



# KANSAS LTAP Newsletter

Spring 2011

A quarterly newsletter of the Kansas Local Technical Assistance Program (LTAP) at the Kansas University Transportation Center with funding from Kansas DOT and the Federal Highway Administration

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## The Safety Edge is Gaining Ground

*This paving technique helps vehicles recover if they run off the pavement.*

The Safety Edge is a simple and effective solution to reduce the likelihood of run-off-the-road crashes. It can help save lives by allowing drivers who drift off highways to return to the road safely. When laying a new layer of asphalt, instead of creating a vertical drop-off at the edge, an attachment added to the paving machine shapes the edge of the pavement to 30 degrees. Research has shown this is the optimal angle to allow drivers to re-enter the roadway safely. The Safety Edge provides a strong, durable transition for all vehicles. Even at higher speeds, vehicles can return to the paved road smoothly and easily.

The Federal Highway Administration (FHWA), as part of its "Every Day Counts" initiative, has set a national goal to increase the use of the Safety Edge on state and local roads, working with States to develop specifications and adopt this pavement edge treatment as a standard practice on all new paving and resurfacing projects.

LTAP Centers across the country



*This shows the Safety Edge during an overlay project and the finished product with the shoulder material in place next to the Edge (inset).*

are helping meet that goal through a variety of ways, including workshops, paving demonstrations, safety edge "shoe" (attachment) loan programs, and education. This article is part of that effort.

*Continued on page 2*

## The Many Benefits of Warm Mix Asphalt

By Lisa Harris

You've heard of cold mix and warm mix. Now the advantages of both have been combined ... in warm mix. Here's information about why FHWA is promoting this technology and some examples of its use in Kansas.

Warm Mix Asphalt (WMA) is the generic term for a variety of technologies that allow producers of Hot Mix Asphalt (HMA) pavement material to lower temperatures at which the material is

mixed and placed on the road. It is a proven technology that can:

- Reduce paving costs.
- Extend the paving season.
- Improve asphalt compaction.
- Allow asphalt mix to be hauled longer distances.
- Improve working conditions by reducing exposure to fuel emissions, fumes, and heat.

*Continued on page 4*



## Safety edge *Continued from page 1*

Kansas LTAP has also obtained two Safety Edge shoes for loan. This article will describe in more detail why the Safety Edge is considered a more effective technology than other methods for creating an angled edge, and how to start using the technology on your paving projects.

### Why are pavement drop-offs so dangerous?

Roadway departures account for 51 percent of all fatal crashes and severe-injury crashes in Kansas. Further, most of those roadway departure fatal crashes occur on rural roads (see Kansas data below). Unforgiving pavement edges have been found to significantly contribute to roadway departure crashes. For example, researchers studying crashes in Missouri during 2002-2004 reported that pavement edges may have been a contributing factor in as many as 24 percent of rural run-off-road crashes on paved roads with unpaved shoulders. This type of crash was twice as likely to include a fatality than other types of rural crashes overall on similar roads.

When a driver drifts off the roadway and tries to steer back onto the pavement, a vertical pavement edge can create a “tire scrubbing” condition that may result in over-steering. If a driver over-steers to return to the roadway without reducing speed, he or she is prone to lose control of the vehicle. The resulting crashes tend to be more severe than other crash types. The vehicle may veer into the adjacent lane, where it may collide with oncoming cars, overturn, or run off the opposite side of the roadway and strike a fixed object or overturn on a slope. Inexperienced drivers are not the only victims of tire scrubbing—it can happen to anyone.

Smaller, lighter vehicles, including bicycles and motorcycles, have an especially hard time climbing a steep pavement edge. At high speeds, the climb is particularly dangerous. According



*A pavement edge without the Safety Edge has an abrupt drop-off that makes it more difficult for errant vehicles to recover back to their lane without over-correcting.*



to in-service evaluations, a vertical or near vertical drop-off of 2.5 inches or more has been shown to pose a significant risk, while pavements built with the Safety Edge showed reductions of more than 5 percent of total crashes.

### Why does the safety edge work?

A drop-off is created during most paving projects. Even when the unpaved shoulder graded back to the pavement edge to eliminate the dropoff, the edge often becomes exposed within a few months. The edge may deteriorate.

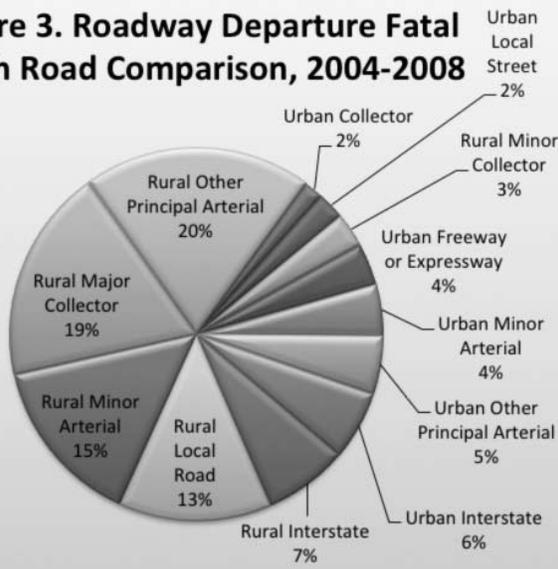
The Safety Edge shapes the edge of the pavement to 30 degrees using a commercially available device (called a shoe) that can be attached to the paver. The asphalt is extruded under the shoe and that provides an additional level of consolidation/compaction. This results in a durable edge that resists edge raveling more effectively than dragging a chain to smooth the edge, for example, which is a common paving practice in Kansas. Research has shown the Safety Edge’s 30-degree shape allows drivers to re-enter the roadway safely.

After paving with the Safety Edge, the adjacent shoulder material should then be regraded flush with the top of the pavement, as this provides the safest pavement edge. The difference between the Safety Edge and other methods is that when the edge becomes exposed over time, this shape can be more safely traversed than a vertical or raveled edge.

### Case study: Iowa’s Safety Edge policy

FHWA’s Iowa Division and the Iowa Department of Transportation (IDOT) recently began working with counties to install the Safety Edge on projects with a history of roadway departure crashes. The Safety Edge was included at the county level on project plans or incorporated as change orders on already-let projects. During one of these county projects, the contractor’s safety officer said the Safety Edge potentially reduced the contractor’s liability by providing

**Figure 3. Roadway Departure Fatal Crash Road Comparison, 2004-2008**



Source: Kansas Roadway Departure data. Figure 3 from the Roadway Departure chapter of the Kansas Strategic Highway Safety Plan (2011 draft), Kansas Department of Transportation.



## Safety Edge in Kansas

by Lisa Harris

**M**ike Crow of the Kansas Asphalt Paving Association says the Safety Edge has been slow to catch on in Kansas. Asphalt contractors use other methods to create a graduated edge. Many road agency specs, including KDOT's, do not include the Safety Edge. But research shows that other methods are not as effective for safety or durability of the pavement edge.

However, the Safety Edge is starting to gain ground in our State. KDOT is planning to install a Safety Edge on a contracted paving project this October in District 3. Miami County will also use the Safety Edge for a six mile project planned in September. Both projects will use Safety Edge shoes borrowed from Kansas LTAP (see below).

Johnson County is planning to pave 15 miles of its roads with the Safety Edge, per Norm Bowers of the KAC. APAC is the contractor and they will be using their own shoe.

Riley County added the Safety Edge to a project a few years ago. Rod Meredith, assistant public works director, said that the edge is holding up well. "The edge is not raveling, even when the shoulders pull back from the edge over time. It's really easy to get back on the road if you happen to drive off the edge; we've tested it. There's no reason not to use it every time," he said.

Adding a Safety Edge to pavement is eligible for High Risk Rural Roads (HRRR) funding available from KDOT, and your HRRR application can include the purchase of a safety edge shoe to do the work.

Want to try before you buy? Kansas LTAP has acquired two Advant-Edge shoes for loan, along with a universal bracket for attaching the shoe to a paving machine. Contact Pat Weaver at [weaver@ku.edu](mailto:weaver@ku.edu) to arrange a loan. Want to see a live demo? Contact Pat to be added to a list for notification of pending projects.

immediate elimination of the vertical drop-off.

After seeing how easily even large vehicles could traverse the pavement edge without loss of control or damaging the edge, the county decided its typical practice of bringing in a gravel wedge before nightfall when a paving project was under way was not necessary when the Safety Edge was present. This saved the county time and money. The results

## Common Questions

**Why should I change my current process to include the Safety Edge?** The Safety Edge improves the short- and long-term safety of the roadway. Studies show that severe crashes may occur when a vehicle drops a tire over the edge of a nearly vertical pavement. The research shows that virtually all drivers can recover, even at high speeds, when the pavement edge is a 30-degree wedge. Using the Safety Edge also improves the durability of the pavement edge.

**Do I need to modify my paving process to install the Safety Edge on asphalt?** Very few changes are needed. The key item is to add a specially designed shoe, per manufacturer's instructions, to the paver to create the Safety Edge. While paving, the shoe should be monitored and adjusted to keep the bottom edge of the device in contact with the road shoulder surface. Using the Safety Edge should not affect the rate of production.

**How much will the addition of the Safety Edge cost per mile?** It will be almost negligible for Hot Mix Asphalt. It does depend somewhat on the specific design and construction parameters, but typically the process compacts asphalt that often otherwise would break off because it was loose. When measured, it has been calculated to be less than one percent additional asphaltic material.

**How can I get started?** If you are contracting-out a paving job, add the Safety Edge to your specs. FHWA has posted a sample one-page Guide Specification at [http://safety.fhwa.dot.gov/roadway\\_dept/pavement/safedge/](http://safety.fhwa.dot.gov/roadway_dept/pavement/safedge/). If your agency uses its own equipment, borrow a Safety Edge shoe from Kansas LTAP to give it a try, or visit the FHWA website above (click on Frequently Asked Questions) for information on the types of Safety Edge shoes currently on the market and where they can be purchased.

were so positive that IDOT decided to use the Safety Edge on one of its own paving projects, and since then, IDOT has adopted the Safety Edge as standard practice statewide.

### For more information

For more information on the Safety Edge or the Every Day Counts Initiative, contact Pat Weaver at Kansas LTAP, (785) 864-2595 or Norbert Muñoz at FHWA's Kansas Division at (785) 271-2448. To view footage of a Safety Edge under construction, watch the Safety Edge video available from our lending library. Read about the video on page 14. ■



Sources:

- FHWA. Safety Edge Pavement Edge Treatment. 2010. [http://safety.fhwa.dot.gov/roadway\\_dept/pavement/safedge/brochure/](http://safety.fhwa.dot.gov/roadway_dept/pavement/safedge/brochure/)
- Kansas DOT. Kansas Strategic Highway Safety Plan. <http://www.ksdot.org/burTrafficSaf/reports/kshs.asp>



## Benefits of warm mix *Continued from page 1*

### **Lower temperatures, shorter project times, lower costs**

WMA production methods use temperatures 30 to 120 degrees Fahrenheit lower than traditional hot-mix asphalt. Because less energy is needed to heat the asphalt mix, less fuel is needed to produce WMA. Fuel consumption during WMA manufacturing is typically reduced by 20 percent.

In paving projects, the greater the temperature difference between the asphalt mix and the outside temperature, the faster the mix cools. Since faster cooling effects durability, cold ambient temperatures adversely affect hot-mix asphalt. In contrast, WMA cools more slowly allowing WMA to be used successfully in lower temperatures. As a result, WMA extends the paving season. It also makes paving more feasible during cooler nighttime temperatures.

Warm mix asphalt saves time and money in other ways, too. Because WMA makes compaction easier, cost savings are achieved by reducing time and labor compacting the mix. Lower temperatures also permit more asphalt mix to be hauled for longer distances, reducing transportation costs with fewer trips back and forth to the plant.

How does it work? WMA technologies reduce the viscosity (the thickness) of the asphalt binder so that asphalt aggregates can be coated at lower temperatures. The key is the addition of additives (water-based, organic, chemical, or hybrids) to the asphalt mix. The additives allow the asphalt binders and asphalt aggregates to be mixed at the lower temperatures. Reducing the viscosity also makes the mixture easier to manipulate and compact at a lower temperature.

### **Good for workers and the environment**

Working conditions are much healthier with WMA. Both at the production plant and on the construction site, workers inhale far less smoke and dust, and the working



www.shutterstock.com / Dmitry Kalinovsky

*Paving crews are enthusiastic about Warm Mix Asphalt. Less smoke and less heat — better than at the above Hot Mix project.*



environment is not as hot. Comments from workers have been highly positive, per FHWA.

WMA also produces fewer emissions, making it possible for paving to be done on some days in urban areas when the air quality would typically put a halt to paving.

### **Better compaction, better performance**

Proper compaction is critical to well-performing pavements. One indication of proper compaction is density. KDOT and federally-funded projects have density requirements as part of their quality control. WMA can help achieve proper density and improve pavement performance.

WMA has been used successfully in a range of pavement thicknesses. It is durable enough to withstand high traffic demands. According to FHWA, Warm Mix Asphalt has been used in all types of asphalt concrete: dense-graded, stone matrix, porous, and mastic asphalt. Multiple WMA technologies are available, so the choice can be adapted to the temperatures and materials required.

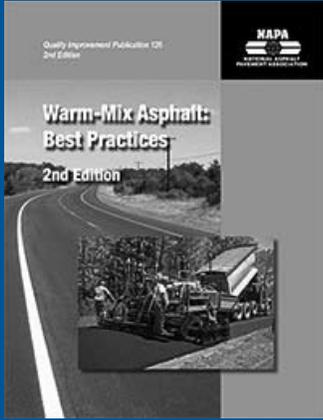
Warm Mix Asphalt has been used successfully in Europe for more than 10 years. In the United States, WMA projects are now in more than 40 States including Kansas.

### **WMA use is growing in Kansas**

Mike Crow, executive director of the Kansas Asphalt Paving Association, said paving contractors in Kansas are latching on to the Warm Mix technology. He thinks that several years down the road, traditional Hot Mix will be a thing of the past.

To date, the two WMA technologies used most frequently by Kansas contractors are 1) a foaming method that employs water, and 2) a method using the chemical additive Evotherm™. For this method, an asphalt emulsion that contains Evotherm is used in place of the traditional asphalt binder. The emulsion is mixed with the aggregate in the HMA plant.

The foaming method with water is popular, said Crow, because there are no extra costs for materials beyond the initial cost for the foaming equipment. WMA methods that use additives have



### Learn More About Warm Mix

The National Asphalt Paving Association has an excellent guide on warm mix asphalt. It is reasonably priced at \$35 for governments and \$25 for NAPA members. It contains detailed information on the different technologies and additives available for producing warm mix and examples of their successful use on projects.

You can order this publication at NAPA's warm mix website at <http://www.warmmixasphalt.com>.

the cost of the additive with each job. However, significantly lower asphalt temperatures can be achieved with chemical additives as compared with water, so the cost savings resulting from cooler temperatures can help recover the cost of the additive.

The manufacturer of Evotherm reports that their product improves aggregate coating, workability, adhesion, and compaction with no change in materials or job mix formula required.

Contractors are using WMA for projects in several KDOT districts. According to Shad Lohman of KDOT's District 3, contractors are now using WMA exclusively on KDOT projects in his district. KDOT does not specify the use of WMA, but it is an option contractors can choose. Most of the contractors use the foaming method and one contractor, Hall Brothers, uses Evotherm. Lohman said the WMA pavements are performing well, and that KDOT has been paying out a higher percentage of bonuses to the contractors for meeting compaction requirements for their warm mix pavements. That indicates better long-term performance for KDOT's investment.

### More information

For more information on Warm Mix, visit the National Asphalt Paving Association website at <http://www.warmasphalt.com>. You might want to also purchase their Best Practices guidebook on the topic (see above).

The Federal Highway Administration also has a good Web page of information at <http://www.fhwa.dot.gov/pavement/asphalt/wma.cfm>. Like the Safety Edge, WMA is a technology promoted by the FHWA's Every Day Counts initiative.

There will also be a few opportunities to attend face-to-face presentations about WMA this fall.

- The MINK Local Roads meeting will have a session on Warm Mix Asphalt on September 21.
- Warm Mix will be a topic at an Asphalt Forum being conducted by the Kansas Asphalt Paving Association, scheduled for November 2-3 in Topeka.
- Finally, Jake Lauer of Hall Brothers will talk about chemical WMA at the 55th Annual Asphalt Paving Conference on December 1 in Lawrence. See page 14 for information on these opportunities. ■



### Sources:

- FHWA. Warm Mix Asphalt Introduction. <http://www.fhwa.dot.gov/everydaycounts/technology/asphalt/intro.cfm>
- Kansas Asphalt Paving Association. Warm Mix Asphalt. <http://www.ksasphalt.com/Warmmix.html>
- Phone interviews with Shad Lohman, KDOT, and Mike Crow, KAPA.

## Want to be an LTAP trainer?

We at Kansas LTAP are keeping an eye out for some new trainers. We're starting to building a list of potential trainers to contact when we're ready to hire new people. We hire trainers on a part-time contract basis, so it's perfect for retirees.

Interested? We are looking for people who are effective at teaching skills or procedures who have experience training one or more of our three main audiences: 1) road and bridge or public works officials, 2) supervisors/foremen or 3) front-line workers. Prior experience doing the job being taught is a big plus.

To add your name to the list, or to learn more about our specific needs for subject expertise, please contact Kristin at (785) 864-2594 or at [kbkelly@ku.edu](mailto:kbkelly@ku.edu). We look forward to hearing from you. ■

## Do you need an engineering license to do this?



Do you need an engineering license to maintain official records on crashes that occur on the roads in your jurisdiction? Answer below. ■

ANSWER: No. An engineering license is not needed.



# “De-Paving” is a Hot Topic in the Plains States

By Lisa Harris



South Dakota LTAP

**S**outh Dakota LTAP's Manager Ken Skorseth is a well known expert on gravel roads. He is the author of *Gravel Roads Maintenance & Design Manual*, considered the top resource in the United States

on the topic. (You can get a copy in hard copy or on CD free from our LTAP library). A subject Skorseth is talking about a lot these days is the practice of taking paved roads back to gravel, or as it is sometimes called, “de-paving.” This practice is increasing in frequency in South Dakota and in other nearby states, including Kansas.

## How much traffic? How many trucks?

Why are counties turning paved roads back to gravel? There are several reasons, and one is simple economics. Counties don't have enough money to maintain and re-surface their paved roads. But Skorseth advises counties to consider how their roads are used before they get too far along in their decision-making. Expected cost-savings could evaporate depending on how much traffic the road carries and how many of those vehicles are heavy trucks. Gravel roads need to be maintained, too.

## Beyond “de-paving”: Alternatives to paving

While “de-paving” has become a commonly-used term about this topic, Skorseth prefers the term “alternatives to paving” to better describe the decision-making process. In a recent presentation Skorseth identified the three main alternatives:

- Simply go back to gravel;
- Deep base with surface treatments, like blotters or seals;
- Stabilized gravel.

The decision to convert a paved road to gravel needs very careful planning, including life cycle cost analysis. That analysis may show that changing to gravel isn't the most cost-effective alternative if average daily traffic is over 170, or if truck traffic is high. A sealant on a deep base may be a good alternative, and has been used successfully in South Dakota (and also overseas in Australia). Skorseth said gravel stabilized with calcium chloride, magnesium chloride or bentonite is a viable alternative, but there is much yet to learn because of a lack of good life cycle data on these surfaces.

A useful resource is a South Dakota DOT-funded study of surface selection for

**K**en Skorseth will be giving three presentations in 2011 in our area on the topic of when and how to consider alternatives to pavement. The first will be at the MINK Local Roads meeting in St. Joseph, MO, **September 21-22**. Download an agenda at <http://www.moltap.org>. The second presentation will be a half-day workshop in Lawrence, KS, on **November 30** (see page 14). Ken will also give a short presentation the Asphalt Paving Conference in Lawrence on **December 1**. View the agenda at <http://www.continuinged.ku.edu/programs/asphalt/agenda.php>

Ken will cover the points made in this article plus a lot more, sharing photos and examples of paving alternatives that worked (and a few that didn't). Don't miss these excellent opportunities to learn from the best!

local government. The study can be found online at: [http://www.state.sd.us/Applications/HR19ResearchProjects/oneproject\\_search.asp?projectnbr=SD2002-10](http://www.state.sd.us/Applications/HR19ResearchProjects/oneproject_search.asp?projectnbr=SD2002-10). Advice from Skorseth: Go in with your eyes wide open when deciding where and how to “de-pave” your asphalt roads. ■

Source: Ken Skorseth. Alternatives to Paving. Presentation at NACE 2011 Annual Conference.

## Harper County's Experience

**H**arper County, Ks., has reclaimed around 55 miles of its old blacktop pavements. According to John McClure, the County's field operations supervisor, these roads carry 50 or fewer vehicles per day, were about four inches thick, and had 40 to 50 potholes per mile ranging from basketball size to five feet across. He said there was no maintenance on these roads over many years because county commissioners did not want to spend the money. Several of the roads have coop elevators on them, so during harvest hundreds of trucks pass over them.

McClure said that when the word got out about turning the roads back to gravel, the public was very upset, but six months later things had simmered down for the most part. McClure said the key was to try and keep the roads in good shape and smooth. “Each mile we added a couple inches of gravel and graded it every time it rained, so usually 3 to 4 times per month per mile... [Now] the roads are all weather and after a rain the traffic does not hurt the roads at all.”

The roads contain millings and gravel with no extra oil. As for ongoing maintenance other than grading after rains, McClure noted that: “The reclaimed roads have kinda tried to form back into a blacktop with traffic and hot weather, so when this happens we add a little gravel over the problem areas.”

Lesson learned: “I still think that with 50 cars a day or less you just can't spend the amount of money it costs to blacktop,” said McClure. “The key is to not let your blacktops get in bad shape, but we did over the last 40 years.” For more information, contact John McClure at (620) 842-5240 or [roadbridge@harpercountyks.gov](mailto:roadbridge@harpercountyks.gov).



# KDOT Korner

## Local safety funding in Kansas now considers high-RISK locations as well as high-CRASH locations

By Lisa Harris



FHWA

*This concrete headwall is a roadside hazard. You can apply for HRRR funds to remove it.*



Every local jurisdiction has a location (or several) that is considered a “crash waiting to happen.” It could be a tight curve. It could be a concrete culvert headwall that a vehicle might hit if it leaves the road. It could be guardrail that is damaged or sits so low to a built-up road after several overlays that it would no longer be effective in a crash.

KDOT has a funding program to help address local safety problems called the High Risk Rural Roads (HRRR) Program. Until recently, the types of projects mentioned above were not eligible for funding under this program, because crashes needed to have happened at eligible locations. That is no longer the case. This article will describe how the program is changed and will encourage you to apply. The deadline has been extended to September 16, 2011.

### How has the program changed?

Before, HRRR projects in Kansas were funded to improve locations or corridors that had a history of crashes. That makes good sense on the face of it, and it fit with the federal requirement that the program be “data-driven.” However, a crash location does not necessarily indicate that a crash has a higher likelihood of

*No crash data needed for several kinds of projects.*

happening there in the future. For some intersections that may very well be true, but for some run-off-the-road crash locations, other factors could be at play in the crash, like distracted driving, falling asleep at the wheel, or drunk driving. The crash could have happened anywhere on the road.

KDOT has had a systematic process for improving safety at curves on state system roads for several years now. The program funds improvements for “horizontal” (flat grade) curves under a certain radius. The smaller the radius, the tighter the curve, and the higher likelihood of a vehicle running off the road at the curve. KDOT’s program adds rumble stripes along the edgeline of those curves, among other measures. KDOT based this practice on statewide crash data rather than site-specific crash data.

This same idea is being applied to improving safety on local roads. KDOT has added eligibility for certain systematic improvements to the HRRR program.

What about the data-driven requirement? That’s still in force, but **KDOT does NOT require you to provide that data.** KDOT already has it in the form of statewide crash data and national research results that show that certain types of improvements reduce crashes.

### What is eligible for funding for local systematic improvements?

KDOT is focusing on a few types of projects in 2011 that include:

- Edge treatments, including installing a Safety Edge on pavement overlays and

adding rumble stripes or strips to new or existing pavement.

- Tree removal.
- Removing a culvert headwall.
- Guardrail upgrade or removal.
- Culvert modification, including lengthening it or adding a traversable grate over the end of the culvert.

### The HRRR application: It’s easy, and here’s a tip

The application requires some basic information about your project and, like the previous round’s application, has a prominent section for you to document crash data. *If you have no crash data, skip this section! – just write across the section: “No crashes – systematic project” and continue on.* The application should not take long to prepare.

HRRR projects require a 10 percent local match, but local agencies can use federal exchange dollars for the local match, including reimbursement for your agency’s crew time to make the improvements if you do the work internally. Also, KDOT now allows federal dollars to be spent on design.

KDOT is ready to take your application(s). Call or email Lynn Berges right away if you do not already have the BLP memo and application form he sent out to local agencies in July. Berges can be reached at (785) 296-0410 or Lynn.Berges@ksdot.org.

Again, the deadline is September 16, 2011. If you miss the deadline, call Berges right away to ask when the next round of applications will take place. ■



Source:

- KDOT Bureau of Local Projects Memo 11-7, July 22, 2011.



# Which Pavement Marking Product to Use?

By Nora Fairchild

*A look at some studies on the subject, and recommendations for different types of roads.*

According to the Federal Highway Administration's Safety website, the United States spends approximately \$200 billion annually on pavement markings. This is money well spent. Without pavement markings' visibility and retroreflectivity, drivers would have trouble staying on the road, especially at night or during inclement weather.

While durability and retroreflectivity of pavement markings are important for drivers to see the road in front of them, cost also is a significant factor when it comes to choosing a pavement marking product. The perspective of local communities, accounting for 75 percent of U.S. roads, is quite significant to the industry. In Kansas, local communities own most of the roads and streets with low average annual daily traffic, or AADT, in the state, and what is cost-effective for those roads is different than for roads and streets with higher amounts of traffic. This article will describe a few common pavement marking technologies and what to consider in choosing a pavement marking product as recommended in a few resources on the topic.

## Paints and thermoplastics

**Paints.** Paint-based pavement markings are classified as conventional or non-durable marking materials. The Federal Highway Administration's (FHWA) *Roadway Delineation Practices Handbook* says markings can be applied either hot or cold, and depending on the type of paint can take from 30 seconds to seven minutes to dry. According to the Minnesota DOT's *Cost of Pavement Marking Materials* report, initial retroreflectivity (ability to reflect light back to a source) starts at 275 mcd/m<sup>2</sup>/lux for white paints and 180 mcd/m<sup>2</sup>/lux for yellow, but deteriorates at a faster rate than thermoplastics. On high-volume roads, paints are usually used only temporarily.

Lead-free latex paints are a viable option for local roads. Latex, or waterborne, paint is relatively easy to apply, clean and dispose-of, and does not contain the high amounts of volatile organic compounds (VOCs) that alkyd paints have been known for in the past. While the FHWA's handbook notes that alkyd paints are less than ideal not only for their toxicity but because they aren't as durable as latex, MnDOT's *The Cost of Pavement Markings* says that alkyd paints have been recently changed so that they no longer contain high levels of VOCs. Regardless, the Minnesota DOT notes that alkyd paints are highly flammable and difficult to store.



*Paint sticks best to pavement that is neither too rough nor too smooth.*



For proper application of paint markings on all types of pavement, roads must be clean and dry. For latex paint markings to work best they must be installed during warm outside temperatures, generally above 50°F, but alkyd paints can be used in cold weather.

Both types of paint are quick-drying, but it is important to also apply the appropriate amount of clear, round, glass beads to ensure retroreflectivity in wet conditions and for the product's lifespan. Glass beads are either part of the paint mixture or are dropped or sprayed with a nozzle located directly behind the paint nozzle, allowing them to adhere to the paint markings almost immediately. By returning light emitted from a car's headlights back to the driver, the beads allow drivers to better see the markings at night and during rainy conditions.

**Thermoplastics.** Thermoplastics are resin-based marking materials that are durable and highly retroreflective, and therefore better seen by drivers at night and during inclement weather. Thermoplastics last longer than paint markings, and are commonly used on high-volume roads to lessen the amount of restriping work (and related traffic delays), or in places where visibility is especially critical, such as sharp curves.

Thermoplastic material starts out as a solid and needs to be heated to become liquid during application to adhere to the pavement when it cools. The product requires special equipment for installation, and the markings must be heated to 400°-425°F to stick to pavement. Because thermoplastic markings tend to weaken with road surface moisture, temperature fluctuations and



damage from snowplows, they should be replaced every three to six years.

**Durability depends on pavement characteristics and traffic counts**

Pavement marking types are chosen based upon their retroreflectivity, lifespan, and cost. Many factors affect the durability of pavement markings, including *pavement type*, which can cause premature wear and tear due to variations in roughness, *heat retention*, and *porosity* (roughness). Concrete, for example, has a very low porosity so it is difficult to get pavement markings to adhere correctly. Road sands and high average annual daily traffic (AADT above 10,000) traffic volumes can also cause both paints and thermoplastics to wear away.

Low-volume local roads are classified as having an AADT of less than 10,000. Paint markings are deemed suitable for local roads, although they only last from 12 to 36 months. It is important to keep in mind that rough pavements such as surface treatments like chip seals can cause paints to wear away prematurely, and that paints are not recommended for concretes.

Thermoplastics can by far outlast paint markings with a lifespan of 3-6 years. Reflective beads are usually mixed in with the material and spread on top, so initial retroreflectivity values should exceed the minimum 275 mcd/m<sup>2</sup>/lux for white and 180 mcd/m<sup>2</sup>/lux for yellow.

Unfortunately, snow plows can damage thermoplastics fairly easily. Another con is that because of their long lifespan, the markings are difficult to remove and replace. Lead contents must be properly disposed of, and if the old markings haven't completely worn away, they have to be

removed either by sandblasting, grinding, chipping, or by using an oxygenization process.

**Cost**

Pavement markings vary in price from about three cents per foot for paint up to \$2.65 per foot for more durable products. For example, paint markings range from three to five cents per foot. Mid-durable paints vary from eight to ten cents, but are not much different in performance from conventional paint. Thermoplastics cost between \$0.19 and \$0.26 per foot and require special installation methods, which may add additional costs to communities who have never used them before. The FHWA handbook says that thermoplastic application equipment can cost over \$150,000 and that local staffs rarely have the prior experience to work with such complex tools and carry out the delicate installation process.

To give you an idea of the cost for contracting-out this service, Bill Francis from Twin Traffic Marking Corporation in Kansas City says that thermoplastic installation from his company on high-volume roads costs approximately 60 cents per foot for a four inch line, while the contracting cost for paint markings is would be 12-13 cents per foot for a four inch line in large installations. Equipment and materials are provided in his estimates.

**What is recommended for low-volume roads?**

The Wisconsin transportation bulletin sums up the pros and cons of paints and thermoplastics well by saying, "Conventional paints are most cost effective for low-volume roads. In higher traffic areas, where conventional paints must be renewed in less than one year, thermoplastics or other durable marking products may be more economical."

So, if you are dealing with multiple restripings and want to try a more durable alternative, thermoplastic markings may be the answer, but if you are satisfied with the way paint-based pavement markings perform on roads with a low-volume AADT, there is no need to invest in the equipment and specialization or extra contracting cost that thermoplastic installation requires.

For more information, consult the sources for this article. ■

*On low-volume roads that have areas where conventional paints must be renewed in less than one year, thermoplastics or other durable marking products may be the more economical choice.*



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## A Leg Up

# The When, Where and How of Mid-Block Crosswalks

By Nate Vander Broek



KS LTAP / N. Vander Broek

**A**s a motorist, you may enjoy driving on a high-speed wide street with few intersections and many lanes. This type of street design, found in many suburbs and commercial areas, may enable you to get from origin to destination quickly and easily. However, if instead of driving you must walk the same route, your perception of that design may be very different. With intersections and pedestrian crossings few and far between, you may decide to cross in the middle of the block.

Crossing in mid-block creates a dangerous situation for both pedestrians and drivers. Pedestrians may put themselves in danger if they misjudge the speed of approaching vehicles and the time it takes to safely cross the street; drivers may be startled and confused by the pedestrian crossing the street, causing a driver to slam on the brakes.

A study in the early 1990s involving several states showed that mid-block events were the second major grouping of pedestrian crash types and accounted for 26.5 percent of all pedestrian crashes (Transportation Research Board). Among this group, the most common crash type (1/3 of all) was the “mid-block dash” where a pedestrian would run

into the street and the motorist’s view was not obstructed (Transportation Research Board). While it’s unlikely that pedestrians will cross only at intersections, it is possible to help them cross roads in between intersections in a more visible and safe manner through the use of midblock crosswalks.

Midblock crossings are locations between intersections where marked crosswalks have been provided. The crosswalk may be signalized or unsignalized. They offer convenient locations for pedestrians to cross in areas without frequent intersection crossings. Installation of midblock crosswalks acknowledges that pedestrians prefer to travel to their destination using the shortest route possible. A midblock crossing creates a safer, more visible and more direct route without requiring the pedestrian to walk to the nearest intersection or cross at a random and sometimes dangerous location.

### Where to consider a midblock crosswalk

Older neighborhoods, with narrow streets, slower moving vehicles, short blocks and many controlled intersections do not typically need midblock

crosswalks. However, in suburbs, long “superblocks” provide a good site for midblock crosswalks. Midblock crossings are also often placed where there is heavy pedestrian traffic near major destinations, such as schools, shopping centers, or transit stops.

### Crossing design

The Federal Highway Administration (FHWA) provides various crosswalk recommendations depending on the road’s classification. On roads with low traffic volume and speeds up to 30 mph, midblock crosswalks can be kept simple and do not require signals or other special traffic control devices. But when the distance between intersections increases, as well as the speed and traffic volume, midblock crosswalks may require the use of other control devices.

**Medians and refuge islands.** It may be necessary to add medians or refuge islands to help pedestrians cross safely. A median is a strip of land that separates traffic moving in opposite directions, and it may run for several blocks. Refuge islands are similar to medians, but are much shorter, usually 100-250 feet in length. These two types of traffic control serve many purposes. Medians and refuge islands provide pedestrians with a place to safely stop in the middle of the road, allowing pedestrians to watch for cars coming from only one direction at a time. Medians and refuge islands can help guide pedestrians to preferred crossing locations. Refuge islands may help slow traffic, from, say, 40 mph to 30 mph. Raised medians landscaped with trees or shrubs also help to reduce traffic speed.

**Signals.** On streets with four lanes, traffic signals should be considered along with medians or refuge islands. According to the FHWA, traffic signals at midblock crossings are helpful or essential under the following conditions:



- On higher volume roadways.
- Where gaps are infrequent.
- In school zones.
- Where elderly or disabled pedestrians cross.
- Where speeds are high.

On roads with six or more lanes, signalization is necessary. The FHWA states that streets with this many lanes create a complex condition for pedestrians trying to cross the street. A high number of rear-end crashes can be expected, especially in areas of high density. Devices used to alert drivers must also be increased. At the minimum, pedestrian crossing signs must be 36 by 26 inches for speeds of 40 mph. Pavement word symbols can be added to enhance pedestrian visibility, and zebra or ladder style crossings should be considered. The FHWA also suggests the use of large overhead signs, flashing beacons, bulb-outs or curb extensions which reduce the distance necessary to cross the street, and even flashing overhead signs in these situations.

### Design specifics

Section 31.06 of the *Manual on Uniform Traffic Control Devices* (MUTCD) suggests referencing the *American Disabilities Act Accessibility Guidelines for Buildings and Facilities* (ADAAG) for the minimum width for refuge islands and design and placement of detectable warning surfaces. Section 4.7.11 of the ADAAG specifies raised islands in crossings shall be cut through level with the street or have curb ramps at both sides and a level area at least 48 in long between the curb ramps in the part of the island intersected by the crossings.

Another technique used to help make midblock crosswalks safer is the use of staggered, or Z-crossing treatments in which the crosswalk is split by a median and is offset on either side of the median (FHWA). The crossing path is not a straight line. This forces the pedestrian to turn while in the median and face oncoming traffic before turning again to finish crossing the street. One issue with staggered crosswalks is it presents a challenge for the visually impaired who are “thrown off course by changes in the direction of the walkway leading to the road”

(FHWA). A solution is to provide railings or detectable warnings to help realign the pedestrian to the roadway just before crossing the street.

### Passive and active sensors

A number of electronic technologies can be used to help pedestrians safely cross midblock crosswalks. If signals are to be used, the sensor may be active or passive.

Active sensors require the pedestrian to push a button. Active sensors work best when sensors are “hot,” meaning the response is immediate. If a pedestrian hits the button and the signal does not change quickly, he or she may cross when traffic allows, without waiting for the signal to change. Then when the signal does finally change, a driver who is stopped at the crosswalk may become frustrated and disrespectful of the crosswalk when no pedestrians are visible. A slow sensor response can also cause pedestrians to avoid using crosswalk altogether. If a median or refuge island is used, a push button should be installed in the median if it is possible that some pedestrians will not be able to cross the whole street at one time (FHWA).

A passive sensor uses an infrared detector to determine the presence of a pedestrian in either the curbside area or the crosswalk. It does not require a pedestrian to push a button to activate the signal. If a pedestrian is detected in the crosswalk, the sensor can extend the time allowed for a pedestrian to cross the street. Passive signals provide an advantage over active signals by ensuring that the signal will be activated by all pedestrians, even those who are unable or unwilling to push the button.

Section 4D of the MUTCD specifies that midblock crosswalks shall not be signalized if they are located within 300 feet of the nearest traffic control signal unless the proposed traffic control signal will not restrict the progressive movement of traffic. Further, a midblock crosswalk location should not be controlled by a traffic control signal if the crosswalk is located within 100 feet from side streets or driveways that are controlled by stop signs or

yield signs. The MUTCD suggests an engineering study be completed to determine the need for a control signal at a midblock crosswalk.

### Crosswalk lighting

Adequate lighting helps to warn oncoming drivers of pedestrians crossing the street at midblock locations and also helps guide pedestrians across the street at night. The FHWA’s *Pedestrian Safety - Report to Congress* sites several new examples of lighting available for use at midblock crosswalks, from simple to high-tech:

*In-pavement lights.* These are amber lights embedded in the pavement on both sides of the crosswalk. These lights are directed towards oncoming traffic. In-pavement lights can be activated by passive or active sensors. Once activated, the lights flash at a constant rate, warning motorists of pedestrians in the vicinity. These lights are typically at crosswalks without stop control devices.

*Overhead lighting.* This system provides pedestrians with light to cross the street at night and warns oncoming vehicles of the potential for pedestrians. Overhead lighting can be activated passively or by pushing a button.

*LED warning systems.* These operate in a similar way to the overhead lighting system but provide an LED sign that warns approaching drivers that a pedestrian is crossing the street. In a study performed in Clearwater, Florida, the use of LED warning lights increased driver yielding behavior of 30 to 40 percent during the day and 8 percent at night. LED warning lights can be used in conjunction with overhead lighting for increased safety during the night.

*High-intensity activated crosswalk, or HAWK.* This relatively new type of signal uses both traditional traffic and pedestrian signal heads but in a different configuration. It includes a sign instructing motorists to “stop on red” and a “pedestrian crossing” overhead sign. It can be activated passively or by a pedestrian pushing a button. When activated, an overhead signal begins flashing yellow and then solid yellow, advising drivers to prepare to stop. It then switches to a solid red light

*Continued on next page*



## Mid-block crosswalks *Continued from page 11*

and shows the pedestrian a “Walk” indication. Finally, it shows a flashing red signal indicating that motorists may proceed when safe after coming to a complete stop. The pedestrian sees a flashing “Don’t Walk” sign indicating the number of seconds left to cross.

### Challenges with midblock crosswalks

Drivers do not expect to see pedestrians crossing at midblock locations. Because of this, it is important to have adequate lighting and signage

to ensure drivers have the necessary time to stop. Midblock crossings that span many lanes may be a challenge for many pedestrians. As stated above, you must provide medians or refuge islands to help reduce the number of lanes that pedestrians must cross at once. Also, the use of curb extensions can reduce the distance that a pedestrian must walk to cross the street.

Midblock crosswalks can be difficult to use safely for those who are visually impaired. If a midblock crossing is

not signalized, people with visual impairments are often unable to tell when there is a gap in traffic or whether all vehicles in approaching lanes have stopped, as the sound of one idling car can mask the sound of approaching cars. (FHWA’s *Designing Sidewalks and Trails for Access*). If the crosswalk is signalized, pedestrians who are visually impaired are often unable to determine when it is their turn to cross the street because their customary cue at intersections, the surge of traffic in the street beside them, isn’t present (FHWA’s *Designing Sidewalks and Trails for Access*). To help, an audible indicator that provides timing information should be installed.

### Costs

According to research done on unsignalized intersections and midblock crossing sites for the Minnesota Department of Transportation, the cost of passive warning crosswalk sites (roadway markings with yellow pedestrian warning signs) facing oncoming traffic typically cost no more than \$500. Active warning sites, featuring these passive warnings accompanied by a flashing light attached to a roadway shoulder sign or suspended above the roadway costs from \$5000 to \$12,000 to install. Their study concluded that people driving towards crosswalks with the active warning systems (flashing lights) tended to drive more slowly than at the passive warning sites without lights.

At left, see some 2007 estimates for

### Estimated Costs for Various Crosswalk Designs

- **Crosswalk/Countdown signal:** \$5,000 per intersection (this includes installation and an additional installed post). This cost can be up to \$15,000 per intersection if a retrofit is done with APS devices.
- **Curb extensions:** \$5,000 - \$25,000
- **Simple neighborhood crosswalks with signs and markings:** \$500 - \$1,500
- **Enhanced crosswalk with special stencils, raised platforms, or special signage:** \$5,000
- **Raised crosswalks:** \$2,000 – \$15,000
- **Refuge island:** \$10,000 – \$40,000
- **In pavement illumination:** \$25,000 – \$40,000 per crossing
- **Pedestrian only traffic signal:** \$40,000 - \$75,000
- **HAWK signal:** \$40,000
- **Midblock flashing crosswalk:** \$20,000 for equipment and \$20,000 to install

Source: [http://www.ncdot.org/bikeped/download/bikeped\\_planning\\_albemarle\\_AppendixE.pdf](http://www.ncdot.org/bikeped/download/bikeped_planning_albemarle_AppendixE.pdf)



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midblock crossing installation from the Albermarle, NC, Pedestrian Plan.

**Conclusion**

In summary, a midblock crosswalk provides pedestrians a safer and more visible way to cross a street than crossing at a random and often dangerous location. Midblock crosswalks are most useful in suburbs and areas where it's common to find long stretches without intersections.

Midblock crosswalks should be located where there is heavy pedestrian traffic and major destinations, such as schools, shopping centers, or transit stops. While all midblock crosswalks must be marked, they can also be enhanced with medians, refuge islands, signals, signs, lighting and curb extensions. Before considering a midblock crosswalk, view the regulations as stated in the MUTCD to see if the midblock crosswalk is

necessary and what features, such as signalization, should be used. And finally, consider elderly and disabled individuals in the design of the midblock crosswalk. The use of passive sensors instead of push buttons helps pedestrians who have trouble reaching or pushing buttons, and an audible indicator helps the visually impaired.

For more information on this topic, consult the sources for this article. ■

**At a Glance: Recommended Practice for Midblock Crossings**

- Consider providing a marked midblock crossing when protected intersection crossings are spaced greater than 400 feet or so that crosswalks are located no greater than 200 to 300 feet apart in high pedestrian volume locations, and meet the criteria below.
- Midblock crossings may be considered when there is significant pedestrian demand to cross a street between intersections, such as connecting to major generators or transit stops.
- Midblock crosswalks should be located at least 100 feet from the nearest side street or driveway so that drivers turning onto the major street have a chance to notice pedestrians and properly yield to pedestrians who are crossing the street.

**Criteria**

- Streets with an average daily traffic volume (ADT) of 12,000 vehicles per day or less.
- Multilane streets carrying less than 15,000 ADT if a raised pedestrian refuge median is provided.
- Operating speeds less than 40 mph.
- A minimum pedestrian crossing volume of 25 pedestrians per hour for at least four hours of a typical day.
- Adequate sight distance is available for pedestrians and motorists.

**Recommendations**

- Conform to Proposed Right-of-Way Accessibility Guidelines (PROWAG) guidelines for the disabled and visually impaired.
- Unsignalized midblock crosswalks should not be provided on streets where traffic volumes do not have gaps in the traffic stream long enough for a pedestrian to walk to the other side or to a median refuge. At locations with inadequate gaps that also meet MUTCD signalization warrants, consider a signalized midblock crossing.
- Consider a signalized midblock crosswalk (including

locator tone and audio pedestrian signal output as well as visual pedestrian countdown signal heads) where pedestrians must wait more than an average of 60 seconds for an appropriate gap in the traffic stream. When average wait times exceed 60 seconds, pedestrians tend to become impatient and cross during inadequate gaps in traffic. If this initial threshold is met, check pedestrian signal warrants in the MUTCD.

- Provide overhead safety lighting on the approach sides of both ends of midblock crosswalks.
- Provide wheelchair ramps or at-grade channels at midblock crosswalks with curbs and medians.
- Provide raised median pedestrian refuge at midblock crossings where the total crossing width is greater than 60 feet, and on any unsignalized multi-lane thoroughfare crossing.
- Use high-visibility (ladder-style) crosswalk markings to increase visibility longitudinally.
- Provide advance stop or yield lines to reduce multiple-threat crashes.
- Provide advance crosswalk warning signs for vehicle traffic.
- Provide curb extensions at midblock crosswalks with illumination and signing to increase pedestrian and driver visibility.
- “Z” crossing configurations should be used for midblock crossings with medians wherever possible (see Figure 9.16). Provide an at-grade channel in median at a 45-degree angle toward advancing traffic to encourage pedestrians to look for oncoming traffic.

**Other considerations**

- A strategy to calm traffic speeds in advance of and at a midblock crossing is to raise the pavement to meet the sidewalk elevation by use of gentle ramps.
- Consider use of overhead flashing beacons.

Source: Institute of Transportation Engineers. Designing Walkable Urban Thoroughfares: A Context Sensitive Approach. <http://www.ite.org/css/online/>



## WHAT'S NEW

By Lisa Harris

See download / ordering information on next page.

### Simple Sign Management Spreadsheet

This spreadsheet, designed by Norm Bowers of the Kansas Association of Counties, covers the basics for complying with the new federal requirements in the MUTCD for having a sign management system. Useful for small agencies with limited resources for asset management.

### The Safety Edge (Video)

This video comes in two formats on a single DVD. The first, the executive version, is geared toward elected officials and the public, and is five minutes long. The technical version is 8 minutes long and goes into more depth on the application technique and cost of the safety edge. The safety edge is an inexpensive and easy-to-install solution to the dangers of pavement drop-off. This technology is part of Federal Highway Administrator Victor Mendez's initiative called "Everyday Counts," which works toward creating accessible tools for highway safety. 2010.

### Warm Mix Asphalt

This technical brief, prepared by the Delaware T<sup>2</sup> Center, describes the development of Warm Mix Asphalt technology in the United States and elsewhere, and a good list of resources for further reading. December 2008. ■

## CALENDAR

Visit our Web site for even more training calendar listings and to register for workshops. Go to <http://www.ksltap.org> and click on "View the LTAP Calendar."

### ■ FALL 2011 TRAINING:

**Road Safety Assessment** ▲L3-e  
September 21 – Pittsburg

**Traffic Impact Studies** ▲L3-e  
September 27 – Wichita

**Asset Management and Cost Accounting** ▲L3-r  
September 28 – Wichita  
September 29 – Topeka

**Concrete Road & Street Maintenance** ▲L1  
October 11 – Salina  
October 13 – Leavenworth

**Snow and Ice Control** ▲L1  
October 26 – Hays  
October 27 – Hutchinson  
October 28 – Manhattan

**Traffic Signal Design – NEW COURSE**  
November 2 – Wichita  
November 3 – Lawrence

**Bridge Maintenance**  
November 9 – Salina  
November 10 – Lawrence

**Legal Permitting and Regulatory Process** ▲L3-r  
December – Check website for date and location. <http://www.ksltap.org> and click on "View the LTAP Calendar."

**NEW! Alternatives to Paving**  
November 30 – Lawrence

**Risk and Liability Issues** ▲L1  
January 18, 2012 – Salina  
January 25, 2012 – Lawrence

### ■ UPCOMING MEETINGS:

**"MINK" Local Roads Meeting**  
September 21-22 – St. Joseph, MO  
Download the agenda and registration form at <http://www.moltap.org>

**Kansas County Highway Association Fall Meeting**  
November 14 – Topeka  
<http://www.kansascountyhighway.org>

**APWA-Kansas Chapter Fall Meeting**  
October 11 in Wichita  
<http://kansas.apwa.net/>

**KDOT-KAPA Fall Asphalt Forum**  
November 2-3 in Topeka  
(local agencies are welcome)  
<http://www.ksasphalt.com>

**55th Annual Asphalt Paving Conference**  
December 1 in Lawrence  
<http://www.continuinged.ku.edu/programs/asphalt/index.php>

For information on calendar items or to suggest a topic for an LTAP workshop, contact: Kristin Kelly, LTAP Training Coordinator, 785/864-2594, [kbkelly@ku.edu](mailto:kbkelly@ku.edu).

▲L1 = KS Road Scholar Program Level 1 — Technical skills required course.

▲L2 = KS Road Scholar Program Level 2 — Supervisory skills courses are provided by the Kansas Association of Counties. Go to <http://www.kansascounties.org> and click on "Education Program."

▲L3-r = KS Road Scholar Program Level 3 — Master Road Scholar required course.

▲L3-e = KS Road Scholar Program Level 3 — Master Road Scholar elective course.



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## TRAINING GUIDES & REPORTS

You are free to keep these unless otherwise noted.  
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### Simple Sign Management Spreadsheet

For a copy of this spreadsheet, email Norm Bowers at [bowers@kansascountries.org](mailto:bowers@kansascountries.org).

### The Safety Edge (video on DVD)

Two video presentations (short and longer) on one DVD.  
See description on page 14.  
 request the DVD

### Warm Mix Asphalt Technical Brief

See description on page 14. Delaware T<sup>2</sup> Center. December 2008. Download at <http://www.ce.udel.edu/dct/T2/T2TechnicalBriefs/Warm%20Mix%20Asphalt.pdf>

### Gravel Roads Maintenance and Design Manual

This is a popular national resource on gravel roads maintenance commissioned by FHWA and produced by the South Dakota LTAP. If you don't already have this in your library, order a copy.  
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## EQUIPMENT LOANS

We offer the following items for loan to local highway agencies.  
Contact [mgivechi@ku.edu](mailto:mgivechi@ku.edu) for counter boards and [weaver@ku.edu](mailto:weaver@ku.edu) for the Safety Edge shoe. There could be a waiting list for these items.

**Safety Edge Paving Shoe.** This Advant-Edge shoe attaches to a paver with a universal bracket, provided with the shoe.

**Turning Movement Counter Board DB-400, Jamar Technologies, Inc.** A basic model for recording turning movements at intersections. The board is lightweight and comes with its own case.

**Turning Movement Counter Board TDC-8, Jamar Technologies, Inc.** Can be used to do turning movement counts, classification counts, gap studies, stop-delay studies, speed studies, and travel time studies. The board is lightweight and comes with its own case.

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