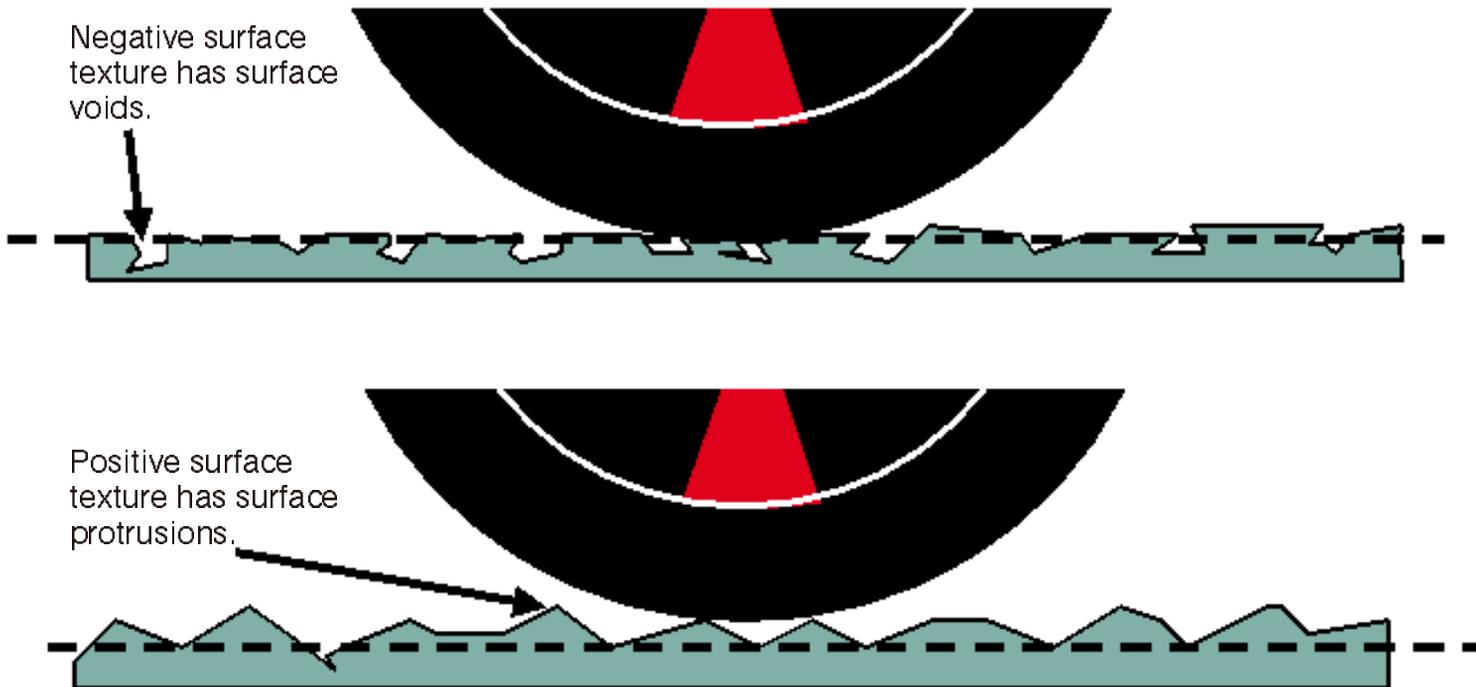
A combination of a high population density and high mobility puts people and highways in close proximity in Europe. This has led to various governments developing policies with regards to noise generated from various transportation sources, and the agencies and industry are coming up with solutions. The Netherlands and the U.K. have

both set ambitious goals for road noise reduction, and Denmark has established maximum allowable noise levels for dwellings near roads. By 2007, noise mapping will be complete for all metropolitan areas, rural areas, and major roads in the European Union with the goal of instituting an action plan to reduce road noise to an acceptable level. Participants from 11 countries are taking part in the SILVIA (Silenda Via) (Silent Road) program designed to develop rational noise mitigation tools for decision makers.

Strategies for dealing with road noise in Europe are different than those in the U.S. For instance, the European countries have a set level of noise to which they are trying to

In the Netherlands, fully 65% of the national road network is currently surfaced with OGFC (below). Even during a prolonged rainstorm there, the two-layer porous asphalt continues to eliminate splash and spray from driving conditions. During a prolonged rain, this porous pavement (below) in Copenhagen, Denmark, drains water away from the traffic, while the water remains on a normal pavement.





Negative, fine-texture is quieter than positive, coarse-texture.

design. In doing so, they have taken the approach that any noise mitigation technique should be considered a contributor to the overall goal. The current U.S. approach is not to design to a specific level of noise in adjoining areas, but rather that for federal participation, any single noise mitigation technique should have an impact of a 5 dB(A) reduction. Pavements are not considered in the U.S. strategy although they are being researched in pilot projects in Arizona and California. This limits the viable solutions in the U.S. to noise barriers, rather than taking an integrated approach through the use of low-noise pavements.

However, there is a case to be made for low-noise pavements through the use of an analogy. When your child has her stereo turned up too loud, and you ask that she do something about it, the first thing she does is close her door. This puts a block (barrier) between the source of the noise and you (the receiver), but it often falls short of providing the level of relief you were seeking. When you next go up

to her room and threaten to turn the stereo into a lawn ornament, this has the desired effect of controlling the noise at the source (like a pavement). And, unlike a noise barrier, controlling the noise at the source is effective no matter whether you happen to be in the same room, in the back yard, or the living room.

The longevity and cost effectiveness of pavement solutions to road noise are often questioned. Most of the European countries visited suggested that while there is some degradation of noise reduction in the long term with most of the low noise pavements, there was a 2 to 5 dB(A) reduction over the life of the surfacing. In the case of porous asphalt surfaces (OGFC), there was a considerable increase in the use of salt during the winter and black ice was an occasional problem in frost areas. However, according to a Danish study, porous asphalt surfaces were anywhere from about 2.5 to 4.5 times more efficient than noise barriers on a unit cost basis at reducing noise. With an initial advantage like this, it is easy to make the case

for increased winter maintenance and periodic resurfacing.

The two biggest keys to producing low noise asphalt pavements are surface texture and porosity. Beyond this, it is important to match the right material to the application. There are instances where porous surfaces would not be appropriate, and a thin, fine-graded SMA-like material could serve to reduce noise almost as well.

Regardless of whether a thin surfacing material or an OGFC system is used, the maximum size of aggregate in the surface has a profound influence on noise generation as does the type of surface texture. For noise reduction, smaller is better and being negative is a positive. Double-speak you ask?

European researchers have discovered that the size of particles on the pavement surface plays a critical role in the interaction with tires in terms of the vibration of the tread. Larger sized surface texture tends to produce greater noise, which is why coarse chip and coarse-graded dense HMA surface mixes can be noisier than those having a smaller maxi-

imum aggregate size. They have found that mixes containing a 5 or 6 mm maximum aggregate size produce the quietest pavements, compared to their reference dense-graded mixes containing a 14 or 16 mm maximum aggregate size.

The type of surface texture is also important. Voids in the pavement surface cause less tire vibration than particles on the pavement surface. Thus, a surface which is relatively flat with voids in it has better acoustical performance than one that has protrusions above the surface. HMA placement and compaction result in a flat pavement surface with voids to achieve this "negative" texture.

Porosity in the surface is a means to achieve even further noise reduction. In the Netherlands, fully 65 percent of the national road network is currently surfaced with OGFC. They have found that this, combined with a smaller aggregate

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size, is very effective in reducing the noise from traffic. In France and Italy, it is very common to see OGFC on high-speed highways. Both of these countries report surface lives of OGFC to be in the range of 12 to 15 years.

There's more – many of the countries are now experimenting with two-layer OGFC's to maintain both safety and noise reduction. The two-layer systems consist of a coarser, underlying porous layer with a finer porous surface layer. Normally, the underlying layer has a maximum aggregate size on the order of 11 to 14 mm and the layer is about 40 to 50 mm thick. The top layer is comprised of a maximum aggregate size of 6 or 8 mm, and it is about 25 to 30 mm thick. This

produces a very quiet pavement that can readily drain, although there is concern about the fine top layer clogging with time. As long as the top layer can keep up with the rate of rainfall, the surface will be dry. This usually means that even after it no longer passes the normal criterion for OGFC permeability, water will still run through it. It is important, however, that the lower layer remain unclogged so that the water can move horizontally off the roadway.

Clogging of OGFC surfaces is addressed in two ways in Europe. The first is that OGFC's are used only on high-speed routes. The action of tires pushing water into the voids and sucking it back out helps keep the surface clean. So,

Example of mix designs for quiet pavements.

Mix Component	Thin Surfacing*	Top Layer OGFC**		Bottom Layer OGFC**	
	Fine SMA	Fine, 5 mm	Fine, 8 mm	Coarse, 16 mm	Coarse, 22 mm
% Passing 22 mm	—	—	—	—	100
% Passing 16 mm	—	—	—	100	—
% Passing 11 mm	100	—	—	—	12
% Passing 8 mm	98	100	100	12	—
% Passing 5 mm	83 – 90	—	—	—	—
% Passing 4 mm	—	66	12	7	7
% Passing 2 mm	14 – 28	10	8	7	7
% Passing 0.075 mm	10	6	8	5	5.5
hydrated lime or portland cement, %	1.5	1.5	1.5	1.5	1.5
limestone filler, %	3.0 – 7.5	3.5	3.0	1.5	1.0
cellulose fibers, %	0.3	0.25	0.25	0.25	0.25
binder, % (by wt. aggr.)	6.5 – 8.5	6.3	5.4	3.9	3.5
Mix design voids, %	5.0 – 10.0	25.5	26	25.5	25.5

* Data from the Danish Road Institute

** Data from Road and Hydraulic Engineering Institute (The Netherlands)

In areas where there is severe winter weather, or the speed limits are lower, the choice is to use thin asphalt surfacings.

generally speaking, OGFC's are used where the posted speeds are greater than 50 kph. Secondly, equipment is readily available that can inject water under high pressure and vacuum it back out. This type of cleaning is recommended on fine-graded OGFC surfaces once or twice per year.

Winter maintenance is also a concern for OGFC surfaces in terms of the application of salt and the occurrence of black ice. Because it is a porous surface, dry salt will tend to collect at the bottom of the OGFC if it is applied in a dry form. Likewise, salt brine will tend to run directly through the porous material, leaving little residue on the surface. The solution is to use prewetted salt. This allows the salt to cling to the irregular surface on the OGFC, and so it remains effective much longer. Even with the use of prewetted salt, European countries anticipate that it will require as much as two times the amount of salt needed for a dense-graded surface. The problem with black ice is handled through the use of advisories and adjusted speed limits when it is a problem.

In areas where there is severe winter weather, or the speed limits

are lower, the choice is to use thin asphalt surfacings, sometimes referred to as thin SMA's or semi-porous pavement. These are used throughout the United Kingdom, the eastern and mountainous portions of France, and in Denmark. This new generation of SMA mixtures is different from those currently being employed in a number of states. First, they have a very small maximum size aggregate, generally about 5 or 6 mm. They have the gap gradation associated with SMA mixtures, with the gap occurring in the range of 2 to 4 mm. The aggregate is 100% crushed material that is very cubical with low polish values. Fibers are used in the mix and polymers or powdered crumb rubber may be employed in the binder.

One big difference between the semi-porous surfaces and typical SMA mixtures is that the semi-porous surfaces have design air void contents between 5 and 10%, much higher than the normal 3 or 4 % design air void content for SMA's, and their in-place void contents are on the order of 15% as opposed to about 6% for normal SMA mixtures. The fine particle size used in the thin surfacings is such that the voids produced are normally encap-

sulated, leaving the material relatively impermeable to air and water. Because of the flat aggregate orientation that occurs during compaction, the surface can take on the quiet negative texture, mentioned earlier.

Does the finer texture of the quiet surfaces result in reduced skid resistance? Not in the long term. Initially, when the road is new and the asphalt coating on the aggregate is fresh, the skid resistance will not be as high as it will when the aggregate surface becomes exposed. This is also true of other mixture types. The primary factor affecting skid resistance is the type of aggregate used in the mix. Aggregates which resist polishing provide better skid resistance, and a smaller aggregate size helps by increasing the contact with the tire.

The keys to reducing the noise generated by tires on pavements are to: 1) Reduce the maximum aggregate size in the wearing course to 6 to 8 mm, 2) Ensure the surface has voids in it to form a negative texture as opposed to particles sticking up from it which gives a positive texture, and 3) Use a porous surface (OGFC) where it is practical. There remains much to be studied about noise reducing pavements, but the essential elements are known and need to be applied. Communities and governments need to adopt an integrated approach to road noise reduction that recognizes that treating the pavement surface is controlling the problem at the source. HMAT

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