By Tom Kuennen, Contributing Editor

Gaining Influence in 2011

Changes are coming to a number of industry practices

There are big changes on the way for a number of existing infrastructure technologies and practices, and they will significantly influence the highway and bridge communities in 2011.

In the coming year, new research, regulations or experience will impact:

- **Highway noise abatement practice**
- **New diesel engines for off-road construction equipment**
- **Raised pavement markers**
- **Precast slab bridge repair, and**
- **High friction pavements**

and they may change the way you do business. Here's a review of these trends for next year.

***Noise-suppressive barriers at cable anchorages on new Tacoma Narrows Bridge** attenuate vibrating 'zipper' sounds from expansion joints.*

Photo courtesy of Concrete Solutions, Inc.

New guidance on noise barriers -- published this past July and effective July 13, 2011 -- will guide road agencies in coming years in suppressing noise from existing, widened and new roadways.

It's among a number of new themes profiled in this year-end edition of *Road Science* that will impact how the industry serves taxpayers next year and in future years.

Title 23: Federal Highway Administration (FHWA), Part 77: 23 CFR Part 772, *Procedures for Abatement of Highway Traffic Noise and Construction Noise*, provides the template that state and independent agencies must use for setting their own noise policies in order to receive federal grants.

In its June publication, *Highway Traffic Noise: Analysis and Abatement Guidance*, FHWA provides information that agencies can use voluntarily to meet the final rule on noise abatement. FHWA points out that today highway noise suppression requires a three-way approach:

• **Control of land use adjacent to highways, executed at the local level.** "Federal agencies encourage state and local governments to practice land use planning and control near highways," FHWA says. "The FHWA advocates that local governments use their regulatory authority to prohibit incompatible development adjacent to highways, or require planning, design and construction of developments that minimize highway traffic noise impacts."

• **Quieter vehicles.** *The Noise Control Act of 1972* authorizes the EPA to establish noise regulations to control major noise sources, including vehicles and construction equipment. It also requires EPA to issue noise emission standards for motor vehicles used in interstate commerce and requires the Federal Motor Carrier Safety Administration to enforce these noise emission standards.

• **Abatement of highway traffic noise for individual projects where feasible and reasonable, via noise barriers and other means.** As mandated by the *National Environmental Policy Act of 1969*, and the *Federal-Aid Highway Act of 1970*, FHWA regulates highway traffic noise via 23 CFR 772, the final edition of which becomes effective this July.

During planning and design of a highway project, the regulation requires:

• identification of highway traffic noise impacts;

• examination of potential abatement measures;

• the incorporation of reasonable and feasible highway traffic noise abatement measures into the highway project;

• coordination with local officials to provide helpful information on compatible land use planning and control; and

• identification and incorporation of necessary measures to abate construction noise.

The regulation contains highway traffic noise abatement criteria for different types of land uses and activities. "Highway traffic noise impacts occur when the predicted highway traffic noise levels approach or exceed the noise abatement criteria, or when the predicted highway traffic noise levels substantially exceed the existing highway traffic noise levels," FHWA says.

Interestingly the regulation does not require meeting the abatement criteria in every instance, and does not define the criteria as design standards for highway traffic noise abatement. "Rather, the regulation requires that FHWA make every feasible and reasonable effort to provide substantial noise reduction when highway traffic noise impacts occur," FHWA says, adding "Compliance with 23 CFR 772 is a prerequisite for granting federal-aid highway funds for construction or reconstruction of a highway."

Moreover, FHWA adds that the federal government cannot legally force an agency to meet noise abatement criteria; the only influence it has is the withholding of highway funds.

The federal code notwithstanding, research on highway noise abatement has been driven at the state level for years. For example, an ongoing *Study of the Performance of Acoustic Barriers for Indiana Toll Roads* is considering the effect of environmental variables on the performance of sound walls.

Recent developments in acoustic

>>>

Full Page with bleed

New off-road construction equipment *will have to meet Tier 4 engine emission standards, beginning Jan. 1, 2011.*

Photo by Tom Kuennen

barrier technology include the study of wind and thermal gradients effects on barrier performance, the effects of surface absorption treatments on barrier performance, and the effect of barrier-top geometry in minimizing scattering into the "shadow" region.

Also, ground and asphalt acoustic properties, and the effects of berms and other features of the surrounding environment on sound propagation are additional factors that play an important role, according to the Transportation Research Board, which has oversight on the research.

The Indiana DOT has been conducting research on sound wall performance for a while, but the above variables have not been part of it, with only barrier height being considered. Non-uniform geometries, optimal placement of sound walls, and wind and temperature gradient issues have not been considered. The Indiana work will develop a better understanding of these phenomena on acoustic barrier performance.

In Washington State, last year the DOT completed noise mitigation aimed at expansion joints on the new Tacoma Narrows Bridge. Prior to the sound walls, each time a vehicle passed over the expansion joints at either end of the bridge, a loud vibrating "zipper" sound reverberated through nearby communities.

Crews erected the first of sections of new noise walls on the southwest corner of the bridge in early 2009. Four noise walls, two on each end of the Tacoma Narrows Bridge between the concrete approach and the expansion joints, were constructed to reduce sounds heard by neighbors of the bridge, reported the Washington State DOT.

The walls are about 100 feet long and range in height from 8 to 10 feet. They are designed to mimic the shape of the bridge anchors and the traffic-facing sides of the barriers are covered with a special concrete sound-absorbing material called *SoundSorb*. SoundSorb, a product of Concrete Solutions, Inc., is a cement-based sound abatement product designed to absorb sound energy and significantly reduce the expansion joint noise heard by nearby communities.

SoundSorb acoustical material mitigates noise by absorbing sound energy, rather than reflecting it, the maker says. The material is integrated with a structural concrete precast panel during the production phase. Effective sound absorption with aesthetic features on sound walls used for noise control is in demand by engineers for several uses.

By using SoundSorb in a random-edged treatment, creating peaks, improved noise abatement was attained on the Tacoma Narrows Bridge. Two-by-two-foot panels of SoundSorb were retrofitted to the crash barriers, as well as to the wall along the bridge.

In addition to SoundSorb, a Wisconsin DOT survey identified other value-added sound-absorbing materials that are reputed to reduce noise, which include:

- *AcoustaCrete*, a sound-absorptive concrete used as facing for retaining walls, mechanically stabilized earth panels and lagging panel walls. *ShoreWall* is a related product that combines noise barriers and retaining walls in concrete post and panel designs. Both are manufactured by Faddis Concrete Products of Pennsylvania.
- *Durisol* is a facing material that uses a wood filler and cement mixture that is water-permeable, insect-resistant and effective at absorbing noise. According to the manufacturer, Armtec, Durisol material offers thermal insulation, energy absorption, non-combustibility, no-toxicity, outstanding exterior durability, and a high strength-to-weight ratio. It's been manufactured since 1953.
- The proprietary *Sound Fighter LSE Panel* is constructed from materials that are water-resistant, rust-proof, noncorrosive, and extremely durable in the harshest outdoor environments, the manufacturer says. Sound Fighter has a high-density, UV- and color-stabilized synthetic shell. Next, premium acoustic absorptive media is inserted to absorb unwanted noise by completely diffusing the sound waves. The LSE Panel also contains an acoustic sound board that eliminates noise from penetrating through it.

'D-Day'

D-Day is Jan. 1, 2011. The "D" in "D-Day" stands for *Diesel*, because that's when the long-awaited Tier 4 clean diesel technology becomes the standard for off-road construction equipment engines.

Three key elements comprise the cleaner diesel program: *cleaner diesel fuel, advanced engine technology* and *aftertreatment*. Now, starting in 2011, this new-generation clean diesel technology known as Tier 4 will be required for the construction industry for off-road engines and equipment.

Tier 4 refers to a generation of federal air emissions standards established by the EPA that apply to new diesel engines used in off-road equipment. Essentially it requires manufacturers to reduce the levels of particulate matter and oxides of nitrogen (NOx) to a level that is 50- to 96-percent lower than the existing generation of diesel engines, reports the Diesel Technology Forum.

Tier 4 emissions requirements apply to new products only and are not retroactive. Examples of regulated applications include excavators, bulldozers, wheel loaders, backhoe loaders, road graders, diesel lawn tractors, farm tractors, logging equipment, portable generators, skid-steer loaders and forklifts.

The "tiered" series of emissions regulations, beginning with Tier 0, has been in effect for more than a decade, governing new off-road engines and equipment, according to the Diesel Technology Forum. These levels of standards establish progressively lower allowable emissions of nitrogen oxides and particulate matter.

"The Tier 4 standards provide manufacturers with a flexibility provision and include an interim step – Tier 4 interim – which requires substantial reduction in PM emissions and flexibility in lowering oxides of nitrogen, the forum says. "A Tier 4 final step includes additional reductions in NOx and HC emissions."

New Tier 4 generation engines and equipment will require the use of ultra-low sulfur diesel fuel, which has no more than 15 ppm sulfur, according to the Diesel Technology Forum. This fuel has been used since 2006 in on-highway vehicles.

"Older off-road machines and engines can continue to use the higher sulfur fuels, which will be available in diminishing quantities nationwide until December 2011," they say. "Supplies of the old 'higher sulfur' diesel fuel will be diminishing rapidly beyond 2010, but still may be available in some more remote locations and areas of the country."

What is on the horizon? Now that Tier 4 diesel emissions are near zero, under the Obama administration EPA may set its sights on carbon dioxide emissions, which are thought to advance presumed global warming. Thus the regulators may be able to continue their career mission: issuing regulations. In the meantime, off-road Tier 4 engines will become a reality in 2011.

For more information, visit the Diesel Technology Forum at *www.dieselforum.org* or visit the Clean Diesel Fuel Alliance at *www.clean-diesel.org*.

>>>

__Precast concrete pavement slab__ is lowered into Utah's I-15 between Clearfield and Layton.

Courtesy of the Utah DOT Research Department

Future Performance of Raised Markers

The Texas Department of Transportation (TxDOT) is looking to recent research to indicate performance of retro-reflective raised pavement markers in 2011 and beyond, it was reported late this year.

As a Sunbelt state, Texas can take advantage of retro-reflective raised pavement markers (RRPMs) to guide motorists on dark and rainy nights (snow plows tend to bust RRPMs off a pavement). Their durability and performance are of critical importance to the agency. But recently TxDOT began to notice an increased number of RRPM failures such as poor retention on pavements, physical damage and loss of retro-reflectivity.

In response, the Texas Transportation Institute (TTI) began to research the causes of premature RRPM failures. "All the markers that TxDOT was using met the requirements set by ASTM specifications," said Yunlong Zhang, TTI assistant research scientist and research supervisor, earlier this year. "However, RRPM performance varied significantly, and the results from existing testing methods also did not correlate with field performance."

TTI was asked to identify or develop new lab testing methods that would help the state more accurately predict marker performance in the field. Over a three-year period, researchers conducted multiple tasks that included lab and field tests, as well as surveying TxDOT districts and RRPM manufacturers to gather information on existing test procedures and marker field performance.

The researchers monitored four test deck locations selected according to traffic condition and pavement type. "For example, one of our test decks was on the I-610 Loop in Houston, which is a very high-volume concrete roadway," Zhang says. "We also had a test deck on a low-volume road with a flexible pavement surface. The goal was to get a wide range of test data in different scenarios."

The research yielded several important findings with respect to RRPM future performance and testing methods:

- Existing testing methods were inadequate and cannot predict field performance of the markers.
- Performance of RRPM products has a wide range and depends on traffic volume, truck traffic and pavement surface type.
- Retroflectivity degrading is directly related to average daily traffic.
- High truck traffic significantly accelerates marker physical damage.
- Marker retention is directly related to installation quality.

Another important finding was that

__Damage to shell of retro-refective raised pavement marker__ could be caused by something as simple as a stone wedged in tire tread.

Courtesy of the Texas Transportation Institute the results from the pendulum impact test – which models the forces on a pavement marker from vehicular impact – had a sound correlation with that of field performance, giving TxDOT a proven marker quality-control tool. The pendulum impact test was developed during this research.

"RRPM failures are not only a public safety issue, but also expensive when you take into consideration having to close the roads for repairs," says Zhang. "With the results of this research, we were able to recommend that TxDOT emphasize the quality of RRPM installation [as] we found it directly relates to performance in the field. And TxDOT is also now able to better predict the life expectancy of these markers for all types of roadways and traffic volumes."

What Utah Learned About Precast Slab Repair

Given the tremendous delays that conventional Portland cement concrete slab repair using ready-mixed concrete can have on traffic, a growing number of state DOTs and toll authorities have been looking closely at precast slabs as a way of expediting future pavement reconstruction, and it is a trend that will continue in 2011.

In September 2010, the Utah DOT articulated "lessons learned" tips from the application of precast concrete pavement slabs on I-15 in Utah Region One.

Precast slabs using the proprietary *Fort-Miller Super-Slab* system were placed by contractor B. Jackson Construction & Engineering along I-15 near Clearfield and Layton, Utah. This was the first full-scale precast pavement project for UDOT and was completed in 2009, and was documented by the Research Division, along with Scott Nussbaum, region materials engineer, and P.J. Roubinet, field engineer.

Here's what Utah DOT's Research Division found:

- For bidding purposes, it is very important to carefully identify all of the locations. Middle lanes require very accurate width verification. Lanes on the edge may require base or shoulder repair.
- Whether the precast slabs are placed together or individually have a dramatic effect on installation costs.
- There needs to be sufficient time between finalizing the detail and the installation to allow for casting and curing of the slabs.
- To gain the benefits of longevity with the precast concrete, wet curing requirements should be tightened up. The standard at the time of the project required wet cure of 14 days.
- Utah DOT's generic option needs additional design work, drawings, and details to reduce risk in bidding. Included should be casting tolerances, requirements for dowel bar caps, reinforcing steel, joint tolerances, details

>>>

In Virginia, a Findlay Irvine grip tester is used to measure continuous skid resistance measurements along the left wheel path of the travel lane of the test sections.
Photo courtesy of Izeppi, Flintsch, McGhee

on how to deal with tie bars and offset transverse joints, bedding grout, and encasement grout.

• Any asphalt patching requirements should be included in project documents.

• Finishing requirements (i.e., a broom finish) should be included in project documents.

• Minimum length of slabs to be allowed to remain in place should be clarified.

• Additional slab removal instruction should be provided.

* Vertical placement tolerances should be increased to allow for a little bit of settlement. On the project, some slabs ended up below the grinding plane.

• Bedding grout is essential to slab stabilization. On the project, traffic caused even the shimmed slabs to squirm and settle a little bit if the grout had not been installed.

• Acceptance testing should be included and encasement grout strength verified.

• Tie bars, No. 5 bars at longitudinal joints, were a construction complication.

Drilling increased work exposure to traffic and was a time-consuming part of the process. The need for and benefit from these tie bars should be re-evaluated.

Additional information on the project can be obtained from Scott Nussbaum at *snussbaum@utah.gov*, Barry Sharp of Central Materials at *rsharp@utah.gov*, or David Stevens of Research at *davidstevens@utah.gov*.

Benefits of High-Friction Pavements

According to a 2010 Virginia Tech Transportation Institute (VTRC) report, high-friction driving surfaces offer long-term performance and a positive benefit-to-cost ratio. The report, *Field Performance of High-Friction Surfaces* was authored by Edgar de León Izeppi, Ph.D., senior research associate, Center for Sustainable Transportation Infrastructure; Gerardo W. Flintsch, Ph.D., associate professor of civil and environmental engineering, and director, Center for Sustainable Transportation Infrastructure Virginia Tech Transportation Institute; and Kevin K. McGhee, P.E., associate principal research scientist, VTRC.

Great attention has been focused on the new concept of pavement preservation, even in place of capacity improvements. As interest in pavement preservation via thin high-performance asphalt overlays grows in this decade, focus will fall on such high-friction driving surfaces as an option for thin-lifts.

The goal of the researchers was to develop guidance for agencies when they consider a high-friction surface (HFS) for low-skid resistance pavements, or where there is a need for high friction.

"HFS systems are specially designed thin surface treatments that provide significant additional skid resistance [for] pavements and bridge decks without significantly affecting other qualities of the surface such as noise, ride quality, or durability," the authors write.

In addition to an overview of HFS locations and climatic conditions, the authors recount experiences reported by user agencies, and summarizes key HFS service-level indicators, such as friction and texture. Agency experiences include a sample benefit-cost analysis from an installation in Wisconsin that justified an HFS application through crash reductions that resulted following the measured increase in skid resistance.

"Optimal surface conditions should exhibit sufficient friction and texture depth to reduce roadway highway accidents," the researchers write. In the context of pavement management, HFS pavements are becoming an appealing alternative to conventional pavements as these systems can increase friction and improve texture immediately after placement without significantly affecting other pavement qualities, such as noise or durability, they say. Such high-friction surfacings consist of high-polished stone value aggregates mixed with some type of resin to hold the aggregate particles together and bond them to the existing pavement surface.

The project also tested HFS systems to determine how effectively these systems are functioning to provide enhanced friction and texture. Texture and friction properties were measured with the *Dynamic Friction Tester* (ASTM E1911); the *Circular Track Meter* (ASTM E2157); and the *GripTester* (ASTM E2340).

All HFS systems can be classified

into two categories depending on the temperature of the binder during their construction: *cold-applied* and *hot-applied* processes, according to the VTRC report. Cold-applied systems use thermosetting resins such as epoxy or polyurethane, which are supplied in different containers and, when mixed, begin a heat-producing chemical reaction that results in hardening. In the hot-applied process, the premixed granular material is provided in bags, heated in a boiler and then applied to the surface while still hot. In this case, the resin used is referred to as thermoplastic.

"There are several types of resins used as binders, and each adds unique capabilities to the system," Izeppi, Flintsch and McGhee say. The main resins used are epoxy-resin, rosin-ester, polyurethane-resin, and acrylicresin.

Aggregates for HFS systems should provide for skid-resistant surfaces, they say. They should be able to resist the polishing effect caused by tire traffic, and be resistant to the disintegration caused by weathering. The higher the polished stone value (PSV) of an aggregate, the longer the aggregate will provide sufficient friction when used in road surfacing, according to the report, adding the surface layer needs to retain its texture for as long as possible to provide skid resistance to traffic.

Because these HFS systems are value-added products, some proprietary, a benefit-cost analysis ought to be undertaken prior to adoption of an HFS, they maintain. Costs include typical construction costs, routine maintenance costs, and typical accident costs.

The authors reported an example set of benefit-to-cost calculations from Italgrip sections in Wisconsin. In this example, the Wisconsin DOT estimated the construction costs for the Italgrip sections in 1999 to be approximately $13 per square yard, and that 2008 costs are estimated at approximately $20 per square yard. The numbers of incidents after the applications are subtracted from the ones that occurred before the applications and multiplied by their respective costs – $4,400 for vehicles and $30,000 for injuries – to quantify the benefits.

Obtaining the benefit-to-cost ratios, the results show that in three of the four sections the alternative is economically justified compared to the base scenario, with benefit-to-cost ratios ranging between 2 and 8.

The authors maintain that local and state highway agencies should consider the use of HFS systems for localized situations in which skid resistance of the existing surface material is low, or the friction demand is very high, and their use will yield benefits that outweigh their costs. ❖