

SQDH Center Researches Tire/Pavement Noise

Unique test facility's goal is a quieter highway — a better neighbor

Most highway noise is caused by tires interacting with the pavement surface – not the occasional bad muffler, noisy engine, clashing gears, honking horns, crashing fenders, or the like. This is surprising to many people, but if you rid yourself of any preconception and listen the next time you are in your car or walking to the mailbox, you will hear the characteristic roars, whines, or high-pitched hums associated with tire/pavement noise.

Tire noise can be heard for miles, depending on atmospheric conditions. For example, if you rise early, before the increase of neighborhood background noise, tire noise can be distinctly heard for two or more miles if the wind is “right.”

The Institute for Safe, Quiet and Durable Highways (SQDH) at Purdue University is the only center in the country dedicated to research aimed at reducing highway noise while still maintaining and improving the safety, durability, and economics of highways. The Institute was formed by the Transportation Equity Act of 1997 (TEA-21), which provided funds for several new university

transportation centers and continued funding for the existing centers; a total of 33 centers have been funded. The program also included certain goals for education and technology transfer in addition to transportation research.

A goal of all of the centers is to attract undergraduate and graduate engineering students to careers in transportation and related fields. Additionally, the centers are to be resources on new technology to the transportation community. SQDH, affectionately known in the industry as the “Squid Center,” is the only one of these centers specifically looking at tire/pavement noise.

Federal funds from the program must be matched on a one-for-one basis. At Purdue, the University provides the matching funds for the education, technology transfer, and administrative expenses of the Institute. This is approximately 25 percent of the funding. The other 75 percent of the funds are dedicated to research; the matching funds for research are secured on a project-by-project basis from various sources. The funding sources are all stakeholders in solving the highway noise issue; they include the Indiana Department of Transportation, the Iowa Department of Transportation,

a consortium of tire companies, and pavement/material associations including the Asphalt Pavement Alliance.

The Institute combines the efforts and talents of the Purdue School of Civil Engineering and the Purdue School of Mechanical Engineering. This is a critical joint venture since the problem of road noise must be considered from both the vehicle (tires) and the highway (pavement) point of view.

The Institute researchers believe that several mechanisms are to blame for highway noise. These include

- ① air that is trapped and compressed between a tire's tread pattern and the road surface eventually bursting from the confining spaces, causing pops and whistles,
- ② the impact of the block-like shapes in the tread design against the road surface, like numerous tiny hammers, and
- ③ the vibration of the tread blocks and the underlying belts that radiate sound outward much like the vibrating cones in stereo speakers.

Tire/pavement noise is directly related to both tire tread and construction and the surface texture

and material properties of the pavement. To test tire and pavement variables without the normal inconsistencies caused by atmospheric conditions, such as wind and temperature, one of the initial studies of the Institute funded the design and fabrication of the Tire/Pavement Test Apparatus (TPTA), Figure 1.

This apparatus is basically a twelve-foot-diameter vertical drum. Pavement samples are formed which are approximately one-sixth of the circumference of the drum. Two arms with mounted tires on wheels then are "driven" around the drum. Pavement specimens can be changed while the tire remains constant or the pavement surface texture remains constant while the tire design is altered. Testing in this manner is far more cost-effective than the traditional method of building full-sized pavement test sites on highways or test tracks.

The Institute's TPTA is the only such apparatus in the world. Previously, tire/pavement interaction noise could only be measured by means of a skirted trailer being towed behind another vehicle or a specially designed truck-like apparatus. The advantage of the TPTA is that it is in its own soundproof room. Background noise and environmental variables can be controlled and eliminated or at least minimized during testing. The measurement of tire/pavement interaction noise by the TPTA produces repeatable results in this laboratory environment, which is a must if this noise is to be understood and controlled.

Tire/pavement interaction noise is just one aspect studied at the Institute. Safety must be maximized – the vehicle must be able to steer and stop on wet surfaces. The pavement must be durable, since highway agencies only have limited resources for pavement maintenance and rehabilitation. And, any pavement design must be relatively economical and cost-



The Tire/Pavement Test Apparatus at Purdue's SQDH Center is the only one of its kind in the world. Here are some vital statistics:

Weight is approximately 38,000 pounds (17,240 kg).

Drum diameter is 12 feet (3.66 meters).

The length of each pavement specimen is approximately 1/6 of the circumference. This was chosen as a practical limitation in making, handling, and mounting pavement specimens.

The design pavement specimen thickness is set for 8 inches (203 mm) or 16 inches (406 mm). However, an alternate thickness is possible with minor equipment modifications.

Up to 1000 pounds (454 kg) of normal pressure may be applied on each tire; this would simulate a two-ton vehicle.

The speed of the two counterbalanced tires is variable up to a maximum of 30 mph (48 kph).

Alternate tire designs can be mounted for testing while maintaining the same road surface. Currently, tire size is limited to approximately 17-inch rims without minor equipment modifications.

Measurements can be made on the tire, in the pavement, and with microphones that travel beside the tire.

Capability will be added to apply brake loads to the tire.

Highway/street background noise could be added in the future to simulate real-world conditions in the controlled laboratory environment.

effective to initially construct.

Research studies at the Institute range from measurement and evaluation of roadside noise generated by transit buses to the engineering of noise-reducing pavement types. The fundamentals of tire behavior and their relationship to noise and vibration is being studied. Superpave mixes, open-graded asphalt friction courses, and other paving materials are being investigated. The Asphalt Pavement Alliance is a partner in the funding of one of the studies.

The Institute is also engaged in updating NCHRP Synthesis 268. A great deal of data has been published since the Synthesis was

originally developed six years ago. The updated version will also include additional factors which pavement designers must consider.

Several of the SQDH Center's projects involve researchers from other universities. This inclusive flavor also is reflected in the makeup of the Advisory Council. The 20-member Council includes representatives of academia, state and national agencies, and manufacturers of automobiles, trucks, and tires.

More details on each of the Institute's research studies is available on the Web site at <http://widget.ecn.purdue.edu/~sqdh/>

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